UNITED STATES COMMISSION OF FISH AND FISHERIES.

PART XVIII.

REPORT

OF

THE COMMISSIONER

FOR

THE YEAR ENDING JUNE 30, 1892.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1894.

Resolved by the Senate (the House of Representatives concurring therein), That the Report of the Commissioner of Fish and Fisheries, covering the operations of the Commission for the fiscal year ending June 30, 1892, be printed; and that there be printed 8,000 extra copies, of which 2,000 shall be for the use of the Senate, 4,000 for the use of the House of Representatives, and 2,000 for the use of the Commissioner of Fish and Fisheries; the illustrations to be obtained by the Public Printer under the direction of the Joint Committee on Printing.

Agreed to by the Senate December 19, 1892.

Agreed to by the House December 20, 1892.

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REPORT

OF THE

UNITED STATES COMMISSIONER OF FISH AND FISHERIES

FOR THE

FISCAL YEAR ENDING JUNE 30, 1892.

The following report exhibits the work of the Commission during the year commencing July 1, 1891, and ending June 30, 1892.

For the current expenses of the work appropriations as follows were made by Congress:

Compensation of Commissioner	$5,000
Propagation of food-fishes	155,000
Distribution of food-fishes	50,000
Maintenance of vessels	45,000
Inquiry respecting food-fishes	20,000
Statistical inquiry	20,000
	295,000

Details of the expenditure of these appropriations were submitted to Congress December 1, 1892 (Mis. Doc. No. 10, House of Representatives, Fifty-second Congress, second session).

DIVISION OF INQUIRY RESPECTING FOOD-FISHES.

This division of the Fish Commission is charged with the inquiry into the causes of the decrease of food-fishes in the lakes, rivers, and coast waters of the United States, the study of the waters of the interior in the interest of fish-culture, and the investigation of the fishing-grounds of the Atlantic, Pacific, and Gulf coasts, with the view of determining their food resources and thus directing and promoting the development of the commercial fisheries.

The responsible direction of the work has continued, as heretofore, under Mr. Richard Rathbun, the assistant in charge. A review of the more important operations of the year will indicate how important and diversified are the duties which devolve upon him, and how diligent and capable has been his administration.

On the Pacific coast the principal investigation related to the fur-seal fishery of the North Pacific Ocean and Bering Sea. The information sought was the ascertainment of other, if any, hauling-grounds for the seals on the Alaska coast than those of the Pribilof Islands, the relations that might exist between the American and Asiatic herds, and a knowledge of the pelagic habits of these animals. These inquiries were conducted for use in connection with the preparation of the Bering Sea case before the proposed Tribunal of Arbitration at Paris. By direction of the President, on July 9, 1891, the steamer *Albatross* was placed at the disposition of the agents of the Government detailed to visit the seal islands, Doctors T. C. Mendenhall and C. Hart Merriam. The ship sailed from San Francisco July 16 and did not return till toward the close of the following month, too late to permit her return to northern waters to prosecute the intended inquiries, and they were deferred till the middle of March, 1892, when they were taken up under the nominal direction of the Secretary of the Treasury, the instructions, however, emanating from the State Department and the Fish Commission. A general outline of the information gained, as also of the cruise of the vessel, will be found in the accompanying report of Mr. Rathbun.

Upon the return of the *Albatross* to the United States on August 22, 1891, she was occupied in an investigation of the fishery resources of Puget Sound and the Strait of Juan de Fuca and in some incidental fishing and dredging trials till September 18, from which date till the following March she was transferred to the direction of the Secretary of the Navy for use in the determination of a practicable route for a telegraphic cable between San Francisco and Honolulu, as provided by the act of Congress approved March 3, 1891.

On the Atlantic coast the principal work of the division was an investigation, through the agency of the schooner *Grampus*, of the distribution and abundance of fishes in Chesapeake Bay and adjacent waters, and the conduct of inquiries off the southern coast of New England for the purpose of determining the physical characteristics of the belt of water bordering the coast through which, in their seasonal migrations north and south, so many important fishes pass, the changes which occur therein, and the causes for such changes. A large part of the year was spent by the steamer *Fish Hawk* in the delineation of the oyster-grounds of Chesapeake Bay and the determination of their condition, with a view of ascertaining the possibilities of increasing the product of this mollusk.

Through arrangements made with Dr. John A. Ryder, experiments were conducted at Sea Isle City, N. J., for the purpose of determining some practical system for the collection of oyster spat so as to permit the utilization of areas of muddy bottom not suitable for oyster-planting by methods now employed. The study of the food of oysters, and of the relations of oysters to their environment in that respect, was conducted near Hampton, Va., by Dr. John P. Lotsy, of the Johns Hopkins University.

Toward the close of the last fiscal year arrangements were made with Dr. Bashford Dean, of Columbia College, New York, to investigate the systems of oyster-culture pursued in France and other European countries. The reports on these inquiries have appeared in the bulletin of the Commission under the titles "Report on the Present Methods of Oyster-Culture in France," and "Report on the European Methods of Oyster-Culture."

The more important investigations of the Commission at the Woods Holl Marine Laboratory were in relation to—

(1) The embryology of certain sponges indigenous to the Vineyard Sound region, which are themselves of no economic importance, but are related in their development and habits to the more important forms of the Gulf coast—by Dr. H. V. Wilson.

(2) The anatomy, embryology, and habits of certain important crustaceans and mollusks—by Profs. Patten, Herrick, Fernald, Kellogg, and Conklin.

(3) Continuous observations through the entire year by Mr. Vinal N. Edwards in reference to the habits, abundance, and movements of the important fishes of the New England coast, and the temperature conditions existing and influencing their movements. The most interesting result of his observations for the current year was that the menhaden, in part at least, is an inshore spawner. The observations as yet are too few in number and over too small an area to warrant any general conclusions, but if more extended and continued observations disclose that this habit is general for the species, the necessity of regulation of the menhaden fishery by reasonable restraints will be as evident and imperative as for the shad and other anadromous species.

In connection with the general study of the interior waters, special attention was given during the year to the Rocky Mountain region of Montana and Wyoming, and of Texas, with the view of determining, in accordance with the special directions of Congress, suitable sites for the location of fish-hatcheries. Inquiries were also made concerning some of the water-courses of Ohio, Indiana, Kentucky, Tennessee, North Carolina, New York, and Wisconsin. Incidentally, in the work of this division, an investigation, in response to complaints, was made of the pollution of the Susquehanna River near Havre de Grace, Md., produced by the overflow of the waste liquors from a large mill manufacturing paper from wood pulp.

At the various rearing-stations of the Commission the amount of their product has been from time to time greatly affected by the presence of disease caused both by peculiar conditions of surroundings and by parasitic animals. Several special cases received the attention of the division during the year, and investigations looking toward a comprehensive study of the subject, on which successful fish-culture so greatly depends, have been inaugurated.

In the prosecution of its investigations this division has had the able assistance of a number of gentlemen connected with our colleges and other institutions of learning, to whom acknowledgment is hereby made by the Commissioner. The names of these gentlemen, and the special inquiries on which they were engaged, as also the fuller details of the work of the division, will be found in the accompanying report of the assistant in charge.

DIVISION OF STATISTICS AND METHODS OF THE FISHERIES.

During the fiscal year 1892 the work of this division continued under the general direction of Mr. J. W. Collins, assistant in charge. He having been designated by me as the representative of the Commission on the Government Board of Control of the World's Columbian Exposition, and his new duties requiring and receiving most of his attention, the immediate direction of the work of the division devolved upon Mr. Hugh M. Smith, principal assistant. His report of operations for the year is appended to and constitutes a part of the report of the Commissioner. A brief summary of the more important features of the year's work in this division is here given.

This division is charged by law with the study of the methods, relations, and statistics of the fisheries with a view to their improvement; the study of the resources of the fishing-grounds of the Atlantic, Gulf, and Pacific coasts, and the determination of methods for the development of the same; the collection and compilation of the statistics of the fisheries of all portions of the United States, including persons employed, capital invested, and quantity and value of products, and the preparation of reports relating to the inquiry.

The geographical scope of the field investigations of the commercial fisheries undertaken by the division during the year had reference to the work accomplished during the two preceding years, when the attention of the office was directed to the New England, South Atlantic, Gulf, and Pacific States. The fisheries of the Great Lakes had not been canvassed since 1885, and no complete study of the fishing industry of the Middle Atlantic States had been made since 1888; and it was, therefore, in these sections that the field force was placed. The regular inquiries heretofore conducted at Boston and Gloucester were continued.

The canvass of the fisheries of the Great Lakes placed the office in possession of interesting and useful data, showing the condition of the industry in the calendar year 1890 and permitting the institution of important comparisons with 1880 and 1885. A full synopsis of the results of the investigation is given in the appended report of the division, and the complete report on the lake fisheries will be found in the appendix (pp. 361–459).

The fisheries of the Great Lakes have from an early date attracted much attention, not only in the States directly bordering thereon, but throughout the country. The general interest which has been manifested has been due to the great extent of the industry, the dissimilarity of the fishes from those taken in other regions, the important fish-cultural operations which have there been carried on, and the probability of a more speedy and complete impairment of the supply by overfishing than would be possible in the case of fisheries prosecuted in the open sea.

This Commission has endeavored to keep well informed regarding the condition of the lake fisheries. In 1885 the thorough canvass made by the office disclosed a very satisfactory state of the industry, the output of the commercial fisheries in that year probably being larger than during any previous year. Several minor special studies were also undertaken in the lake region in the years intervening between 1885 and the next general canvass in 1891.

The results of the inquiries conducted during the year show that, taking the entire region into consideration, 9,738 persons were directly employed in the industry, $5,420,778 was invested, and the value of the catch was $2,471,768. The yield of the principal species was as follows: Whitefish, 12,401,335 pounds; lake trout, 12,890,441 pounds; sturgeon, 4,289,759 pounds; lake herring, 48,753,349 pounds; other fish, 35,563,647 pounds.

General comparisons for the entire region show that in 1890 the number of persons employed, the amount of capital invested, and the quantity and value of the catch were greater than in 1880, while the number of fishermen and the value of the catch were less than in 1885, although the investment was considerably larger.

A knowledge of the variations which have occurred in the abundance of the principal fishes, as determined by the catch, is of great importance in shaping legislation and applying fish-cultural methods for the maintenance of the supply. Whitefish, which in 1880 were taken in larger quantities than any other species, were surpassed in 1890 by lake trout and lake herring; the decrease in the output was 43 per cent between 1880 and 1890, and 30 per cent between 1885 and 1890. The catch of lake trout increased to only a slight extent since 1885, but was almost twice as large as in 1880. The yield of sturgeon has exhibited a steady decrease, which was especially marked in the last five years. The most noticeable change has been the catch of minor whitefishes, usually classed under the general name lake herring, of which the cisco (*Coregonus artedi*) is the type. From the second place, which these fish occupied in 1880, they advanced to first in 1885, and maintained the same relative rank in 1890, becoming, at the same time, the most valuable of the lake fishes. The aggregate production of all other species was about the same in 1890 as in 1885, and was somewhat more than double that in 1880.

The general increases and decreases which have occurred in the yield of the different fishes must not be regarded wholly from the standpoint of abundance, but should be interpreted in connection with the special conditions prevailing in each lake, among which may be noted variations in the amount of apparatus used and the transfer of fishing operations from one lake to another or from American to Canadian waters in the same lake.

During the fiscal year 1892 the field investigations in the Middle Atlantic States were, on account of the small force available for such duty, confined to the basin of the Chesapeake Bay and to the adjoining ocean shores of Maryland and Virginia. The extent of the fisheries prosecuted in this region justified the very complete inquiries made, and fully warranted the expenditure of the time necessary to study the statistics and methods of the industry in all the tributary streams of the region to the limits of economic fishing. This basin is the most productive inland fishing-ground in the country, if not in the world; the quantity of products withdrawn from it annually is enormous, and the value to the fishermen is over $10,000,000, or more than one-fifth that of the fisheries of the entire country, while the number of persons immediately connected with the industry is about 65,000 and the capital invested is nearly $10,500,000.

An interesting question comes up in connection with the consideration of the fisheries of this region: In view of the enormous annual drain on the fishery resources, what is their present condition compared with any earlier year for which data are available, and is the supply apparently being maintained? Since 1880, an increase has occurred in the fishing population amounting to over 18,000 persons, of whom two-thirds are fishermen proper and one-third shore employés. A corresponding advance has taken place in the amount of the invested capital aggregating over $2,250,000, the increase representing the use of larger numbers of boats and practically every form of fishing appliances. Especially worthy of comment is the remarkable augmentation in the number of pound nets operated, indicating a tendency to substitute this more modern class of apparatus for the less effective means of capture that formerly prevailed.

The increase in fishing population and apparatus would naturally be expected to produce an augmented yield, provided the supply had not been seriously impaired by overfishing. The returns show a general advance in output commensurate with the increases noted. The aggregate increase in the value of the yield is about $3,274,000, or nearly 50 per cent, a sum in which most of the important products are represented.

Foremost among the fishery resources of this region is the oyster, the value of which is about four-fifths that of the entire fishery output. The conservation of the oyster supply is a question that has received great attention, and the anticipation of a serious reduction in the output under existing methods is borne out by the data at hand. Notwithstanding an increase of nearly 10,000 oyster fishermen and $1,800,000 in the capital devoted to the oyster industry, the yield of oysters diminished over 1,500,000 bushels, although the market value of the output was considerably greater, the average price increasing as a result of the comparative scarcity. It is hoped that the States immediately interested in this industry will adopt such measures as will not only secure the preservation of this important natural resource, but will permit an expansion of the fishing operations and ultimately an increased production.

The inquiries conducted by local agents at Boston and Gloucester, Mass., referred to in my previous reports, have been continued. The detailed study of the fisheries centering at these cities is warranted by the great importance of the industry. The investigations cover the operations of a large proportion of the offshore fishing fleet of New England, and the information obtained has a permanent value in permitting the institution of comparisons by which the condition of these important fisheries from time to time may be clearly judged.

The work at Boston has been efficiently performed by Mr. F. F. Dimick, who has unusual opportunities for collecting data by reason of his wide acquaintance with the fishermen and his position as secretary of the Boston fish bureau. At Gloucester, Capt. S. J. Martin, a retired vessel fisherman of extended experience, has rendered very satisfactory service.

The quantities of fish landed at Boston by American fishing vessels in 1891 was about 70,000,000 pounds, having a value to the fishermen of $1,840,000. The fish most largely represented in the receipts is the haddock, of which over 33,000,000 pounds, valued at $824,000, were landed. Of cod, the next important fish, 16,655,000 pounds, worth $548,000, were brought in.

The receipts of fish at Gloucester directly from fishing vessels are larger than at Boston; they consist chiefly of salt fish, while the fares landed at Boston are practically all fresh. In 1891, about 77,000,000 pounds of fish, valued at $2,785,000, were taken to Gloucester by the American fishing fleet. Of this amount, fresh and salt cod constituted over 44,000,000 pounds, worth $1,563,000.

During the year the consideration of the fisheries of the international lakes attracted much attention, and the agitation of the subject finally resulted in a series of meetings in New York and Canada, at which representatives from the provinces of Ontario and Quebec and most of the States bordering on the Great Lakes were present. In October, 1891, a preliminary meeting was held in New York City, which was attended by special commissioners from the Canadian provinces and the State of New York, and by other persons interested in the lake fisheries. The meeting was presided over by Hon. Robert B. Roosevelt. The object of the conferences was stated to be the protection, preservation, and propagation of food-fish in the Great Lakes, and a committee was appointed to meet at Rochester, N. Y., in November, and formulate a report for presentation to a full conference of Canadian and State representatives to be called later. At the Rochester meeting, Gen. Richard U. Sherman acted as chairman. The lake fisheries were fully considered, and recommendations for submission to the full meeting were determined on. The final conference was held at Hamilton, Ontario, in December, and was presided over by Hon. Donald McNaughton. The recommendations of the Rochester session were affirmed, and the meeting adjourned with the understanding that similar conferences would be called each year if the condition of the lake fisheries warranted attention. At all these meetings this Commission was represented by Dr. Smith, to whose detailed account of the conferences reference is made.

A number of reports and special papers emanating from this division and germane to its work were issued during the year. Some of these were general in their scope, and some related to special subjects. There is a very active demand among the commercial fishing interests for papers of this class, and the Commission endeavors to make as judicious an allotment of such publications as the limited supply will permit; in the case of several of the more important reports, extra editions were required to satisfy the calls on the office.

The accompanying report of the assistant contains notes on the condition of some of the more prominent commercial fisheries and on some conspicuous events that transpired in connection with the fishing industry during the year. The special branches or subjects referred to comprise the great ocean fisheries for cod, haddock, halibut, and other ground fish; the mackerel fishery; the Pacific salmon industry; the whale fishery; the fur-seal fishery; the lobster fishery; the oyster fishery; improvements in fishing vessels; the attempt to establish a beam-trawl fishery on the New England coast; the Newfoundland bait question; inauguration of red-snapper fishing on offshore banks in the Gulf of Mexico.

DIVISION OF FISH-CULTURE.

The control and direction of the work of this division was retained by the Commissioner. During the year the following stations were operated:

1. Schoodic, Me
2. Craig Brook, Me.
3. Green Lake, Me.
4. Gloucester, Mass.
5. Woods Holl, Mass.
6. Cold Spring Harbor, N. Y.
7. Delaware River (steamer *Fish Hawk*).
8. Battery Island, Md.
9. Bryan Point, Md.
10. Central Station, Washington, D. C.
11. Fish Ponds, Washington, D. C.
12. Wytheville, Va.
13. Put-in Bay, Ohio.
14. Northville, Mich.
15. Alpena, Mich.
16. Duluth, Minn.
17. Quincy, Ill.
18. Neosho, Mo.
19. Leadville, Colo.
20. Baird, Cal.
21. Fort Gaston, Cal.
22. Clackamas, Oreg.

Summary of fish furnished for distribution, July 1, 1891, to June 30, 1892.

Source of supply.	Species.	Eggs.	Fry.	Adults and yearlings.
Schoodic Station, Me	Landlocked salmon	277,000	68,692	42,184
Craig Brook, Me	Atlantic salmon	450,000		254,232
	Landlocked salmon			9,979
	Loch Leven trout			10,935
	Rainbow trout			105
	Von Behr trout			698
	Swiss lake trout			45
	Brook trout			1,677
Green Lake, Me	Landlocked salmon			116,000
Gloucester, Mass	Cod	4,953,100	27,124,500	
	Pollock		2,473,500	
Woods Holl, Mass	Sea bass		200,000	
	Scup		35,000	
	Cod	560,500	25,671,500	
	Flatfish	2,763,800	3,510,400	
	Lobster		5,799,500	
Cold Spring Harbor, N. Y	Quinnat salmon			5,900
Delaware River (steamer *Fish Hawk*), N. J.	Shad	5,983,000	15,833,000	
Battery Island, Md	do	7,595,000	32,616,000	
Bryan Point, Md	do	13,378,000		
Central Station, Washington, D. C.	Catfish			76
	Shad	* 1,989,000	9,891,000	
	Von Behr trout		21,978	
	Whitefish		313,000	
	Sunfish			338
Fish Ponds, Washington, D.C.	Carp			157,490
	Tench			9,600
	Golden ide			3,400
	Goldfish			10,700
	Shad			1,000,000
Wytheville, Va	Carp			4,485
	Goldfish			6,915
	Rainbow trout	154,500		49,792
	Black bass			215
	Rock bass			15,182
Put-in Bay, Ohio	Whitefish	32,500,000	6,000,000	
	Lake herring		262,500	
	Pike perch	32,600,000	40,000,000	
Northville, Mich	Loch Leven trout	185,500		3,709
	Von Behr trout	305,500		7,327
	Brook trout	10,500		13,034
	Lake trout	1,900,500		45,722
Alpena, Mich	Whitefish	12,370,000	17,750,000	
Duluth, Minn	Von Behr trout		20,000	
	Lake trout		480,000	
	Whitefish		16,727,000	
	Pike perch	30,000,000		
Quincy, Ill	Catfish			4,351
	Yellow perch			32,648
	Pike perch			100
	White bass			2,115
	Black bass			13,792
	Crappie			6,447
	Rock bass			6,502
	Pike			2,028
	Sunfish			9,884
Neosho, Mo	Catfish			62
	Carp			7,184
	Tench			26,432
	Goldfish			3,576
	Rainbow trout			11,124
	Von Behr trout			10,222
	Brook trout			6,327
	Black bass			7,559
	Crappie			109
	Rock bass			9,376
Leadville, Colo	Von Behr trout			54,200
	Black-spotted trout			19,000
	Brook trout			38,550
Baird, Cal	Quinnat salmon	2,902,000	25,500	
Fort Gaston, Cal	do		290,000	25,000
Clackamas, Oregon	do		1,332,400	
Received from Max von dem Borne, Germany.	Von Behr trout	27,000		

* Sent to fish ponds, Washington.

DISTRIBUTION OF FOOD-FISHES.

The distribution during the year is shown by the following table:

Summary of distribution, 1891-92.

Species.	Eggs.	Fry.	Adults and yearlings.	Total.
Catfish (*Ictalurus punctatus* and *Ameiurus albidus*, chiefly).			4,326	4,326
Carp (*Cyprinus carpio*)			157,093	157,093
Tench (*Tinca tinca*)			35,592	35,592
Golden ide (*Idus melanotus*)			2,186	2,186
Goldfish (*Carassius auratus*)			20,651	20,651
Shad (*Clupea sapidissima*)	2,497,000	66,927,000	1,000,000	70,424,000
Quinnat salmon (*Oncorhynchus chouicha*)	2,902,000	1,647,900	30,870	4,580,770
Atlantic salmon (*Salmo salar*)	450,000		254,232	704,232
Landlocked salmon (*Salmo salar*, var. *sebago*)	232,000	68,692	163,163	463,855
Loch Leven trout (*Salmo levenensis*)	110,500		14,579	125,079
Rainbow trout (*Salmo irideus*)	140,000		54,734	194,734
Von Behr or brown trout (*Salmo fario*)	80,500	41,978	69,179	191,657
Black-spotted trout (*Salmo mykiss*)			18,000	18,000
Brook trout (*Salvelinus fontinalis*)	10,500		58,969	69,469
Lake trout (*Salvelinus namaycush*)	900,500	480,000	43,864	1,424,364
Whitefish (*Coregonus clupeiformis*)	20,800,000	44,467,000		65,267,000
Lake herring (*Coregonus artedi*)		262,500		262,500
Yellow perch (*Perca flavescens*)			29,950	29,950
Pike perch (*Stizostedion vitreum*)	45,000,000	49,300,000	100	94,300,100
Sea bass (*Serranus atrarius*)		200,000		200,000
White bass (*Roccus chrysops*)			1,946	1,946
Black bass (*Micropterus salmoides* and *M. dolomieu*)			19,753	19,753
Crappie (*Pomoxis annularis* and *P. sparoides*)			6,311	6,311
Rock bass (*Ambloplites rupestris*)			26,208	26,208
Sunfish (*Lepomis*)			9,604	9,604
Pike (*Lucius lucius*)			1,966	1,966
Scup (*Stenotomus chrysops*)		35,000		35,000
Cod (*Gadus morrhua*)		52,795,500		52,795,500
Pollock (*Pollachius virens*)		2,473,500		2,473,500
Flatfish (*Pseudopleuronectes americanus*)	2,764,000	3,510,000		6,274,000
Lobster (*Homarus americanus*)		5,799,000		5,799,000
Total	75,887,000	228,008,070	2,023,276	305,918,346

NOTE.—In addition to the foregoing there were furnished for distribution, but lost in transit, during the year 1891-92, fry, as follows: Shad, 1,442,000; Whitefish, 10,000; Pike Perch, 8,300,000; also adults and yearlings as follows: Catfish, 128; Carp, 1,915; Tench, 428; Golden Ide, 327; Goldfish, 300; Quinnat Salmon, 30; Landlocked Salmon, 5,000; Loch Leven Trout, 65; Rainbow Trout, 6,279; Von Behr Trout, 3,111; Brook Trout, 617; Lake Trout, 1,858; Yellow Perch, 2,698; White Bass, 167; Black Bass, 1,627; Crappie, 243; Rock Bass, 4,838; Pike, 62, and Sunfish, 618.

There were also deposited for rearing and distribution 1,989,000 shad fry in the United States fish ponds, Washington, D. C., and 700,000 in the United States fish ponds at Neosho, Mo., and the following adult and yearling fish were collected from the sloughs and planted in the Illinois River, near Meredosia, Ill.: Catfish, 250,000; White Bass, 15,000; Carp, 5,000; Buffalo, 20,000; Yellow Perch, 35,000; Crappie, 5,000; but none of these figures is included in the above table.

STATION REPORTS.

SCHOODIC STATION, MAINE (CHARLES G. ATKINS, SUPERINTENDENT).

The work at Grand Lake Stream during this year was conducted jointly with the Maine State Fish Commission, the immediate charge of the station being placed under Mr. W. O. Buck.

The 50,000 fry of the landlocked salmon held from June, 1891, for rearing, were counted and weighed during the first half of October, and liberated in Grand Lake. There were found to be 42,184, showing a total loss for the season of a little over 15 per cent, and their weight was 204,625 pounds, or an average of 7.76 ounces per hundred.

The capture of adult salmon for spawning was begun in October, the first fish being taken October 25, but no ripe females were found until November 3. Notwithstanding this unusually late start, the last ripe fish was obtained on November 23, about the usual date. In all, 579 fish were captured, 380 being females and 199 males. The males averaged 20.1 inches in length, with a weight of 3.23 pounds; the females, 19.9 inches in length, with a weight of 3.29 pounds.

The total number of eggs taken was 627,937, the product of 351 fish, or an average of about 1,785 eggs to each. The losses in these eggs up to the time of division amounted to 131,887, leaving available 496,050, of which 100,000 were allotted to the State of Maine and 396,050 to the U. S. Fish Commission. Of these latter, 119,050 were reserved for Grand Lake, in which 68,692 fry were liberated between June 11 and 18, 1892, at the end of the sac stage and 50,000 fry held beyond the year for rearing. The loss during June in the 50,000 fry retained was 159.

The following table shows the distribution of the 277,000 eggs and other information connected therewith:

Consignee.	No. of eggs.	Date of shipment.	Reached destination.	Condition.	Loss.
U. S. Fish Commission stations:					
Craig Brook, Maine	25,000	Feb. 23, 1892	Feb. 25, 1892	Excellent.	51
Clackamas, Oregon	20,000	Feb. 29, 1892	Mar. 10, 1892	Bad	20,000
State fish commissions:					
Vermont, Roxbury	20,000	....do	Mar. 2, 1892	Good	10
New Hampshire, Plymouth	17,000	....do	Mar. 1, 1892	....do	....
New York, Caledonia	15,000	....do	Mar. 2, 1892	....do	47
Minnesota, St. Paul	15,000	....do	Mar. 4, 1892	....do	43
Nevada, Carson City	25,000	....do	Mar. 7, 1892	....do	40
California, San Francisco	30,000	....do	Mar. 8, 1892	....do	80
Wilmurt Club, Newton Corners, N. Y.	25,000	....do	Mar. 3, 1892	Fine	173
	5,000	Mar. 14, 1892	Mar. 19, 1892	Good	35
Tuxedo Club, Tuxedo Park, N. Y	10,000	Feb. 29, 1892	Mar. 2, 1892	....do	14
A. N. Cheney, Glens Falls, N. Y	10,000	....do	Mar. 3, 1892	....do	34
Blooming Grove Park Association, Glen Eyre, Pa	10,000	....do	....do	....do	33
Mexican Government, Mexico City	25,000	....do	Mar. 10, 1892	Warm	8,760
W. P. Greenough, Lachevrotiere, Canada	10,000	....do	Mar. 6, 1892	Good	18
H. B. W. Whitmore, Bridgeworth, England	15,000	Feb. 23, 1892	Mar. 7, 1892	....do	No report.

CRAIG BROOK STATION, MAINE (CHARLES G. ATKINS, SUPERINTENDENT).

In the report for the previous year reference is made to the commencement of the building of a superintendent's dwelling, under contract dated March 5, 1891. This building was completed in the fall and accepted from the contractor October 3. The other construction work was the building of two capacious filters, one for the water supplying the south ponds, and the other for the north stand of rearing troughs and the ponds connected with it; the construction of an aqueduct 800 feet long, to supply the superintendent's dwelling; the underpinning of the west end of the stable; the building of a winter road down the hill near the north stand of troughs, and the grading of the grounds near the dwelling.

The following table presents the results of the eggs of the different kinds of salmon and trout brought over from the previous year, ending June 30, 1891:

Kind.	Number of eggs at start.	Hatched.	Reached feeding stage (June 1).	Distributed in June.	October count.	Died after counting.	Distributed Oct., Nov. and Dec.	Reserved.
Atlantic salmon	317, 218	316, 308	309, 308	....	254, 955	306	238, 652	15, 997
Landlocked salmon	21, 906	21, 824	20, 269	5, 289	9, 723	12	7, 401	2, 310
Brook trout	23, 146	14, 524	8, 569	4, 251	1, 555	3	1, 352	200
Von Behr trout	15, 119	13, 824	2, 554	....	800	....	....	800
Loch Leven trout	16, 583	16, 457	14, 900	....	10, 796	172	10, 524	100
Scotch sea-trout	12, 374	9, 367	146	....	87	....	....	87
Total	406, 346	392, 304	355, 746	9, 540	277, 916	493	257, 929	19, 494

From these figures we may deduce the following percentages: Starting with eggs as counted in winter or early spring, and counting the few fish distributed in June as though they had been kept till October, we find that of all kinds 71 per cent were carried through. Leaving out the Von Behr and Scotch sea-trout, the eggs of which reached the station in exceedingly bad condition and the fry of which mostly died before reaching the feeding stage, the percentage is 76; of the Atlantic salmon, 80, and Loch Leven trout, 65 per cent, respectively. Starting from the fry stage, the percentage of other kinds is 81, and of the Atlantic salmon, 82. This season must therefore be ranked as an exceedingly successful one.

As in past years, part of the fish were fed on chopped meat and part on maggots. The relative growths of the several lots furnished further evidence of the superiority of live food.

The following exhibits the disposition of reared fish during the year:

Kind.	When hatched.	When liberated.	Number.	Waters in which placed.
Atlantic salmon	1891	Oct. and Nov., 1891	158,584	Tributaries of Penobscot River.
Do	1891	Mar. and Apr., 1892	15,552	Do.
Do	1891	Oct. and Nov., 1891	80,064	Tributaries of Penobscot River and other waters, by Maine Fish Commission.
Do	1890	Apr., 1892	32	Alamoosook Lake.
Landlocked salmon	1891	Oct., 1891	7,401	Toddy Pond, Orland, Me.
Do	1891	Apr., 1892	563	Do.
Do	1891	...do	1,499	Burnt Land Pond, Deer Isle.
Do	1890	...do	343	Toddy Pond.
Do	1890	...do	29	Craig Pond, Orland.
Do	1889	...do	2	Do.
Do	1889	...do	14	Toddy Pond, Orland.
Do	1888	...do	28	Craig Pond, Orland.
Do	1888	...do	9	Toddy Pond, Orland.
Do	1888-89	...do	91	Do.
Brook trout	1891	Dec., 1891	1,352	Craig Pond, Orland.
Do	1891	Apr., 1892	198	Alamoosook Lake, Orland.
Do	1889	...do	127	Craig Pond, Orland.
Rainbow trout	1889	...do	105	Heart Pond, Orland.
Von Behr trout	1891	...do	698	Toddy Pond, Orland.
Swiss lake trout	1890	...do	45	Do.
Loch Leven trout	1891	Oct., 1891	6,002	Do.
Do	1891	Dec., 1891	4,522	Do.
Do	1890	Apr., 1892	411	Do.
			277,671	

Atlantic salmon.—Adult salmon were collected between June 1 and 8, 1891, and 267 safely confined in the inclosure at Dead Brook. For the first time in the history of the station, a steamer was employed in collecting the fish, and the work was so facilitated as to permit of its completion and the inclosing of the fish in eight days. The steamer being able to make daily trips, the necessity of keeping the salmon in the cars from day to day, as was usual in previous years, was avoided. Whether from this cause, or from the coolness of the water at the time of collection, but a single fish was lost in transit, and the loss in those confined up to the spawning season was but 42. Of the 225 surviving fish, 137 were females, which yielded 1,203,285 eggs.

These eggs were placed in the hatchery between October 24 and November 25. They, however, proved to be of inferior quality, and the ratio of impregnation was lower than ever before at this station. To February, 1892, the time of division and shipment, the losses aggregated 331,835, of which probably not less than 250,000 were from lack of impregnation. No clue as to the cause of the trouble was discovered. The remaining eggs, 871,450, were divided between the United States and the Maine fish commissioners on the basis of their respective contributions towards the payment for the adult fish, 550,000 being assigned to the former and 321,450 to the latter.

The Maine Commission subsequently presented to the United States 200,000 of the eggs allotted them, thus increasing the share of the United States to 750,000. Of these eggs, 300,000 were assigned to the Pennsylvania Fish Commission, 150,000 being sent to each of the hatcheries at Corry and Allentown, and 150,000 to the New York Fish Commission, which were sent to their hatchery at Cold Spring Harbor.

The balance, together with 12,784 eggs obtained from salmon which had been artificially landlocked at the station, were retained for hatching. When about midway in the sac stage (the latter part of April) they were attacked by an epidemic that continued for several weeks, destroying almost the entire stock, and leaving at the beginning of the feeding season, about June 1, but 3,874 fry, and these far from healthy. The disease appeared to be of the same character that visited the station two years ago. The other kinds of fish at the station escaped the epidemic wholly and appeared as thrifty as usual, with the exception of the brook trout, of which about 37 per cent perished in May and June of what appeared to be a distinct disease.

Brook trout.—The taking of the eggs of this species was carried on during October and November, the total number secured being 83,068, of which 78,191 were obtained from the breeding stock at the station, and 4,877 in the vicinity of the Schoodic Station at Grand Lake stream. Reference to the epidemic which attacked them in the spring following has been heretofore made.

Landlocked salmon.—On February 25 was received the consignment of 25,000 eggs of this species transferred from the Schoodic Station, the number of eggs lost in transfer being only 51.

Whitefish (*Coregonus labradoricus*).—In February there were received from Schoodic Station 1,845 eggs of this whitefish, known as Musquaw River whitefish and as "whiting," which were placed in the hatchery.

From the eggs of the kinds of fishes obtained during this year, fry, for rearing, were secured as follows:

Atlantic salmon (measured)	305, 353
Landlocked salmon (counted)	20, 070
Brook trout (counted)	68, 107
Whitefish (counted)	1, 803

Owing to causes already mentioned this number was greatly reduced, so that at the commencement of the feeding stage they aggregated—

Atlantic salmon	3, 874
Landlocked salmon	19, 740
Brook trout	50, 773
Whitefish	767

At the close of the year the complete stock of fish at the station was as follows:

Kinds.	Hatched in—						Total.
	1892.	1891.	1890.	1889.	1888.	1888–1889.	
Atlantic salmon	2, 010		46		47		2, 103
Landlocked salmon	19, 538		30			30	19, 538
Brook trout	39, 531			30			39, 561
Rainbow trout				30			30
Von Behr trout		49					49
Loch Leven trout			51				51
Twin Lake trout			30				30
Saibling			4				4
Scotch sea-trout		86					86
Whitefish	442						442
	61, 521	135	161	60	47	30	61, 954

Preparatory to the work of the following year, in the propagation of the Atlantic salmon, adult fish were purchased conjointly with the Maine Fish Commission, and impounded at Dead Brook. As in the previous season, use was made of a steamer in their collection, but the work was longer protracted. The number of fish secured was 222, of which 19 were lost during transfer, owing to the hot weather; and by the close of the year there was a further loss of 12.

GREEN LAKE STATION, MAINE (H. H. BUCK, SUPERINTENDENT).

The water-supply flume, contracted for toward the close of the last fiscal year, was completed and accepted by the end of September, and the hatchery and dwelling-house by the end of the following month. During October the troughs and other apparatus in use at Mann Brook were transferred to the new station. Two of the temporary dwellings at Mann Brook were taken down and the material used in the construction of a temporary ice-house.

The other work under the appropriation for the establishment of the station consisted in graveling the banks of the reservoir, laying out roads, grading the grounds, improving the old buildings on the property, and constructing troughs and other apparatus required for the use of the station. A conduit was also laid under the south reservoir pond so as to permit the water to be run directly from the flume to the supply pipe leading into the hatchery, for the purpose of insuring a supply of clear water when the reservoir is muddy from storms, and also to insure a lower temperature of the water during hot weather.

Pending the completion of the hatchery and other constructions at the station, the use of the temporary station at Mann Brook was continued. At the beginning of the year the fry of the landlocked salmon kept for rearing from the previous season were estimated at 120,000. A good proportion of these were successfully carried through the summer to the fall, when they were distributed, with the exception of 4,000, which were retained through the winter in troughs, and in the following spring placed in the reservoir ponds at Great Brook, where their growth was rapid. Of those distributed, 20,000 were delivered in November to car No. 3 for planting in Vermont waters, the loss en route being estimated at 5,000. The remainder, estimated at 80,000, were planted during the latter part of October; 16,000 being placed in Patten Pond, Ellsworth, and 64,000 in Green Lake and its tributaries, principally Great Brook.

In the month of October preparations were made at Great Brook for the capture and impounding of spawning fish, the first fish being captured October 18 and the last November 18. The taking of eggs began November 5 and ended November 19, 148,000 being secured. Ninety-one fish were handled, 45 of which were females. Attempts were also made to secure spawning fish at the other inlets of the lake by means of net pounds, but without success; nor was any evidence obtained of the spawning of the fish at any other place on the lake than Great

Brook. The eggs commenced to hatch the beginning of the following April and concluded April 22. The development and hatching of the eggs were carried on at the new hatchery under considerable inconvenience, owing to the lack of its permanent interior fittings, as also to the presence in the water supply of fine clay sediment from the new reservoir ponds. All were safely carried through the winter, however, and hatched without unusual loss.

In January, 1892, 50,000 eggs each of the Loch Leven and Von Behr trouts were received from the Northville Station in good condition and placed in troughs. These finished hatching on April 7. On the 28th of May an unusual mortality occurred among them. The loss had been large for two weeks, and was first supposed to be due to the fact that the fry (of the Von Behr trout) were weak and puny. The landlocked salmon, however, which were an unusually fine and vigorous lot and ate well, suffered in like manner, and the cause was therefore ascribed to the high temperature of the water—68° and 69° F.—and also to its passage through a closed flume which prevented its sufficient aëration. The fish on hand at the close of the year were estimated to be—landlocked salmon, 60,000; Loch Leven trout, 16,000; Von Behr trout, 10,000; landlocked salmon hatched April, 1891, 3,800.

GLOUCESTER STATION, MASSACHUSETTS (A. C. ADAMS, MASTER, SCHOONER GRAMPUS, IN CHARGE).

Preparation for the season's work was begun October 5, 1891, in the commencement of the repairs and overhauling of the machinery and other equipment of the station. Active fish-cultural work was started December 1, on which date 876,600 cod eggs and 1,649,400 pollock eggs were secured. The taking of cod spawn continued till March 30, and of pollock till December 21. The total number of eggs in good condition received at the station during the season was about 57,075,000, of which 51,600,000 were cod and 5,475,200 pollock. Of the cod eggs, over 46,000,000 were taken in Ipswich Bay, landed at Kittery Point, Me., and thence transferred in sealed jars by rail to the station; the balance of the cod eggs, as also those of the pollock, were obtained off Gloucester. The following tables exhibit the details of the season's propagation and distribution:

Cod.

Date.	Number of eggs taken.	Loss during incubation.	Number of fish hatched.	Number of fish from which eggs were taken.	Planted.	
					Date.	Place.
1891.					1891.	
Dec. 1	876,600	338,000	538,600	13	Dec. 18	Off mouth of harbor.
3	1,971,700	1,678,500	293,200	10	Dec. 18	Do.
4	1,145,100	634,000	511,100	12	Dec. 21	Do.
7	665,600	93,400	572,200	9	Dec. 24	Off Eastern Point.
8	1,132,100	126,300	1,005,800	6	Dec. 26	Off mouth of harbor.
10	1,109,600	126,300	983,300	....	Dec. 28	Do.
11	789,700	160,500	629,200	3	Dec. 31	Do.
11	827,300	64,900	762,400	....	Dec. 31	Do.
12	350,100	18,400	331,700	3	Dec. 31	Do.

Cod—Continued.

Date.	Number of eggs taken.	Loss during incubation.	Number of fish hatched.	Number of fish from which eggs were taken.	Planted. Date.	Planted. Place.
1891.					1892.	
Dec. 15	471,300	157 800	313,500		Jan. 2	Off mouth of harbor.
18	284,300	57,800	226,500	1	Jan. 2	Do.
19	208,300	173,600	34,700	2	Jan. 5	Do.
19	681,900	242,000	439,900		Jan. 5	Do.
21	402,800	240,500	162,300	2	Jan. 7	Do.
21	683,100	307,800	375,300	1	Jan. 7	Do.
22	250,400	65,800	184,600		Jan. 9	Do.
23	181,700	84,200	97,500	1	Jan. 9	Do.
24	524,000	73,700	450,300	2	Jan. 9	Do.
24	260,900	11,800	249,100		Jan. 9	Do.
28	329,100	136,800	192,300	2	Jan. 19	In Goose Cove Pond.
28	810,800	182,800	628,000		Jan. 19	Do.
29	273,800	127,600	146,200		Jan. 22	Off mouth of harbor.
29	695,500	177,600	517,900		Jan. 23	Do.
1892.						
Jan. 1	1,421,600	472,300	949,300		Jan. 26	Do.
4	1,690,200	998,400	691,800		Feb. 1	Do.
12	450,600	146,000	304,600	2	Feb. 6	Do.
12	708,400	173,600	534,800		Feb. 6	Do.
13	1,234,800	482,800	752,000		Feb. 6	Do.
15	731,900	* 731,900				
18	400,300	360,300	40,000	2	Feb. 15	In outer harbor.
19	137,000	77,000	60,000	2	Feb. 15	Do.
22	1,397,900	1,147,900	250,000		Feb. 26	Do.
23	721,300	576,200	145,100		Feb. 26	Do.
Feb. 1	2,832,600	1,979,800	852,800		Mar. 5	In mouth of harbor.
2	1,090,000	273,600	816,400		Mar. 5	Do.
8	2,153,400	724,800	1,428,600		Mar. 8	Off mouth of harbor.
9	50,000	17,100	32,900	1	Mar. 8	Do.
22	1,468,900	239,400	1,229,500		Mar. 21	In Squam Pond.
29	589,700	160,500	429,200		Mar. 26	Do.
Mar. 7	2,440,300	125,000	1,075,500			In mouth of harbor.
		172,300	1,067,500		Apr. 2	In Squam Pond.
8	430,600	121,000	309,600		Apr. 4	In mouth of harbor.
9	1,371,500	189,400	1,182,100		Apr. 1	In Squam Pond.
16	2,077,000	584,000	1,493,000		Apr. 6	In mouth of harbor.
17	1,532,200	252,600	1,279,600		Apr. 7	Do.
21	1,024,000	664,500	359,500		Apr. 8, 9	Off mouth of harbor.
22	3,498,700	1,303,700	2,195,000		Apr. 8, 9	Do.
	44,378,600	17,254,200	27,124,400			

* All dead February 10, 1892.

In addition to the foregoing there were secured a number of eggs which were disposed of as follows:

Cod.

Date.	Number taken.	Loss during incubation.	Number of good eggs.	Number of fish from which eggs were taken.	Disposition. Date.	Disposition. Destination.
1892.					1892.	
Mar. 22	173,700	32,900	140,800	1	Apr. 8, 9	Planted off mouth of harbor.
24	363,300	289,400	73,900	1	Apr. 4	Shipped to Woods Holl.
24	808,200	101,600	705,600		Apr. 4	Do.
26	768,700	231,500	537,200		Apr. 6	Planted in outer harbor.
28	3,385,400	1,110,300	2,275,100		Apr. 6	Do.
30	1,719,500	499,000	1,220,500		Apr. 4	Shipped to Woods Holl.
	7,218,800	2,265,700	4,953,100			

Pollock.

Date.	Number taken.	Loss during incubation.	Number of good eggs.	Number of fish from which eggs were taken.	Disposition. Date.	Disposition. Destination.
1891.					1891.	
Dec. 1	1,649,400	915,200	734,200	6	Dec. 11	Planted off mouth of harbor.
2	2,773,300	1,517,200	1,256,100	9	Dec. 12	Do.
3	403,700	237,800	165,900	3	Dec. 14	Do.
					1892.	
21	648,800	331,400	317,400	2	Jan. 4	Do.
	5,475,200	3,001,600	2,473,600	20		

The best results in hatching were obtained with the water at 38° to 45° F. Towards the latter part of January, the temperature of the water in the hatchery reached 34½°, causing a retarding and non-uniformity in the development of the eggs. With a view of obviating this difficulty, the Commissioner, who visited the station on February 18, directed the utilizing of the warm water from the condenser of the boiler by arranging for its discharge through the main suction pipe to the supply tank. By the use of valves, this discharge could be either entirely cut off or regulated, which permitted the maintenance of a practically uniform temperature of the water furnished the hatchery. The results of the season's work were considerably augmented by this arrangement.

It was anticipated that, as in previous years, a large supply of spawn could be secured from the fishing-grounds of Gloucester, but not till the end of March, as the station was about being closed, were ripe fish secured in any quantity. From this it would appear that there is no uniformity as to the time the fish return to their spawning-grounds.

Regarding the collecting of eggs in Ipswich Bay, Capt. Adams reports:

During the early part of December cod eggs were found plentiful among the net fishermen in Ipswich Bay, and from day to day each spawn-taker took from one to three millions, which appeared in good condition, but would nearly all die inside of twenty-four hours, this being something new to our oldest spawn-takers even. These eggs were invariably taken from live fish, which is always the case, and we found that our work was being seriously injured. One experienced spawn-taker took about three millions in the usual way, half of which died in three or four hours, and before he landed with them at Kittery Point. Finally, a few vessels fishing with trawls came into the bay, and Mr. Conley very soon found that eggs taken from fish caught on trawls could be taken to Gloucester in good condition. As soon as possible, the force was placed on the trawling vessels, after which good eggs were secured throughout the winter. Early in March, as the trawling vessels began to leave the bay, the men were gradually returned to the net fishermen, and this time they found good eggs. These being the facts, I mention them, hoping that some good will be derived from them for future work.

It may also be worthy of mention here that our largest take of eggs in Ipswich Bay during the past season occurred immediately after easterly storms. During cold, offshore winds codfish are supposed by the fishermen to be gradually nearing the shores or beaches, the fishermen following them up with their trawls till an easterly or onshore wind comes on, when the undertow starts them offshore again in double-quick time and the ripe fish are attracted by the trawl baits.

Woods Holl Station, Massachusetts (John Maxwell, Superintendent).

The fish-cultural work at the station was commenced about the first of November, and carried on till the close of the fiscal year. Attention was mainly given to the propagation of the cod, the flatfish, and the lobster, some experiments being made with the sea bass and the scup. Till the end of March the direction of the fish-cultural work was under Mr. Alexander Jones, and from that time till the close of the year under Superintendent Maxwell.

Cod.—The station being dependent for a supply of breeding fish by purchase from fishermen, in September an agreement was made with Messrs. Spindle & Co., of Woods Holl, large fish-dealers, to deliver at the station between October 25 and December 25, 3,000 live codfish of a minimum weight of 5 pounds each. Owing to a succession of severe storms the smack fishermen, from whom the supply in question had been expected, were unable to get on the fishing-grounds till the first part of November, and the time limit of the contract was therefore extended till the end of February. The smack fishermen, however, could not be induced to go offshore to the deep water at that season of the year, and the contractors were, therefore, unable to furnish the number of fish that had been anticipated. But 1,620 fish were furnished, of which 1,341, caught off Nantucket Island, and called by the fishermen "inshore" cod, were delivered between November 6 and December 7, and 279, caught off Block Island, were brought to the station November 23. The fish from each of these grounds were kept separate for the purpose of comparing their relative fecundity, the result being in favor of the Block Island fish, the former averaging 93,800 eggs to each fish, and the latter 118,200. Of the Nantucket fish there were but 281 gravid, while of the Block Island fish there were 163. The fish, as received from the fishermen, were placed in floating fish-boxes and occasionally fed. From December 1, the date the first eggs were taken, the fish were at intervals overhauled for spawn till February 8, during which time 444 fish were stripped, yielding 45,627,200 eggs, producing 25,671,500 fry.

The following table presents the details of hatching:

Number of eggs taken.	Number of fry hatched.	Apparatus.	Period of incubation.			Average temperature of water.
			Commenced.	Ended.	No. of hours.	
			1891.	1891.		°F.
1,692,500	603,300	Chester jars	Dec. 1	Dec. 17	408	44
1,576,500	682,300	do	Dec. 4	Dec. 21	408	42
3,050,400	1,309,300	do	Dec. 7	Dec. 23	384	42
2,503,800	1,520,100	do	Dec. 10	Dec. 28	432	41
2,828,600	1,777,100	do	Dec. 12	Dec. 30	432	41
3,779,100	2,582,300	do	Dec. 14	Dec. 31	408	41
1,830,600	1,958,600	McDonald boxes	Dec. 16	Jan. 4	456	41
2,086,600		do	Dec. 16	Jan. 4	432	41
2,689,400	1,374,400	do	Dec. 18	Jan. 5	432	39½
2,635,700	1,226,100	do	Dec. 21	Jan. 8	432	39½
2,249,000	1,091,700	do	Dec. 23	Jan. 13	480	39½
3,779,100	2,358,800	Chester jars	Dec. 26	Jan. 16	504	39½
3,315,500	2,812,500	do	Dec. 28	Jan. 20	552	39
1,312,500	881,300	do	Dec. 31	Jan. 22	574	38½
			1892.	1892.		
2,967,700	2,267,700	McDonald boxes	Jan. 1	Jan. 25	600	38
2,109,500	1,055,000	do	Jan. 4	Jan. 28	576	37
417,300	208,700	do	Jan. 6	Feb. 1	600	36
510,100	255,000	do	Jan. 8	Feb. 2	600	36
463,700	194,800	Chester jars	Jan. 11	Feb. 8	672	35½
602,800	230,000	do	Jan. 15	Feb. 12	672	35½
626,000	312,000	do	Jan. 18	Feb. 18	744	34
811,500	405,200	do	Jan. 22	Feb. 27	716	31¼
695,500	340,000	do	Jan. 25	Mar. 1	864	31¼
533,300	225,300	do	Jan. 29	Mar. 7	840	31¼
440,500	(*)	do	Feb. 2	....	....	32
120,000	(*)	do	Feb. 8	....	....	32
45,627,200	25,671,500					

* Placed in open waters March 7, before completion of hatching.

In addition to the eggs secured from the supply of fish at the station, on April 4 a consignment of 2,000,000 eggs, carried in eight 4-pound butter jars which were sealed and packed in ice, was received from the Gloucester Station. Three of the jars contained about 779,500 eggs, which were taken March 24 and in which the embryos were well developed. All these were dead on arrival. The remaining jars contained eggs taken on March 30. Of these, only 400,000 were alive, but notwithstanding their having the usual care they soon died. From these facts Mr. Maxwell concludes that if the eggs had been transferred immediately after being fertilized, instead of being deferred till an advanced stage of development, when they are more tender, better results would have been possible.

Flatfish.—The propagation of this species was prosecuted during the period from February 2 to April 14, the last lot of eggs being obtained March 18. The parent fish were secured from a fyke net placed in Woods Holl Harbor. From 94 fish were taken 8,527,800 eggs. The largest number of eggs taken from one fish was 384,000. The weight of this fish when secured was 3 pounds, but after stripping $1\frac{3}{4}$ pounds.

The details of propagation follow:

Number of eggs taken.	Number of fry hatched.	Period of incubation.			Average temperature of water.
		Commenced.	Ended.	Number of hours.	
					°F.
57,600	20,000	Feb. 2	Mar. 1	638	31½
76,800	35,000	Feb. 8	Mar. 7	638	31½
288,000	(*)	Feb. 12	....	696	31½
268,800	(*)	Feb. 13	....	672	31½
76,800	(*)	Feb. 15	....	624	31½
326,400	(*)	Feb. 16	....	600	31½
306,200	(*)	Feb. 17	....	576	31½
326,400	(*)	Feb. 18	....	552	31½
172,800	(*)	Feb. 20	....	480	30¼
384,000	225,000	Feb. 22	Mar. 23	696	31½
259,600	170,000	Feb. 23	Mar. 23	696	31½
192,000	90,000	Feb. 26	Mar. 26	696	32
307,200	185,000	Feb. 29	Mar. 27	638	32
614,400	450,000	Mar. 1	Mar. 28	672	32
454,800	260,400	...do....	Mar. 29	696	33
384,000	220,000	Mar. 3	Mar. 31	672	33
307,200	180,200	Mar. 4	Apr. 1	638	34
230,400	160,000	Mar. 5	Apr. 1	624	34
345,600	205,300	Mar. 8	Apr. 1	552	34½
614,400	425,400	Mar. 9	Apr. 1	528	34½
307,200	199,600	Mar. 10	Apr. 8	672	37
345,600	221,100	Mar. 11	Apr. 8	658	37
768,000	(†)	Mar. 14	....	....	32
230,400	(†)	Mar. 15	....	....	32
384,000	253,400	Mar. 16	Apr. 13	672	34
230,400	100,000	Mar. 17	Apr. 14	672	34
268,800	110,000	Mar. 18	Apr. 14	696	34
8,527,800	3,510,400				

* Deposited March 12, before completion of hatching, owing to stoppage of water supply.
† Deposited March 14, before completion of hatching, owing to stoppage of water supply.

Lobster.—In prior seasons the propagation of the lobster has been conducted during the months of April, March, and June; this year, however, it was decided to try the experiment of hatching eggs secured during the winter months. Eggs were first obtained on December 12 and continued to be taken till January 25. During this period 148 lobsters were stripped, yielding 1,717,700 eggs, which were placed in the McDonald hatching jars, the temperature of the water being about 45° F. None of these eggs, however, began hatching till May 25, the water being 54°, and on the 6th and 7th of June 856,500 fry were released in local waters. The period of incubation, therefore, ranged from about 5½ to 4½ months, the loss being a little over 50 per cent. From January 25 to April 25 no eggs were taken. On this latter date the taking of eggs was again commenced and prosecuted till June 28. In this period 5,883,200 eggs were obtained from 456 lobsters. From these 4,943,000 fry were produced, which were liberated at intervals from May 30 to June 30. The period of incubation of these eggs ranged from 840 hours for those taken April 25 to 264 hours for those taken June 18 and 48 hours for those secured June 28, the water temperature on the dates mentioned being 50½°, 64½°, and 64½°. The loss was about 16 per cent. The largest number of eggs taken from one lobster was 24,300, the individual measuring 12½ inches, and the smallest number, 6,000, from one measuring 8½ inches. The average take from 131 lobsters, varying in size from 8½ to 13½ inches, was 12,265.

Sea bass.—On June 16th 208,600 eggs of the sea bass, taken from fish caught in Buzzards Bay, were brought into the hatchery and placed in the McDonald and Chester boxes. The period of incubation was four days and the number of fry produced 200,000, which were released in local waters.

Scup.—On June 17th 50,000 eggs of the scup were secured in Buzzards Bay and brought to the hatchery and hatched in three days, producing 35,000 fry.

COLD SPRING HARBOR STATION, NEW YORK (FRED. MATHER, SUPERINTENDENT).

Through the courtesy of the fish commission of New York the privilege of using the facilities of this station as a depot for the receipt of consignments of eggs of foreign species of fishes presented to the United States, as also for the shipment of eggs of our indigenous species to other countries, was continued. In addition the United States made use of the station for the propagation and rearing of certain species of fish, the distribution of which was mainly to waters of the State.

The receipts of eggs at the station were as follows:

Date.	Kind.	Number.	Loss.	Whence received.
1892.				
Jan. 3	Von Behr trout	18,380	380	Germany.
Feb. 16	Whitefish	40,000	All.	Do.
16	Lake trout	5,000	All.	Do.
16	Brook trout	9,000	All.	Do.
Mar. 14	Von Behr trout	10,000	970	
Feb. 4	Atlantic salmon	80,000	39	Craig Brook Station.
11	......do	70,000	120	Do.

The 18,000 good eggs of the Von Behr trout received in January were forwarded to the Commission's station at Northville, Mich. Of 9,030 eggs of the same species received March 14 from Mr. von dem Borne, half were sent to Central Station, Washington, and the remainder were retained at this station as the property of the New York Fish Commission. The loss in the latter was very great, and but 1,530 were saved. The number of fry resulting from the 150,000 eggs of the Atlantic salmon was 142,000, which were planted at the expense of the New York Fish Commission in the waters of the State, as follows:

Date.	Locality.	No.
Apr. 19, 1892	Nissequogue River, Long Island	10,000
May 4, 1892	Clendon Brook, Glens Falls	50,000
9, 1892	Balm of Gilead Brook, North Creek	30,000
9, 1892	Raymond Brook, North Creek	30,000
9, 1892	Carr Brook, North Creek	22,000

All of these waters, with the exception of the first mentioned, are tributaries of the Upper Hudson River.

On November 6, 1891, there were delivered to Mr. J. F. Ellis, in charge of the Commission's car No. 3, 3,500 quinnat salmon from 2½ to 6 inches long and nine months old, which were planted in the Battenkill, a tributary of the Hudson River. On the first of the following month 2,400 of the same species, averaging from 3 to 7½ inches long, were planted by Mr. Mather in the Nissequogue River at Smithtown.

The consignment of eggs of the whitefish (*Coregonus wortmanni*), lake trout (*Trutta lacustris*), and brook trout (*Salmo salvelinus*) received February 16, 1892, from Mr. Max von dem Borne, Berneuchen, Germany, was entirely spoiled on receipt. These eggs were to have been shipped on a steamer sailing several days earlier than that on which they arrived, but were left on the wharf at Geestemunde.

The foreign shipments from the station, with the exception of a few adults of several varieties of our more common fishes delivered to Dr. Charles von dem Borne for Mr. Max von dem Borne, consisted of a consignment on January 5, 1892, of 10,000 eggs each of the brook trout, Von Behr trout, and Loch Leven trout to Dr. J. G. Bluhm (Rio Negro), Sabanilla, Colombia, for his government. These eggs were furnished by the Northville, Mich., Station.

Delaware River Shad-Propagating Station (Lieut. Robert Platt, U. S. N., in charge).

Owing to the unfavorable results which had been obtained at the shore station at Gloucester City, N. J., in previous years, it was decided to close it and reassign the work of propagating the shad of the Delaware River to the officers and crew of the steamer *Fish Hawk*. The vessel was moved off Gloucester City and the first eggs obtained May 9 and the last June 1. During this time eggs to the number of 30,521,000 were taken from 611 fish. The number of fry produced was 15,833,000; eggs partially developed to the number of 2,497,000 were placed in Timber Creek, and 3,486,000 were transferred to the cars of the Commission to be hatched en route to distant waters. The work was stopped June 6. As in previous years, dependence was had on the larger fishing shores in the vicinity—Faunce's, Bennett's, and that at Howell Cove—for the supply of spawn. During the entire season the condition of the water was muddy.

The following table exhibits the take of eggs, etc., during the season:

Date.	Fish stripped.		Number of eggs.	Noon temperatures.	
	Male.	Female.		Air.	Water.
				° F.	° F.
May 9	37	37	2,045,000	65	63
10	27	27	1,140,000	69	64
11	15	15	623,000	65	64
12	18	18	998,000	64	63
13	39	39	2,003,000	63	62
16	84	84	4,764,000	75	63
17	46	46	2,486,000	71	64
18	29	29	1,581,000	72	64
19	17	17	953,000	65	64
20	20	20	861,000	65	64
23	43	43	2,118,000	62	62
24	24	24	1,240,000	64	60
25	30	30	1,729,000	69	59
26	24	24	957,000	73	60
27	22	22	1,256,000	66	61
28	2	2	129,000	62	61
30	62	62	2,578,000	81	64
31	40	40	1,878,000	75	65
June 1	32	32	1,182,000	81	67
	611	611	30,521,000		

BATTERY ISLAND STATION, MARYLAND (W. DE C. RAVENEL, SUPERINTENDENT).

Preparations for the conduct of the propagation of the shad were commenced in the early part of April. The auxiliary station on the mainland in the vicinity of the railroad station at Havre de Grace, which had been used for several years on account of the facilities it furnished for the transfer of eggs and fry to the messenger force of the Commission, was abandoned, owing to the limited funds available for the work on the Susquehanna River, and the operations were confined to the Battery Island Station. In lieu of the auxiliary station, two serviceable launches were furnished, which permitted the shipments of eggs and fry to be properly made, and also allowed the seines and gill nets to the eastward of the island to be more readily attended.

A small force, under the direction of Alexander Jones, fish-culturist, commenced early in April to get the hatchery equipped and the boats and other apparatus in order. On April 21 the spawn-taking force, 18 in number, was employed, and the collection of eggs commenced. From this date to May 31 the work was actively pushed, though the force was materially reduced on May 25, owing to the interruption to the collection of eggs occasioned by the heavy freshet prevailing in the river. The result of the season's work was 53,556,000 eggs, from which were obtained 32,616,000 fry, in addition to 7,595,000 partially-developed eggs which were transferred to the cars to be hatched en route to distant waters. The fry were unusually strong and stood transportation well, due, to some extent, to the low temperature of the water during April and part of May.

The temperature from April 15 to April 30 was much below that of any previous season recorded at the station, averaging 49° F. The take of eggs, however, was about the same as in 1889 and 1890, when the average temperature during corresponding periods was 57° and 56°, respectively.

The catch of shad at the head of the bay was the best for several years, particularly with gill nets between Battery and Pools islands; and but for the two freshets during the season, the one occurring on May 7, when the fishing was at its best, and the other on May 20 and lasting for eight days, the number of eggs collected would unquestionably have been greater than in any previous year, possibly excepting 1888.

The following table exhibits the take of eggs, etc., during the season:

Date.	Fish stripped.		Number of eggs.	Noon temperatures.		Date.	Fish stripped.		Number of eggs.	Noon temperatures.	
	Male.	Female.		Air.	Water.*		Male.	Female.		Air.	Water.*
1892.				° F.	° F.	1892.				° F.	° F.
Apr. 21	8	8	282,000	46	47	May 13	84	84	2,316,000	62	65
Apr. 22	4	4	106,000	51	49	May 14	85	85	2,771,000	57	58
Apr. 23	2	2	63,000	55	51	May 15	10	10	331,000	63	61
Apr. 25	18	18	761,000	44	48	May 16	67	67	2,721,000	72	66
Apr. 26	25	25	733,000	52	52	May 17	69	69	2,379,000	72	65
Apr. 27	31	31	1,101,000	56	53	May 18	28	28	1,153,000	67	65
Apr. 28	120	120	4,643,000	59	55	May 19	8	8	198,000	66	69
Apr. 29	98	98	5,071,000	56	55	May 20	......	......	....	67	66
Apr. 30	63	63	2,949,000	56	56	May 21	1	1	28,000	56	60
May 1	49	49	1,673,000	62	58	May 22	......	......	....	58	60
May 2	132	132	4,767,000	71	62	May 23	2	2	48,000	60	59
May 3	95	95	3,869,000	72	68	May 24	......	......	....	62	59
May 4	232	232	6,637,000	65	67	May 25	......	......	....	65	60
May 5	28	28	1,455,000	62	65	May 26	......	......	....	71	62
May 6	38	38	1,346,000	62	62	May 27	17	17	526,000	66	68
May 7	2	2	101,000	65	66	May 28	3	3	100,000	62	64
May 8	3	3	257,000	60	60	May 29	6	6	225,000	68	64
May 9	19	19	766,000	62	63	May 30	15	15	529,000	69	66
May 10	21	21	863,000	63	63	May 31	20	20	610,000	71	68
May 11	25	25	879,000	65	66						
May 12	32	32	1,299,000	60	60		1,460	1,460	53,556,000		

*At surface.

Striped bass were caught in large quantities during the early part of the season, and efforts to obtain their spawn were made, but without success. Occasionally a ripe female is found, but only about once in six years are both sexes found together in condition for spawning. Several attempts were made to impregnate the eggs of the shad with the milt of the striped bass, but unsuccessfully. In every instance observed by Mr. Ravenel eggs so treated have failed to hatch.

The title to Battery Island was vested in the United States by deed from Mr. T. B. Ferguson, bearing date of July 11, 1891, and the consideration therefor passed July 15, 1891.

BRYAN POINT STATION, MARYLAND (S. G. WORTH, SUPERINTENDENT).

The propagation of the shad of the Potomac River had for a number of seasons past been conducted at the military reservation at Fort Washington, Md., under authority granted by the Secretary of War, and the use of the unoccupied buildings and other facilities of the place permitted the work to be done advantageously and economically. The expense also of caring for the equipment of the station from season to season was avoided through the courtesy of the custodian of the reservation, Ordnance-Sergeant Joyce, U. S. Army, by whom many acts of voluntary assistance were also rendered.

Shortly after the close of the season of 1891 preparations were made by the War Department for the construction of a new battery. A large wharf for the receipt of material was built near the middle of the seine-haul, and the use of the buildings occupied by the Commission was withdrawn, as they were needed by the construction force. It therefore became evident that if the propagation of the shad of the Potomac was to be continued another site for a station must be secured. Accordingly, on November 30, 1891, the Commissioner appointed a committee, consisting of Mr. S. G. Worth, superintendent in charge of the Commission's work on the Potomac River; Mr. C. E. Gorham, the civil engineer of the Commission, and Mr. L. G. Harron, seine captain, to make an investigation with the view of obtaining a suitable location. The committee recommended Bryan Point, situated on the Maryland side of the river at the junction of Accokeek Creek, about 2 miles below Fort Washington, and a lease of the same for five years, at an annual rental of $100, together with an option for the purchase of the property within the period at $1,300, was made with the owner, Mr. F. Snowden Hill, of Baltimore, Md.

On March 9, 1892, the removal of the equipment and certain small buildings from Fort Washington to Bryan Point was commenced. The buildings transferred were a small hatchery, a boiler and pump house, and a small quarters building for the use of the seine captain. These were supplemented by the repair of several dilapidated structures belonging to the property, consisting of a large boat shed, which was utilized for boat and general storage, and quarters for the seine-haulers. The frame of another building was made use of to provide a mess room, to which was joined a part of another old building to serve as a kitchen. A wharf 10 feet wide and running out 132 feet to water 10 feet deep at ordinary low tide was built.

The removal of the buildings and boiler from Fort Washington was very difficult, but was accomplished and the buildings set up at Bryan Point in good order, the boiler being transferred and put in place without even disturbing its asbestus covering. The work was done under the direction of Lieut. Robert Platt and Mate J. A. Smith, of the *Fish Hawk*, with the aid of the vessel crew and the use of a small scow kindly loaned for the purpose by Maj. C. E. L. B. Davis, Corps of

Engineers, in charge of the Army construction work at Fort Washington. The removal from Fort Washington was commenced April 5 and completed in about six days. In this connection attention is called to the intelligent and energetic aid given by Lieut. Platt and Mate Smith in all this work. The station not being owned by the Government, no expenditure for a building for the office and spawn-taking force was made. Accommodations, however, were provided through the courtesy of Gen. Albert Ordway, commanding the District of Columbia Militia, who loaned 5 hospital and 11 wall tents. The station was laid out and staked off by Mr. Worth and Mr. Harron without the aid of an engineer, and in this matter, as also in the transfer and successful opening and operation of the station, they deserve much credit. The thanks of the Commission are also due to Mr. James Bryan, the owner of the adjacent property, for the cordial support extended by him to the work.

Bryan Point is central to the egg-producing area of the river, and affords a proper shore for the operation of a seine for the collection of parent fish. The water is deep and well adapted for the development of eggs, also allowing the landing of river steamers for the delivery of the station supplies and the shipment of the station's product. The facilities for the construction of rearing ponds are excellent and the water supply from Accokeek Creek ample.

Disappointment was experienced in the seine operations, owing to the foul state of the berth, which had been lying idle for ten years and had become filled with sunken logs. By unflagging effort the obstructions were finally removed, cords of logs and stumps being pulled ashore.

The first eggs were taken by the station seine on April 16 and the next on the 20th, both lots being placed in the river and not included in the following table of shipments. Besides the shipments 68,000 eggs obtained from the Stony Point seine were lost May 5 by the breaking of a jar. No eggs were hatched at the station, owing to the continuance throughout the season of the work necessary to adjust the station.

The following table exhibits the shipments of eggs made to Central Station, as also the sources of supply:

Date.	From seines at—				From gillers.	Total.
	Bryan Point.	Chapman.	Stony Point.	Tulip Hill.		
May 2	436,000		26,000	461,000	1,498,000	2,421,000
3	231,000					231,000
4	84,000			694,000	397,000	1,175,000
5	362,000	147,000	181,000	432,000	1,035,000	2,157,000
6	142,000	77,000	465,000	232,000	264,000	1,180,000
7	194,000	42,000	327,000	327,000	527,000	1,417,000
8	186,000	146,000		121,000	354,000	807,000
9	110,000	126,000			93,000	329,000
10	50,000				432,000	482,000
11	21,000	122,000		164,000	399,000	706,000
12		45,000		32,000	591,000	668,000
13		24,000		40,000	566,000	630,000
14					331,000	331,000
15		69,000			210,000	279,000
17					565,000	565,000
Total	1,816,000	798,000	999,000	2,503,000	7,262,000	13,378,000

Of the eggs secured from gillers, there were obtained from the men fishing off Moxley and Bryan Points 4,899,000; White House, 1,587,000; and Mount Vernon Flats, 776,000, the first being the product from 11 gillers, the second from 10, and the third from 1.

This season's collection of eggs was the smallest of any year since the commencement of the work on the Potomac River, though the quality of the eggs was better than usual.

Shad were very scarce; one of the largest seines caught but 32,000 as against 52,000 in 1891, 66,000 in 1890, and 72,000 in 1889. The Commissioner's seine caught but 1,082, but this is of no value for comparison for reasons already stated. A fair standard can be arrived at by a comparison of the number of eggs obtained from gillers during the seasons mentioned below, from 1888 to 1892:

Season.	Moxley Point gillers.	White House gillers.	Total.
1888	20,007,000	7,820,000	27,827,000
1889	15,726,000	4,705,000	20,431,000
1890	13,114,000	4,886,000	18,000,000
1892	4,899,000	1,587,000	6,486,000

As regards the weather, it may be said that few such bad springs are known in this latitude. The prevailing winds were from the west and northwest, from which latter point a blow set in on March 10 and lasted for a week. What effect the weather had on the run of shad does not appear quite clear. At Battery Island Station on the Susquehanna River the temperature of the water was lower than at Bryan Point, yet at the former place the catch of shad and production of eggs was very good. The condition of the Potomac River was the same as during the two previous seasons, clear, resulting in a poor catch. During the seasons of 1887 to 1889 it was the opposite, with numerous freshets, and greatly increased catch. The fact that more fish can be caught in stained than in clear water is scarcely a sufficient reason for this difference, nor does a comparison of the water temperatures afford any further light on the subject. During the three freshet seasons the yield of eggs was 59,435,000, 81,117,000, and 58,233,000, respectively, an average per year of 66,282,000; and during the seasons of clear water 34,865,000, 32,445,000, and 13,446,000, respectively, an average per year of 26,918,000. The water temperatures during these seasons were as follows:

Date.	1887.	1888.	1889.	1890.	1891.	1892.
Mar. 2–11	47.30	40.15	39.90	39.70	36.65	40.70
12–21	37.80	41.10	48.95	50.50	43.05	37.25
22–31	39.10	44.80	52.95	47.80	45.02	42.46
Apr. 1–10	52.85	60.60	53.40	55.85	44.60	53.73
11–20	55.95	52.25	59.35	56.25	58.50	51.02
21–30	57.55	63.00	62.45	63.35	66.75	54.33
May 1–10	72.35	71.35	69.05	69.05	63.52	65.66
11–20	74.80	62.10	77.00	72.20	63.57	67.66
21–30	72.80	68.75	65.05	71.95	67.37	65.50

As showing the fluctuations in the yields of eggs on the Potomac River the table below will prove of interest:

Table of Potomac River shad-egg production, by localities and years, 1880–92.

Sources.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Indefinite	20, 749, 000						
Gunston and Pomonkey		43, 200, 000					
Moxley Point seine			15, 800, 000	7, 518, 000		4, 228, 000	
Bryan Point seine			6, 000, 000				
Fort Washington seine				1, 089, 000	6, 000, 000	7, 280, 000	11, 848, 000
Chapman Point seine				1, 097, 000		1, 610, 000	5, 506, 000
Ferry Landing seine				3, 312, 000		2, 536, 000	4, 349, 000
White House seine				5, 315, 000			1, 487, 000
Gillers				5, 943, 000	10, 000, 000	5, 361, 000	10, 981, 000
Other seines					3, 000, 000		
Greenway seine						432, 000	
Pomonkey seine						333, 000	
Tent Landing seine						796, 000	
Stony Point seine							2, 191, 000
Total	20, 749, 000	43, 200, 000	21, 800, 000	24, 274, 000	19, 000, 000	22, 576, 000	36, 362, 000

Sources.	1887.	1888.	1889.	1890.	1891.	1892.	Total.
Indefinite	38, 479, 000						59, 228, 000
Gunston and Pomonkey							43, 200, 000
Moxley Point seine		18, 828, 000	8, 987, 000	1, 078, 000			56, 439, 000
Moxley Point gillers		20, 007, 000	15, 726, 000		13, 114, 000	4, 899, 000	53, 746, 000
Bryan Point seine						1, 816, 000	7, 816, 000
Fort Washington seine	20, 956, 000	22, 657, 000	17, 738, 000	10, 224, 000	5, 378, 000		103, 170, 000
Chapman Point seine		1, 723, 000	6, 834, 000	2, 842, 000	1, 660, 000	798, 000	22, 070, 000
Ferry Landing seine		2, 250, 000	1, 717, 000				14, 164, 000
White House seine							6, 802, 000
Gillers				17, 223, 000			49, 508, 000
Other seines							3, 000, 000
Greenway seine							432, 000
Pomonkey seine							333, 000
Tent Landing seine							796, 000
Stony Point seine		838, 000				1, 067, 000	4, 096, 000
Tulip Hill seine		3, 340, 000		3, 835, 000	4, 231, 000	2, 503, 000	13, 909, 000
White House gillers		7, 820, 000	4, 705, 000		4, 886, 000	1, 587, 000	18, 998, 000
Sandy Bar gillers		3, 714, 000	2, 526, 000				6, 240, 000
Greenway gillers					2, 503, 000		2, 503, 000
Craney Island gillers					1, 208, 000		1, 208, 000
Mount Vernon Flats gillers						776, 000	776, 000
Total	59, 435, 000	81, 177, 000	58, 233, 000	35, 202, 000	32, 980, 000	13, 446, 000	468, 434, 000

During many years it has been observed that the eggs secured from certain seines have developed badly, notably in those obtained from the Stony Point fishery. The seine at this fishery is probably the largest in the world, being 1⅓ miles long and sweeping on each ebb tide an area of 3 square miles. Great numbers of spawning shad are caught there, but the quality of eggs was so poor as to cause dissatisfaction both to the proprietor of the shore and to the Fish Commission's employés. The greater the take of eggs the greater the disappointment when the eggs were measured for payment, and as a consequence it was deemed best to greatly intermit the attendance on the shore. During the season Mr. Worth personally investigated the matter and attended the hauls as often as other work would permit, stripping the fish himself. He discovered that no eggs could be depended upon which were found in partially spent fish, and that it was unprofitable to devote time to that class of spawners, however numerous. He then gave his attention only to those fish which were found by actual handling to be plump and full-roed, and made a gain in quality of 50 to 75 per cent. The application of this principle was not infallible, however, as the eggs in some of the shad were dead, a condition not always discernible at the time of stripping.

It is recommended that the gillers of Occoquan Bay, Mattawoman Creek, and Craney Island flats, where about 30 boats with good outfits operate in shoal water, be attended with as much regularity as those nearer the station, as these latter, owing to the poor condition of their equipments, would not be able to catch many fish were they ever so abundant.

The hatching of the white perch should also have some attention. During the season the station's seine caught between 200 and 300 large fish containing full roes, with some of the eggs in excellent condition for impregnation, but attempts to fertilize them were unsuccessful. Their propagation could probably be successfully accomplished by digging shallow right-angled trenches in the ground near the hatchery tank, flooring the bottoms and making partitions or walls with old roofing slates, and then keeping them filled with the river water, transferring the fish into the subdivisions by pairs (male and female). When the slates are found to be covered with eggs, the parent fish could be removed and returned to the river. These recommendations are based upon observations made in the distribution of the perch, the eggs of which are often seen adhering to the sides of the distributing cans.

CENTRAL STATION, WASHINGTON, D. C. (S. G. WORTH, SUPERINTENDENT).

As in previous years, the hatching of the eggs of the shad secured in the Potomac River was conducted at this station. While the number received was small, for reasons stated in the Bryan Point Station report, the quality was better than ever before known. The following table gives a comparison of the development of the eggs of the shad secured on the Potomac River during the past eight years:

Year.	Shipped from collecting station.	Received at Central Station.	Number of fry shipped.*	Losses.			
				In transfer.		Hatching.	
				Number.	Per cent.	Number.	Per cent.
1885	21,019,000	16,581,000	14,791,000	4,438,000	21.11	1,790,000	10.80
1886	33,254,000	28,260,000	26,560,000	4,994,000	15.00	1,700,000	6.02
1887	54,979,000	45,450,000	44,736,000	9,529,000	17.33	714,000	1.60
1888	70,249,000	58,151,000	53,015,000	12,098,000	17.22	5,136,000	8.33
1889	54,954,000	47,254,000	34,501,000	7,700,000	14.00	12,753,000	27.00
1890	34,446,000	29,884,000	26,812,000	4,562,000	13.26	3,072,000	10.28
1891	32,448,000	26,940,000	23,172,000	5,508,000	16.62	3,768,000	14.00
1892	13,378,000	12,698,000	11,880,000	680,000	5.00	818,000	6.44

* Including developed eggs transferred to cars for hatching en route to distant waters.

As in several years past, the eggs were placed on trays and transferred from the collecting station to Central Station by steamer. The field stations being from 12 to 14 miles below Washington, the eggs were thus kept out of water several hours.

The other kinds of fish hatched at this station were:

Kind.	Number of eggs.	Whence received.	Number of fry produced.
Von Behr trout	20,000	Northville Station	18,454
Do	4,515	Germany	3,524
Whitefish	314,000	Alpena Station	313,000

There were also received at the station and distributed therefrom the following yearling and adult fish:

Kind.	Number received.	Whence received.	Distributed.
Catfish (*Ictalurus punctatus*)	76	Fish Ponds, Washington, D. C	1,300
Do	1,248	Quincy Station, Illinois	
Catfish, spoonbill	3	do	3
Carp, scale	60,860	Fish Ponds, Washington, D. C	58,595
Carp, scale, blue	2,500	do	2,500
Carp, leather	91,004	do	86,244
Carp, leather, blue	263	do	
Goldfish	10,716	do	
Do	775	Neosho Station, Missouri	15,161
Do	5,300	Wytheville Station, Virginia	
Golden ide	2,901	Fish Ponds, Washington, D. C	2,901
Tench	9,695	do	15,675
Do	6,300	Neosho Station, Missouri	
Rainbow trout	2,560	Wytheville Station, Virginia	2,445
Brook pike	30	Quincy Station, Illinois	28
Yellow or ring perch	3,692	do	1,770
Pike perch	37	do	37
Black bass	926	do	
Do	215	Wytheville Station, Virginia	3,048
Do	1,900	Neosho Station, Missouri	
White bass	33	Quincy Station, Illinois	26
Crappie	320	do	305
Rock bass	246	do	
Do	2,532	Wytheville Station, Virginia	7,772
Do	5,168	Neosho Station, Missouri	
Do	350	Fish Ponds, Washington, D. C	
Sunfish	338	do	571
Do	286	Quincy Station, Illinois	
Gars	5	do	5
Dogfish	8	do	8
Turtles	2	do	2

There were also received from the Wytheville Station two lots of eggs of the rainbow trout, 20,000 and 30,000, respectively, which were forwarded to France and the United States of Colombia.

In addition to its fish-cultural work this station serves as the purchasing and shipping agency for many of the supplies of all the other stations of the Commission, also as the freight receiving and shipping office of the general offices, and the custody of the distribution equipment. During the current year much of the time of its employés has been consumed in assisting in the preparation of the Commission's exhibit for the World's Columbian Exposition.

Considerable attention was given to experiments in keeping fishes alive in standing water aërated by spray atomizers. Very encouraging results were obtained in holding yearling trout, one of the species most difficult to thus care for. Owing to the insufficiency of the air supply under pressure, conclusions could not be reached. Enough was learned, however, to warrant the belief that by this method the transportation of fish can be made more uniformly successful as well as more simple and economical. The system may also prove to be capable of practical application to aquaria, doing away with the necessity of new-water circulation. The idea is to atomize the water in a vessel under an inverted cylinder so as to return the aërated water without evaporation, and to cause the waste air used in atomizing to pass through the water of the vessel, thereby imparting to it additional oxygen. The water which is atomized is drawn from the bottom of the vessel, thus inducing circulation. In experiments made in 1889 it was found that one atomizer would aërate 100 gallons in twenty-four hours under 10 pounds air pressure. This method is free from the objection found in the use of nozzle jets, which cover the bodies of the fish with air bubbles. It can also, probably, be made applicable in the movement of fry, which can not be done with the first method.

FISH PONDS, WASHINGTON, D. C. (R. HESSEL, SUPERINTENDENT).

In addition to the propagation of the carps, tench, golden ide, and goldfish, and the rearing of the shad, the culture of the black bass and the spotted catfish was also undertaken. The distribution of the product of the station was made through Central Station, the work having been commenced in November.

Carp.—The fish distributed in the fall of 1891 were reared in two large and two small ponds, the product being:

Leather carp	94,000
Blue leather carp	2,630
Scale carp	54,300
Blue scale carp	6,560
Total	157,490

The arrangements necessary for the spawning of this and the other species of fish propagated at this station were changed from previous years owing to the attention given to the black bass and spotted catfish, and the pond space formerly allotted to the carp was reduced. The stock of large breeding fish was placed in the ponds about the middle of May, 1892, and a few days after they gave the first indications of spawning, which quickly followed. The eggs developed rapidly and three days after their appearance the dark spots were plainly visible, and on the fourth and fifth days the young appeared in considerable numbers. Large quantities of eggs secured from the other breeding fish were also placed in the ponds in proper beds, and they also rapidly developed. The growth of the young was not so rapid as in the preceding season. The cause of this is ascribed to the cool nights of May, which lowered the temperature of the water and thereby retarded their growth.

Tench.—The product of this species for the summer of 1891 was 9,600, the fish being reared in four small ponds. In 1892 they were confined to two ponds. They commenced to spawn the early part of June, sparingly in one, but abundantly in the other, with a fair prospect of satisfactory results, though it is impossible to estimate the number, owing to the habit of the fish of keeping close to the bottom of the ponds.

Golden ides.—The number of this species raised was 3,400, the distribution of which was commenced in the early part of November, 1891. On April 13, 1892, they spawned in two ponds, and the prospect for an early and fair result was good. The eggs, however, had been deposited on the water plants near the surface of the water when one night's frost, making ice one-half inch thick, killed them all.

Goldfish.—Early in May, 1891, the ponds were well stocked with healthy brood fish. The temperature of the summer of 1891 was lower than for several seasons, making the water too cool and causing a scarcity of live food. Efforts to replace this by artificial means met with no good result, a large number of the fish dying, and the survivors being unthrifty. Many also failed to attain their golden color. The product was about 10,700. Immediately after the emptying of the ponds in the fall they were carefully cleaned, especial care being taken to destroy all injurious fish, crustaceans, and vermin. Early in April, 1892, 10 ponds were stocked with the brood fish, partly with the Japanese and partly with the ordinary variety. Spawning began May 8 and on May 18 and 19 a few additional spawning beds were placed in the different ponds. The low temperature of the season, however, as in the case of the carp, greatly retarded the growth of the young brood.

Shad.—In April, 1891, there were placed in the west pond ($6\frac{3}{4}$ acres surface area) 2,054,000 fry of the shad. They thrived marvelously well, finding abundance of suitable food about the water-grasses (*Daphnia*, *Cyclops*, etc.), and in July quantities of *Gammarus pulex.* Constant care had to be given to freeing the pond from obnoxious weeds, introduced and disseminated by the great flood of 1889, and which greatly interfered with the proper growth of such plants as were advantageous to the culture of the fish. As illustrative of the density of the vegetation caused by the overflow mentioned, from the one pond where the shad were reared not less than 600 and from the north pond some 400 cart loads of these weeds were removed. Their rapid growth and early decay rendering the water unwholesome, necessitated their prompt destruction. The result of the rearing of the shad was very gratifying, and in November, when they were released in the Potomac River, a very large percentage of the fry had reached a length of from 3 to 4 inches. An extremely conservative estimate of the number released is not less than 1,000,000. On May 9 and 10, 1892, consignments of fry aggregating 1,989,000 were sent from Central Station and placed in the west pond.

Black bass.—As before indicated, during this year was inaugurated the first systematic effort at this station for the propagation of the black bass. In the fall of 1891 there were received from the Neosho Station 173 specimens of this fish, which were placed in the north pond.

Thirty of the consignment were subsequently transferred to the Wytheville Station. On their arrival at the fish ponds the fish were apparently in excellent condition, but some died shortly afterwards and others in quick succession, and but 13 strong, healthy specimens were left. A careful investigation showed that the fish had been injured by the jolting of the cars while in transit from Neosho to Washington, broken points of fins being found in their bodies, showing that during their close contact and long confinement they had wounded one another. These wounds produced sores which soon became more and more inflamed and caused death in a short time. Two fish, weighing 2½ pounds each, were subsequently procured from Mr. Samuel Einstein, of the health office, District of Columbia. These 15 fish commenced to spawn about May 18, but the muddiness of the water, caused by constant rains, prevented regular and daily observations. On May 30 the young were seen for the first time, and their innate voracity was shown by their attacks on tadpoles and other animal life that came within their reach. At first food was furnished in the shape of frog and toad spawn, later in that of chopped and live fish, 20 to 30 pounds being supplied them daily. Their appetite was unappeasable, apparently; the more they were fed the hungrier they seemed to become. As they grew older their voracity knew no bounds, and in the absence of other food they hesitated not to devour each other. This trait undoubtedly will cause a reduction in the number that will be available for distribution in the fall.

Spotted catfish.—There were also received from the Neosho Station 30 specimens of the spotted catfish for a brood stock. These were held during the winter in one of the small ponds and in March, 1892, transferred to the south pond, which had an abundant and favorable vegetation and a depth of 2 to 5 feet. They immediately disappeared and no glimpse was had of them, even at the feeding hour (they apparently preferred feeding at night), nor was there any knowledge of the existence of their eggs till May 29, when their young were noticed for the first time. From that date they were seen in considerable numbers. They were fed daily and a good result may be expected.

WYTHEVILLE STATION, VIRGINIA (GEORGE A. SEAGLE, SUPERINTENDENT).

The work of this station was confined to the propagation and rearing of the rainbow trout, black-spotted trout, carp, black bass, rock bass and goldfish.

Rainbow trout.—The station has about 2,500 breeding rainbow trout, of which probably 35 to 40 per cent do not spawn each year. The spawning season began November 10 and ended March 20, during which time 491,000 eggs were collected. Of these, 154,500 were transferred to other hatcheries, national, State, private, and foreign, and the remainder, 336,500, held at the station for incubation, producing 147,500 fry. The loss during incubation, 189,000, was greater than usual, due mainly to a period of muddy water. There was also a larger number of the hard, "glassy" eggs. There was a further loss up to the end of the fiscal year in the fry and young fish of 27,500, leaving 120,000 fish, from 4 to 6 months old, to be reared for distribution in the fall of 1892.

The distribution of the young fish brought over from the preceding year was begun December 22, and finished February 18, the whole, with the exception of three shipments of 50 each, being done by car No. 2, in charge of Mr. Giles H. Lambson. The number distributed was 49,670. In addition, 122 adult fish were planted, 115 being placed in local waters.

Black-spotted trout.—There remain of this species about 200 two-year-old fish, the survivors of the fish produced from the consignment of 5,000 eggs received from the Leadville station July 29, 1890.

Black bass.—The year opened with 810 bass, all young with the exception of two spawners. At the end of the year the whole stock was estimated at 1,200. But 215 yearling fish were distributed during the year.

Rock bass.—On October 10 the ponds were drawn for the purpose of bringing together, ready for assignment, the rock bass, carp, and goldfish, the first shipment being made November 3. The number of rock bass, of a season's growth, distributed were 15,182.

Carp.—The number of yearling carp distributed was 4,395, of which number 1,260 were released in Reed Creek, a local stream. In addition, 90 breeders, from 3 to 6 years old, were supplied to applicants in Bland and Wythe counties, Va.

Goldfish.—The number of goldfish distributed was 6,915, of which 5,300 were consigned to Central Station for shipment to applicants from Washington.

On July 1, 1892, the kinds and numbers of fish retained at the station were as follows:

Rainbow trout (counted)	120,000
Black-spotted trout (counted)	200
Black bass (estimated)	1,200
Rock bass (estimated)	15,000
Carp (estimated)	8,000
Goldfish (estimated)	6,000

PUT-IN BAY STATION, OHIO (J. J. STRANAHAN, SUPERINTENDENT).

The work at this station, as in previous years, was mainly with the whitefish and pike perch, some experimental work being done in the cultivation of the lake herring and the crossing of the lake herring with the whitefish.

Whitefish.—The first eggs, about 300,000, were obtained November 4, being taken at the fishery at North Bass. During the early part of the spawn-taking period the season was favorable, but the run of fish was light; as the period approached when we expected to secure our largest yield of eggs, heavy gales prevailed, which injured many of the nets and drove the fish from their spawning-grounds. The collecting of eggs ceased on November 21. During the heavy gale from the south-west on November 17, the new suction pipe, which had been placed 150 feet out in the lake, parted about 70 feet from the shore, and as the heavy wind had forced the water down the lake both the old and new suction pipes were exposed, thus preventing pumping and leaving the hatchery without water supply, other than that held in the tanks, for ten hours. On the 23d of November a similar storm had a like effect on the water supply. The collecting fields and the number of eggs taken at each were:

Monroe and West Sister Island (delivered at Toledo)	5,256,000
Port Clinton	12,528,000
Catawba Island	2,592,000
Kelley Island	3,708,000
The Bass Islands	42,732,000
Total	66,816,000

Of these eggs there were delivered to the superintendent of the Sandusky station of the Ohio Fish Commission (November 7–25), 8,000,000; to the superintendent of the Erie station of the Pennsylvania Fish Commission (November 7–25), 12,500,000, and forwarded to the U. S. Fish Commission station at Duluth (February 26), 12,000,000; making a total of 32,500,000. The remainder were hatched out at the station and the fry placed in Lake Erie. The plantings were made from April 4–10, as follows:

Near North Bass Island	1,000,000
Near Rattlesnake Island	750,000
Near Middle Bass Island	1,000,000
Near Kelley Island	1,000,000
Near Put-in Bay Island	1,000,000
Near Ballast Island	1,250,000
Total	6,000,000

The small percentage of fry produced from the eggs retained at the station is undoubtedly partly due to the temporary suspension of the water supply to the hatchery during the first month of incubation, and also in part to the rough weather during the spawning season, which not only made the taking and proper impregnating of eggs difficult, but also prevented the daily lifting of the pounds and gill nets, so that much spawn was obtained from fish which had been netted and held in the pounds two or three days. By the end of December the eggs were all eyed. The hatching began toward the end of March and was completed by the early part of April. The fry deposited were in excellent condition.

Pike perch.—The collection of the eggs of the pike perch was carried on from April 11 to 22. The season opened with good prospects, but a severe gale which set in on April 14 drove the fish from their spawning-grounds, to which they returned only in small numbers. The total take of eggs was 134,560,000, which were obtained from the following grounds:

Toledo	42,400,000
Port Clinton	11,200,000
East Sister Island	22,400,000
Bass Island	58,560,000

Of these, 15,000,000 were delivered on April 27 to the agent of the Pennsylvania Fish Commission for its Erie hatchery; 17,600,000 were transferred at Toledo to U. S. Fish Commission car No. 3 and taken to Louisville, Ky., where they were hatched, the fry being estimated at 10,000,000 and placed in Kentucky waters. The remaining eggs were held and hatched at the station, producing 40,000,000 fry, of which 12,000,000 were planted in Lake Erie and the balance mainly in the waters of Michigan, Ohio, and Indiana, the period of distribution being from May 13 to 25.

Lake herring.—Experiments were made in the propagation of the lake herring, 1,500,000 eggs of this species being obtained. The eggs are non-adhesive, and average about 75,000 to the quart. They can be impregnated and handled as readily as those of the whitefish, with which they were simultaneously hatched, a good percentage of fry being produced. Further attention to the propagation of this species will be given the next season.

Table of water temperatures (at 8 a. m.).

Date.	Temp.	Date.	Temp.	Date.	Temp.	Date.	Temp.
1891.		1891.		1892.		1892.	
Nov. 1	50	Dec. 1	36	Mar. 28	35	Apr. 27	45
2	48	2	37	29	35	28	46
3	48	3	37	30	35	29	46
4	47	4	37	31	36	30	47
5	49	5	36	Apr. 1	37	May 1	48
6	47	6	35	2	39	2	48
7	48	7	35	3	40	3	48
8	48	8	37	4	41	4	50
9	48	9	36	5	43	5	50
10	48	10	35	6	42	6	49
11	48	11	35	7	48	7	50
12	47	12	36	8	47	8	50
13	46	13	36	9	46	9	50
14	46	14	36	10	42	10	51
15	45	15	36	11	42	11	51
16	45½	16	36	12	42	12	50
17	45	17	35	13	43	13	50
18	42	18	34	14	42	14	52
19	40	19	34	15	42	15	53
20	41	20	35	16	42	16	54
21	42	21	35	17	42	17	55
22	42	22	35	18	43	18	54
23	42	23	36	19	43	19	56
24	41	24	36	20	43	20	56
25	39	25	35	21	43	21	57
26	40	26	34	22	43	22	57
27	39			23	44	23	57
28	38			24	45	24	57
29	37			25	44	25	58
30	37			26	45		

NOTE.—From Dec. 27, 1891, to Mar. 27, 1892, the temperature remained uniformly 33° to 34°.

NORTHVILLE STATION, MICHIGAN (FRANK N. CLARK, SUPERINTENDENT).

The operations of this station were confined to the propagation and rearing of trouts.

Von Behr trout.—The spawning of this trout began October 30, 1891, and ended January 7, 1892, during which time 587,000 eggs were secured from the station's stock fish, 795 females and 653 males being used. In addition to these, a consignment of 18,000 eggs was received from Germany, making a total of 605,000. Of this number, 116,000 were hatched (commencing in February) and retained at the station for rearing; the remainder were distributed as follows:

Date.	Consignee.	Number.
Dec. 1, 1891	Prof. J. E. Reighard, Ann Arbor, Mich	500
16, 1891	Central Station, Washington	20,000
28, 1891	Duluth Station, Mich	50,000
30, 1891	New York Fish Commission, Cold Spring Harbor	10,000
Jan. 5, 1892	Leadville Station, Colorado	50,000
6, 1892	John H. Gordon, Cheyenne, Wyo	20,000
9, 1892	Wyoming Fish Commission, Laramie	10,000
16, 1892	Mexican Government, City of Mexico	20,000
21, 1892	Green Lake Station, Maine	50,000
22, 1892	Fort Gaston Station, California	25,000
Feb. 12, 1892	Nebraska Fish Commission, South Bend	20,000
13, 1892	Leadville Station, Colorado	30,000

Record of spawn-taking.

Date.	Males.	Females.	Eggs obtained.	Average number eggs per female.	Date.	Males.	Females.	Eggs obtained.	Average number eggs per female.
Oct. 30, 1891	1	1	600	600	Nov. 30, 1891	25	30	18,600	620
Oct. 31, 1891	3	3	3,000	1,000	Dec. 1, 1891	2	2	3,450	1,725
Nov. 2, 1891	15	19	15,000	790	Dec. 2, 1891	3	3	1,500	500
Nov. 3, 1891	3	3	3,300	1,100	Dec. 3, 1891	15	20	18,300	915
Nov. 4, 1891	1	1	450	450	Dec. 4, 1891	1	1	600	600
Nov. 5, 1891	36	54	42,300	783	Dec. 5, 1891	1	1	300	300
Nov. 6, 1891	1	1	2,500	2,500	Dec. 7, 1891	30	35	23,100	660
Nov. 7, 1891	21	27	22,900	848	Dec. 9, 1891	4	4	1,500	375
Nov. 9, 1891	40	64	43,900	686	Dec. 10, 1891	1	1	450	450
Nov. 10, 1891	7	7	7,250	1,035	Dec. 11, 1891	12	12	7,350	612
Nov. 11, 1891	25	34	25,500	750	Dec. 14, 1891	1	1	1,800	1,800
Nov. 13, 1891	65	72	55,200	766	Dec. 15, 1891	8	8	6,600	825
Nov. 14, 1891	4	5	9,600	1,920	Dec. 18, 1891	10	10	7,950	795
Nov. 16, 1891	75	81	51,900	640	Dec. 21, 1891	1	1	400	400
Nov. 17, 1891	1	1	450	450	Dec. 24, 1891	5	9	5,700	630
Nov. 18, 1891	60	78	64,850	831	Dec. 28, 1891	5	7	6,000	857
Nov. 20, 1891	35	41	26,700	651	Dec. 31, 1891	2	2	1,000	500
Nov. 21, 1891	1	1	400	400	Jan. 2, 1892	1	1	300	300
Nov. 23, 1891	60	68	56,100	886	Jan. 4, 1892	1	1	400	400
Nov. 24, 1891	1	1	300	300	Jan. 7, 1892	3	3	1,050	350
Nov. 25, 1891	30	39	22,500	577					
Nov. 27, 1891	35	40	24,000	600		653	795	587,000	736
Nov. 28, 1891	2	2	1,950	975					

The distribution of yearlings was commenced January 23, 1892, and terminated March 28. The fish to distant waters were consigned to applicants in Kentucky, Ohio, Indiana, Illinois, Wisconsin, Pennsylvania, and Michigan. The number sent out was 7,127; the transfers being made by car No. 1. In local waters 200 fish were planted.

Brook trout.—Owing to the heavy mortality that had occurred during the previous spawning season in the breeding fish of this species, it became necessary to replenish the stock. Accordingly, in the early part of July, 1891, Mr. S. P. Wires, the foreman of the Alpena Station, was sent to Grand Marais, Mich., to secure a number of the wild trout from the streams of that vicinity. With the aid of a small force of men he secured 600 specimens, which were shipped to this station July 14. These readily adapted themselves to domestication and suffered no loss.

On October 19 the spawning season commenced, and continued till January 19. The number of females stripped was 294, 264 males being used. In all, 147,200 eggs were obtained. Of these, 500 were sent to Prof. J. E. Reighard, at the University of Michigan, and 10,000 to Mr. Mather, at Cold Spring Harbor, N. Y., for reshipment to the United States of Colombia. The balance of good eggs, about 100,000, were retained at the station for rearing. They began hatching in January. The average number of eggs per fish was 500; the largest number obtained from 1 fish being 1,800, on November 28, 1891, and the smallest number, 180. (900 being taken from 5 fish December 7).

The number of yearlings distributed was 13,000. Of these, 10,000 were placed in the stream near the hatchery on October 23, and 3,000 sent by car No. 1, on July 24, 1891, to Dubuque, Iowa.

Loch Leven trout.—The season of spawning of this species was from October 27, 1891, to January 19, 1892. The number of fish spawned was 1,229 (males used, 1,023), which furnished 571,850 eggs. Of these, 132,000 were retained at the station for hatching (commencing in February) and rearing, and the balance of good eggs, 185,500, shipped as follows:

Date.	Consignee.	Number.
Dec. 19, 1891	Prof. Reighard, Ann Arbor, Mich	500
19, 1891	New Hampshire Fish Commission, Plymouth	25,000
29, 1891	Leadville Station, Colorado	25,000
30, 1891	Government of United States of Colombia*	10,000
31, 1891	Vermont Fish Commission, Waterbury	30,000
Jan. 15, 1892	Green Lake Station, Maine	50,000
26, 1892	A. N. Cheney, Glens Falls, N. Y.†	20,000
29, 1892	West Virginia Fish Commission, Romney	10,000
30, 1892	Nebraska Fish Commission, South Bend	15,000

*Through Fred Mather, Cold Spring Harbor, N. Y. †Through C. F. Orvis, Manchester, Vt.

The greatest number of eggs from 1 fish was 1,900, that of 3 fish spawned November 18 being 5,700; the lowest 336, the average of 83 fish spawned December 22; the average for the whole take of eggs, 465.

The distribution of the yearling fish extended from January 17 to March 15, 1892, the number shipped being 3,709, which were consigned to applicants in Wisconsin, Michigan, Kentucky, and Pennsylvania.

Lake trout.—The eggs of this species were collected by the employés of the Alpena Station, under the report of which station are given the details of the work. Of the 2,853,000 eggs received, 1,900,500 were shipped as follows:

Date.	Consignee.	Number.
1891.		
Dec. 1	Prof. Reighard, Ann Arbor, Mich	500
26	Duluth Station, Minnesota	500,000
1892.		
Jan. 4	do	250,000
6	Cheyenne, Wyo., for J. H. Gordon, South Bend, Wyo	50,000
8	Duluth Station, Minnesota	250,000
9	Wyoming Fish Commission, Laramie	100,000
11	Minnesota Fish Commission, St. Paul	50,000
12	New York Fish Commission, Saranac Lake Village	300,000
13	Vermont Fish Commission, Waterbury	100,000
14	New Hampshire Fish Commission, Laconia	100,000
19	Nebraska Fish Commission, South Bend	200,000

The eggs retained at the station, which began in January to hatch, produced 200,000 fry.

The distribution of yearlings was commenced January 23, 1892, and completed April 12. The number shipped was 45,722, which were consigned to applicants in Wisconsin, Michigan, Iowa, Indiana, Ohio, Kentucky, New York, Pennsylvania, and Vermont.

Black-spotted trout.—On February 5, 1892, 1,000 seven-months old trout of this species were received at the station, having been brought by Mr. H. D. Dean, superintendent of the Leadville Station. They were immediately placed in tanks, and commenced feeding well.

Whitefish.—Of the 370,000 eggs of the whitefish received from the Alpena Station, 100,000 each were forwarded to Switzerland, France, and the Indiana Fish Commission at Richmond.

A noticeable feature in the work of the station was the success which attended the shipments of eggs. In no shipment, which was reported upon, was the loss more than 5 per cent, and in many cases there was none.

The loss among the rearing fish during the season was very great, especially among the brook trout, which were attacked by a fungus. The cause of this was not definitely determined, but was probably due to the scarcity of water occasioned by the continued drought and unprecedentedly warm weather during the whole season. The following table exhibits the progress of trout fry produced from the eggs of the fall of 1891 to July 1, 1892:

Items.	Von Behr.	Brook.	Loch Leven.	Lake.	Totals.
Fry hatched	116,000	100,000	142,000	200,000	558,000
Lost	52,000	40,800	72,000	125,000	289,800
Distributed		200			200
On hand July 1, 1892	64,000	59,000	70,000	75,000	268,000

For the purpose of incorporating them in the exhibit of the Commission at the World's Fair, specimens of artificially reared trout were obtained from several of the stations. Those furnished by that at Northville were of the following kinds, ages, and weights:

Age.	Von Behr.	Brook.	Loch Leven.	Lake.
	Ounces.	*Ounces.*	*Ounces.*	*Ounces.*
One year	$\frac{3}{4}$	$\frac{3}{4}$ and $1\frac{3}{4}$	1	1
Two years	4	$3\frac{1}{2}$ and 4	4 and $6\frac{1}{2}$	$6\frac{1}{2}$ and 7
Three years	13 and 14	8 and 9	$10\frac{1}{2}$ and 15	....
Four years	....	$13\frac{1}{2}$ and $14\frac{1}{2}$	....	....
Five years	34 and 38	....	....	....
Six years	....	....	50 and 56	....

The stock of breeding fish on hand towards the close of the year consisted of 939 Von Behr trout, 616 brook trout, and 2,975 Loch Leven trout.

ALPENA STATION, MICHIGAN (FRANK N. CLARK, SUPERINTENDENT).

The occupancy of this station has continued under lease from Mr. George N. Fletcher, of Alpena, and its supply of water under contract with the Alpena Water Company. The operations of the station, consisting of the collection of the eggs of the lake trout for the Northville Station and the propagation of the whitefish, were under the immediate direction of Mr. S. P. Wires, foreman. Owing to the frequent and severe gales of wind during the last of October and throughout November and December, fewer eggs than usual, of all kinds, were taken at the spawning-grounds of lakes Huron and Michigan and Detour Passage. The especially severe and cold gales in the early part of December on Lake Michigan were the cause of an unprecedentedly small catch of fish in that lake, which accounts for the small supply of whitefish eggs taken from Beaver Island and Charlevoix.

Lake trout.—The eggs of this species were obtained from the spawning-grounds of Lake Huron on reefs in the vicinity of Thunder Bay Island, and from Lake Michigan on reefs near the Beaver Islands off Thompson. The first eggs, which were of the shoal-water race, from Thunder Bay, were received about October 15, and the work of collection was carried on till about the 1st of November, when a severe gale tore up the nets and prevented its continuance. The eggs were developed at the station and then transferred to the Northville Station, seven consignments being made between November 4 and December 14. The season of collection represented two hundred and twelve days of one man's time, during which 2,853,000 eggs were secured, as follows:

From Manistique, Lake Michigan, seventy-five days	2,275,000
From North Point and Alpena, Lake Huron, seventy-five days	280,000
From Au Sable, Lake Huron, sixty-two days	298,000

Whitefish.—The first eggs, 160,000, were received November 4, and the last 1,600,000, from Beaver Island, on December 16. The season's receipts were 40,700,000 eggs, as follows:

Lake Michigan.	Days.	Number.	Lake Huron.	Days.	Number.
Epoufette	41	2,600,000	Point Savitan	21	1,500,000
Naubinway	46	3,200,000	Hay Point and Detour Passage	30½	2,400,000
Heymann's fishery	17	1,280,000	Middle and Thunder Bay islands } North Point and Alpena }	53	6,620,000
Schlein's fishery	26	3,500,000	Sturgeon Point	21	4,700,000
Scott Point and Point Patterson	28	1,800,000	Miller Point	30	11,500,000
Beaver Island	41	1,600,000			

The loss of eggs during development was 10,580,000, nearly 26 per cent. This loss was mainly due to neglect on the part of the fishermen in not hauling their nets oftener, frequently allowing them to remain four or five days during severe storms and bad weather. Eggs taken from fish caught in gill nets are invariably poorer than those from fish taken in any other manner, from the fact that when the spawn is taken many of the fish are in a half-lifeless condition. Another factor was the quantity of sawdust in the water supplied to the hatchery. Owing to the direction of the prevailing winds during November and the early part of December, the sawdust which was deposited in the bottom of the bay was so stirred up at times as to be forced into the hatchery in such quantities as to almost stop the working of every jar.

Of the good eggs there were shipped between February 12 and March 15, 1892, to the Northville Station 370,000; to the Duluth Station, 8,000,000, and to Central Station, 4,000,000. The balance of the eggs, 17,750,000, were hatched at the station and the fry distributed from April 15 to May 4 at points in lakes Huron, Michigan, and Superior. The first eggs hatched April 5, but owing to the very low temperature of the water the hatching was very slow and not completed till April 25. The temperature of the water fell from 55° on October 1 to 33° on December 5, remaining at 32½° from December 6 to March 29. From 33° on March 30 it rose to 39° on April 10, falling back to 36° on April 13, where it remained till April 15. On the 16th it had advanced to 40°, rising slowly until May 8, when it was 48°.

DULUTH STATION, MINNESOTA (R. O. SWEENY, SR., SUPERINTENDENT).

The operations of this station were confined to the propagation of the whitefish, lake trout, pike perch, and Von Behr trout.

Whitefish.—On February 27, 1892, 10,000,000 eggs were received from the Put-in Bay Station, and on March 9, 8,000,000 from the Alpena Station. The first lot began to hatch February 29, and the second lot, the delivery of which to the station had been delayed by reason of the intensely cold and stormy weather, on the day of their receipt. On March 5 the first planting of fry was made, these being placed in the current of Lester River, off its mouth, by which they were carried into the lake, this being rendered necessary owing to the rough and hummocky condition of the ice, which made it impossible to get out to the usual planting-grounds with the cans of fry. Plantings were continued at intervals till the 30th of April, during which time 11,727,000 fry were placed off Lester River; 3,000,000 at the mouth of the ship canal, Duluth, and 2,000,000 in Lake St. Croix, St. Croix River, near Hudson, Wis. The loss in eggs and fry was 1,273,000.

Lake trout.—On September 23, 1891, one man was sent to the north shore of Lake Superior, in the vicinity of Isle Royale, to arrange for the taking of eggs of this species. Owing to the continued rough and stormy weather no eggs were secured by the force till the second week in October, the first consignment reaching the station October 13, and the last November 10, and at the end of the month there were in the hatchery about 700,000 good eggs. The eggs of the Lake Superior lake trout are larger and of deeper color than those from the Lake Erie fish, and the fry, when hatched, are much larger and more vigorous and grow more rapidly. The eggs commenced to hatch January 12, 1892, and on March 31 there were 504,500 strong fry from this collection. In addition to the eggs collected by this station there were received from the Northville Station, of eggs collected by the Alpena Station, three consignments, on December 29, January 7, and January 10, from which were obtained 920,300 good eggs. On January 10 these eggs began to hatch. The distribution of fry commenced June 6, during the month 480,000 being planted, all in Lake Superior. Of these, 130,000 were produced from eggs obtained at Isle Royale and 350,000 from those sent from the Northville Station. The number of fry retained at the station after the close of the year was 843,400.

Pike perch.—The eggs of this fish were obtained from Pike River, an affluent of Vermilion Lake, in the vicinity of Tower, Minn., and from the St. Louis River, near Fond du Lac, Minn. The fish in Pike River usually spawn a week to ten days earlier than those in the St. Louis River. On April 18 one of the men was sent to Pike River to make preparations for the gathering of eggs as soon as the fish began to run and indicated their readiness to spawn. A short distance up the river is a sloping barrier of rock, which stops the ascent of the fish, and here they congregate in countless numbers as the spawning season approaches. The fish of the first catches were hard and unripe and were held in crates till ready to spawn, a course that had proved successful in previous years. At Pike River this season it failed completely, the eggs from fish held for twenty-four hours proving worthless, the spots being so defined as to give a mottled appearance to the mass in the pans upon first extrusion and in an hour or two the entire egg becoming opaque and lifeless.

On April 25 a man was sent to the St. Louis River, the fish having there commenced to run, but no ripe ones were secured till May 7, and on May 12 the work was terminated, owing to the rising river and heavy current, which practically stopped the run of the fish. The eggs taken were abnormal, but not to the same number or extent as those from Pike River, nor were those from fish held in cribs more badly affected than the ones taken from fish freshly caught. The total take of good eggs from both sources was 48,000,000. The foul condition of the hatchery's supply of water, owing to the continued succession of rain storms, injured about 18,000,000 of the eggs. The balance were developing normally, and to save them they were planted between May 20 and 26 in the clear water of Lake Superior, about 2 miles from the shore. Good fertilized ova were deposited between May 1 to 6, to the number of 15,000,000 in Pike River, and from May 1 to 12, 10,000,000 in the St. Louis River.

Von Behr trout.—The eggs of this species shipped from the Northville Station were received on January 1, 1892, in the best condition, the number of dead eggs on arrival being 374. On the basis of measurement by Dr. Sweeny there were 36,125 eggs, which began to hatch January 20. The loss during hatching on account of the condition of the water was very great. On June 3d 15,000 fry were planted near Amberg, Wis., and on June 22d 5,000 in Baptism River, Minnesota.

Quincy Station, Illinois (S. P. Bartlett, Superintendent).

The work of this station was continued on the same lines as in previous years. The fish obtained were mostly large, of a breeding size. The number distributed for this season was less than in former years, but the area of distribution was greatly enlarged. The following table shows the distribution work of the season:

State.	Catfish.	Pike.	Pike perch.	Yellow perch.	Black bass.	Crappie.	Rock bass.	White bass.	Sunfish.	Total.
California	500	500	....	6,980	2,610	285	500	....	....	11,375
Illinois	180	923	....	2,980	655	1,580	1,764	200	2,639	10,921
Indiana	300	200	....	....	511	155	325	....	600	2,091
Iowa	440	190	....	....	795	240	619	500	700	3,484
Kansas	300	70	....	4,600	2,150	570	100	225	1,090	9,105
Kentucky	95	....	100	4,500	1,715	992	395	....	1,410	9,207
Michigan	....	....	....	....	85	....	....	....	....	85
Missouri	480	25	....	425	455	925	150	450	1,060	3,970
New Mexico	80	....	....	350	77	....	350	25	....	882
Ohio	375	90	....	5,088	1,540	300	550	....	1,150	9,093
South Dakota	....	....	....	3,300	1,175	390	1,270	....	....	6,135
Texas	140	....	....	....	940	....	....	80	160	1,320
Washington	200	....	....	500	125	270	....	600	500	2,195
Wisconsin	....	....	....	233	233	408	233	....	328	1,435
Central Station *	1,261	30	....	3,692	726	332	246	33	247	6,567
Total	4,351	2,028	100	32,648	13,792	6,447	6,502	2,115	9,884	77,865

* For distribution.

The distribution of this collection necessitated the use of the three cars of the Commission, which performed a total mileage of 36,420 miles, of which 27,899 miles were given free by the railroads, and 8,521 miles paid for.

The main collecting-grounds were in the vicinity of Meredosia, Ill., among lakes and sloughs formed by the overflow of the Illinois River. Owing to the continued dry season these so rapidly dried up that their supplies of fish could not be cared for by the available facilities for transportation, and many, which would otherwise have died, were gathered and placed in the Illinois River.

The plantings thus made consisted of:

Catfish, yearlings	250,000
Carp, different varieties and sizes	5,000
Buffalo, different varieties and sizes	20,000
Yellow perch, yearlings	25,000
Crappie, yearlings	5,000
White bass, yearlings	10,000
White bass, matured	5,000
Total	320,000

There were also deposited in the river at Meredosia the following fish that had become fungussed during their retention in the live-boxes while awaiting distribution:

Spotted catfish	1,000
Pike	500
Black bass	2,000
Crappie	3,000
Rock bass	1,500
White bass	5,000
Sunfish	10,000
Total	23,000

During the season there were taken by the fishermen of the vicinity quantities of carp of varying sizes. A ready sale of these was had in the markets, Chicago paying 8 cents per pound, double the price of other varieties of fish indigenous to the locality.

NEOSHO STATION, MISSOURI (WILLIAM F. PAGE, SUPERINTENDENT).

Rainbow trout.—The fish retained from the product of the spring of 1890 for brood stock began to spawn in December, 1891, though but 20 months old. The first eggs were taken December 15, and the last February 23. During this period 112,185 eggs were obtained from 207 fish, an average of 542 eggs to each. The number of males used was 288. Great difficulty was experienced in securing proper impregnation of the eggs, and not more than 35 per cent of the eggs taken were fertilized. The trouble was the same as is described by Mr. Frank N. Clark in his report of the operations at the Northville Station during 1882. (Report U. S. F. C., 1882, p. 819.)

On January 16, 1892, Prof. Charles E. Riley, of Drury College, Springfield, Mo., arrived at the station, and made a microscopic examination of the eggs and milt, in various stages, to discover, if possible, the cause of the hard, glassy eggs so frequently occurring in this trout, and a cure for the disease. His stay at the station was limited, but at his request a series of eggs were prepared in a hardening mixture, and sent him for further examination. In eggs which had had no contact with milt, as also in the fluid which so frequently accompanies the extrusion of these hard, plump eggs, he discovered a tapeworm-like parasite. It is hoped that from the results of Prof. Riley's investigation means may be discovered to overcome this difficulty in the propagation of this species.

On February 11 a package of rainbow trout eggs, consigned as 20,000, were received from the Wytheville Station. These eggs, Mr. Page reports, were the largest ever seen by him and in fine condition. When counted, however, there were found to be but 14,538, the discrepancy being probably due to the consignor's using a measure established for eggs of normal size. On June 30, 1892, the number of fry on hand that were produced from these eggs was 12,000; from those taken at the station, estimated, between 25,000 and 28,000.

During the breeding season a continual warfare was waged among the breeding males. Every effort was made to stop the fighting, but it was ineffectual, and the loss among them averaged about 10 a week.

The season of distribution was from January 14 to March 2, 1892, during which there were sent out 11,110 yearlings (product of season of 1890–91) and 14 fish two years old.

Brook trout.—On March 27, 1892, there was received from Mr. James Annin, jr., of Caledonia, N. Y., a consignment of 8,000 eggs of the brook trout. These were in good condition on arrival, the loss en route being 218. The eggs hatched with reasonable loss, but the fry produced were weak and puny, and the death rate among them very high. At the end of the year there were but 1,500 alive and in very poor condition.

From the fry brought over from the previous year there were available for distribution 6,327 yearlings, which were shipped from the station between January 28 and March 12.

Von Behr trout.—From the 25,900 eggs of this species received from the Northville Station in the spring of 1891, there were produced by November 1, 1891, actual count, 15,200 fish, and 10,222 were distributed between December 17 and March 17, 1892.

Black bass.—Of the stock of breeding fish, 175 three-year olds were sent to Washington in December, 1891, leaving but 33 at the station. Owing to the continued cold rains and cloudy weather the bass were somewhat late in spawning. Immediately after hatching and before the schools had dispersed, the fry were netted and transferred to another pond. It is estimated that the number available for distribution in the fall of 1892 will be about 2,000. The distribution of yearlings was commenced November 27 and ended February 8; 7,384 fish were shipped.

Rock bass.—The number of yearlings distributed was 9,374; of 3-year olds, 2.

Crappie.—Of this species 95 yearlings and 14 breeding fish were distributed.

Tench.—The gratifying results attained the previous season in the propagation of the tench made it desirable to increase the work during the present year, and 40 of the largest fish were reserved and added to the brood stock, and an additional pond, two in all, assigned to them. The number of yearling fish available for distribution was 26,432, which were shipped between November 9 and February 8.

Carp.—The work with the carp was restricted to two ponds. The brood stock continue in good condition. The number of yearlings distributed was 7,184, all to private ponds with the exception of 1,000 placed in Shoal Creek near Neosho.

Golden ides.—The parent fish are in good condition, and occupy one of the best ponds. No young were obtained from these fish last year, and success with them at this station is doubtful.

Goldfish.—The goldfish spawned (in pond No. 5, February 24, 1892) freely and frequently, only to have their eggs and fry killed by the cold rains. The number for distribution in the fall will be small. The number of yearlings distributed during the year was 3,576.

Spotted or channel catfish (*Ictalurus punctatus*).—The want of success with this fish during the previous year being thought to be due to overstocking, but one-third, or twenty of the breeders, were retained at the station. In May, 1892, they were quite active, and it is believed have prepared several nests. Of the breeders, 30 were transferred to the fish ponds at Washington, and 27 to the Missouri Fish Commission.

Shad.—On June 3, 1892, 700,000 shad fry were received from the Gloucester Station, N. J. Their growth during June was satisfactory, and the very large schools of them seen throughout the entire pond excited the interest and admiration of the numerous visitors to the station. These were for rearing and final liberation in Gulf tributaries.

In January, 1892, a severe cold spell prevailed from the 17th to the 22d, the temperature falling to 22° F. On the 19th, pond No. 1, in which is kept the brood stock of rainbow trout, froze over for the first time. Unusually heavy rainfalls prevailed during April and May, the total precipitation from May 3 to 30 being 11.12 inches. The disastrous effect of these rains, coming at the spawning time of most of the pond fishes, is made apparent by the limited number of fish hatched during this season. The following table exhibits the midsummer and midwinter temperatures of the water in the pond:

Water.	Summer, August 6, 1891.*				Winter, December 23, 1891.†			
	Inlet.	Outlet.		Fish in pond.	Inlet.	Outlet.		Kind of fish.
		Surface.	Bottom.			Surface.	Bottom.	
Spring	58	58	58		57	57	57	
Hatchery	58	58	58		57	57	57	
Trout pools	58	59	59	Rainbow, brook, Von Behr trout.	57	57	57	Rainbow, brook, and Von Behr trout.
Pond No. 1	58	64	63	Rainbow, 17 months	56	54	52	Rainbow, brood stock.
2	63	73	72	Golden ides	56	48	49	Golden ides.
3	72	74	74	Carp, breeders	49	47	47	Carp.
4	74	76	76	Carp, fry	47	46	46	
5	58	70	70	Goldfish	57	46	46	Goldfish.
6	75	78	78	Crappie	48	46	46	
7	60	74	72	Catfish	49	48	48	Catfish, large.
8	62	74	72	Rock bass	55	48	49	Rock bass.
9	74	77	77	Tench	48	44	45	Tench.
10	60	76	74	Black bass	57	49	49	Black bass.
11	76	78	76	do	48	46	46	
12	64	69	68	Carp fry	54	51	51	
13					57	55	55	

* Air, 73° in shade; cloudy and showery.

† Air, 43°; clear.

The residence and annex to hatchery which were under construction at the close of the last report were finished by October 1. In the ice room of the annex 50 tons of ice, which was cut from the large pond, were stored in January, 1892. Two footbridges, leading, respectively, to the residence and annex buildings, were built across Hearrell Branch. An additional pond, No. 13, was built during the year. It affords a water surface of 1,200 square feet, and its greatest depth is 18 inches. In December, 1891, 30 American arbor-vitæ and 30 Norway pines were planted about the grounds.

Food.—The base of the food used at this station is a mush made of "shorts" or mill-middlings, to which beef liver is added in varying proportions, according to the season and the kinds of fish to be fed. The best quality of shorts is used, as the mush made from the inferior qualities is too readily soluble in water and divides into particles finer than the fish will eat. To obviate this it is arranged that when the shorts runs poor 5 to 10 per cent of common flour is mixed by the miller. A 25-gallon farm boiler is nearly filled with clean water, which is brought to the boiling point; shorts is then added, about half a peck at a time, and thoroughly stirred in, so as to cook in an even pasty mass without lumps; 3 to 4 pints of salt is added during boiling, and the whole mass is kept constantly and vigorously stirred. When a thick mush is attained, it is poured into pails, in which it is allowed to become well set and cool before using, as thereby it is not so liable to too freely dissolve in the pond. With each 25 gallons of water about 30 pounds of shorts is used, which produces 166 pounds of mush. Forty-five minutes is usually sufficient time to prepare this quantity.

For preparing the liver a No. 22 meat cutter, made by the Enterprise Manufacturing Company, of Third and Dauphin streets, Philadelphia, is used. The size of the "cut" of the liver is regulated by a plate, which has perforations varying from one-sixteenth to three-eighths of an inch, providing food of a size suitable for all sizes of fish, except very young trout. The machines cost $4 each, and will prepare 10 pounds of liver in four to five minutes.

Mr. Page summarizes in regard to the methods of feeding as follows:

Our present (April 12, 1892) stock of brood rainbow trout number 1,000. They are 2 years old. Their aggregate weight is about 1,500 pounds. They are fed morning and evening. Their daily ration consists of 30 pounds of mush and 3 pounds of liver well mixed. Such has been their diet for twelve months. They are and have been in perfect health, many of them weighing 2 pounds. We have never lost a fish from this stock by reason of choking, "pop-eye," or inflamed intestines, fatal diseases usually resulting from improper feeding.

Of young trout we have at present (April 12, 1892) 40,000 rainbow trout, averaging 6 weeks old. To these we are feeding daily from 6 to 7 pounds of liver, without any mush. When the trout are from 2 to 3 months old we commence to mix a little mush with their food, gradually increasing the proportion of mush (and quantity of food) until, by the time they are 6 months old, the proportion would be one part mush to one part liver. After that time the addition of mush is made freely, so that, by the time the fish become "yearlings," the proportion of liver may be reduced to a minimum. They can then easily be made to eat mush without any liver for several days in succession. They do not allow this "unnatural" food to sink to the bottom and eat it lazily, but rise to the surface, lashing the water into foam, and exhibit every appearance of enjoyment.

The black bass (*Micropterus salmoides*) in our ponds decline mush in any form, and can not be made to eat it. When sometimes mixed with considerable liver they will take it in the mouth, but quickly spit it out. The same results have attended frequent trials with crackers, bakers' bread, and dog biscuit. They seem averse to vegetable diet. We have been able to induce them to eat nothing but liver—and it must be fresh and sweet. (Of course we have not tried minnows or other fish, our efforts being to overcome their natural instincts to eat fish.) When the liver, as it will occasionally in the summer, becomes the least tainted, the bass decline it. Occasionally they decline any and every thing to eat. This peculiarity of the bass is well known to anglers. (Book of the Black Bass, Henshall, p. 360.) In our ponds they never eat on "nasty," raw days; but on pretty days they follow one around the pond seeming to beg for food. They are very active after the flies here in summer (but less so than the rainbow trout), and have been seen to kill and partially eat a snake. Unquestionably they devour the largest part of their young after the school leaves the nests and disperses.

The channel catfish (the original stock from Grand River, Indian Territory) eat the mush greedily. During the late fall, winter, and early spring they are dormant and never come for their food. Such as may be offered to them at this time sinks to the bottom and remains unnoticed. At other times of the year they rise to the surface and eat the mush ravenously, reminding one of pigs. They are, as is generally known among anglers, very fond of liver, it, in fact, being a favorite bait for them. Very rarely we mix a small amount of liver with their mush. (*See* U. S. Fish Commission Bulletins, 1883, p. 419; 1884, p. 321; 1886, p. 137.)

To our rock bass we occasionally give a small quantity of liver, but it is very doubtful if they ever eat any of it. They will at times pugnaciously dart out and take a small piece in their mouth, to immediately spit it out, It is thought that the presence of small quantities of liver in their pond assists in breeding the insects which seem to furnish the bulk of their food.

To the golden ides, goldfish, tench, and carp we feed mush unmixed with liver. They are fond of liver, but it does not seem necessary to their keeping.

The quantity of food given to the pond fish is varied according to the number of fish, size of pond, season of year, and condition of weather. No definite rule seems possible. Not only does the appetite of the fish vary, but scarcely any two ponds have the same capacity for producing natural food to supply the lacking necessary ingredients of the artificial food. Again, the artificial food which might be economically used in one locality would be beyond profitable employment in another. It may be found that cotton seed can be profitably employed in feeding certain warm-pond fish in some southern localities. It would scarcely be economical in Pennsylvania or Ohio. At the Cold Spring Harbor hatchery on Long Island, New York, they have been using horse meat for the past six months At the Forest Hill hatchery, St. Louis, Mo., the refuse of the cracker factories of St. Louis is used for feeding carp.

The trout mentioned in the letter following was 28 months old at the time of capture:

ROGERS, ARK., *June 3, 1892.*

DEAR SIR: Your kind favor of April 21 was received. To-day I received a rainbow trout from Silver Springs race and spring, where we deposited 500 trout received from you December, 1890, or January, 1891. It weighs, dressed, 3 pounds, measures 22 inches from tip to tip, and was full of spawn. Am sorry it was caught. We do not allow fishing, but this one jumped the bars. Have taken a cast of it in plaster. Two or three smaller fish have been taken out, but this seems to show what they can do in our water. No food has been furnished them. * * *

Respectfully, yours,

J. G. BAILEY,
President Silver Springs Milling Company.

MR. PAGE, *Neosho, Mo.*

LEADVILLE STATION, COLORADO (H. D. DEAN, SUPERINTENDENT).

The operations of this station were confined to the propagation of the trouts; the varieties handled being the black-spotted, yellow-finned, brook, rainbow, Loch Leven and Von Behr. On July 1, 1891, fish and eggs as follows were on hand:

Species.	Breeders.	Yearlings and fingerlings.	Fry.	Eggs.
Black-spotted trout (*Salmo mykiss*)	1,025	1,631		37,244
Yellow-finned trout (*Salmo mykiss macdonaldi*)				5,379
Brook trout (*Salvelinus fontinalis*)	149	18,773	49,604	
Rainbow (*Salmo irideus*)	5			
Loch Leven (*Salmo levenensis*)		552		
Von Behr (*Salmo fario*)			65,493	
Total	1,179	20,956	115,097	42,623

Black-spotted trout.—On August 11, 1891, a trap was placed in Lake Creek, about 1 mile from the hatchery, and kept there until the last of September. During this time 543 fish, of an average length of 6 to 8 inches, were caught and transferred to the station. The collection of eggs was commenced in May. From May 10 to June 6, 120,300 eggs were secured from 218 stock fish, an average of 550 eggs to each fish. The greatest take of eggs on one day was 36,500 on May 24. In May 5,100 eggs were secured from Twin Lakes; of these, about 40 per cent hatched. From the same waters, through the courtesy of the Colorado Fish Commission, 96,000 eggs were taken between June 24 and 29, 75 per cent of which were good. Through the kindness of Gen. A. H. Jones, of Denver, 121,000 eggs were obtained at Black Lake in the early part of June. Of these about 50 per cent were good. The time of incubation of the eggs of this trout is from twenty to thirty days.

Brook trout.—As in previous years, an agreement was made with Dr. John Law, by which the Commission was to spawn his stock of fish, and after furnishing him with 350,000 eggs, receive the balance secured for the Leadville Station. The spawning season of these fish was from November 2 to January 29, during which 2,283 fish were stripped, producing 672,400 eggs, the station's share being 322,400. The largest number of eggs, 29,900, was taken November 29. The stock fish of the station spawned from November 9 to December 5, 21,000 eggs being taken from 25 fish. Hatching commenced in the middle of February, 1892. During the last of the egg-taking season difficulty was experienced in finding enough ripe males. Accordingly 21,500 eggs were fertilized with the milt of the Von Behr trout. Of this lot but 2,000 were alive by the end of April.

During the last week of March, when the sac was about half absorbed, the fry commenced dying rapidly. They were liberally treated with salt and earth, and for a short time given salt every day. In three or four days the disease was checked and the mortality was then not greater than usual. The younger fry were given occasional doses of salt and escaped the disease entirely. Salt and earth were thereafter put in all the nursery tanks two or three times a week till the fry were transferred to the ponds.

Loch Leven trout.—On January 2, 1892, the 25,000 eggs of this trout shipped from the Northville Station December 29, 1891, were received, in good condition, and hatched during the month, producing 24,746 fry. The white spot in the sac soon appeared, and a heavy mortality occurred during February and March.

Von Behr trout.—Eggs of the Von Behr trout were secured from the stock fish of Dr. John Law. The spawning season commenced in December, and was over by February 3. There were taken 21,400 eggs, which were very poor, only 20 per cent being good. From the Northville Station there were received on January 9, 1892, 50,000 eggs, shipped January 5, and on February 16th 30,000 eggs, shipped February 13. Both lots were in good condition on arrival at the station. At the end of February about 70 per cent of the good eggs had hatched, and the remainder were all hatched before the close of May. The number of fry on hand May 31 was 72,986, nearly the whole of which were from the eggs sent from the Northville Station. In June 10,000 were placed in waters of Lake County, as follows: Arkansas River, 5,000; Rock Creek, both above and below the falls, 3,000, and in Lower Evergreen Lake, 2,000.

At the close of the year the stock of fish, fry, and eggs at the station was as follows:

Species.	Breeders.	2-year olds.	Yearlings.	Fry.	Eggs.
Black-spotted trout	938	733	321	91, 168	144, 983
Yellow-finned trout	....	....	1, 314	1, 755	....
Brook trout	93	1, 480	1, 907	169, 492	....
Rainbow trout	3	30	....	1, 900	3, 145
Loch Leven trout	....	105	....	12, 013	....
Von Behr trout	....	....	....	56, 190	....
Total	1, 034	2, 348	2, 542	332, 518	148, 128

The distribution from the station commenced October 16, 1891, and was completed by November 18, with the exception of one shipment of 1,000 black-spotted trout, which were taken by the superintendent on February 3, 1892, to the Northville Station. There were distributed 19,000 black-spotted trout, 54,200 Von Behr trout, and 38,550 brook trout.

Before the introduction of water from the lower Evergreen Lake, November, 1891, the temperature of the water was 43° F., and the growth of the fish was slow. Prior to May 1, 1892, the lake water lowered the temperature to 39° F., but after that date there was a rapid rise, ranging from 52° to 60°, the average daily change being about 6°. In May and June, 1892, the fish grew rapidly, owing to the higher temperature of the water and the increase therein of vegetable and animal food. On account of the uneven growth of the fish the product of the station will undoubtedly be reduced by increased cannibalism among the fish.

During the summer and fall of 1891 the dwelling-house and stable were completed, as also 32 rearing and 5 other ponds.

BAIRD STATION, CALIFORNIA (GEORGE B. WILLIAMS, JR., SUPERINTENDENT).

The work at this station is confined to the quinnat salmon. Fishing was commenced on August 31, 164,500 eggs being obtained, and continued to September 19. The total of eggs secured was 3,026,000. The fish were unusually large and productive and the eggs healthy. Some difficulty, however, was experienced with a few of the females first taken, on account of the fluid ejected when being stripped, preventing full impregnation. The eggs in the hatchery matured rapidly, and on September 29 shipments to the State hatchery at Sisson were commenced. For shipping, preference was given to the packing-chests with canton-flannel trays, over the method of crates and moss. The superintendent of the hatchery reported that each of the seven shipments arrived in good condition, and favorable reports were also received in regard to the 50,000 eggs sent to the Mexican Government at the City of Mexico. This latter shipment was made in December and from eggs taken from fish of the late run.

The second run of fish commenced October 24, on which date about 100 fish were caught in the traps, but they were mostly unripe ones. Hauling of the seine was begun on October 27, but few ripe fish were secured. On October 30 the fish on hand were spawned, and the fishing was continued till November 10. The total of eggs secured from this run was 350,000. Of these, 25,500 were hatched at the station, and when sufficiently matured the fry were placed in the McCloud River.

In the latter part of September, after the close of the first run of the quinnat salmon, there were caught in one of the traps two females and one male of the humpback salmon (*Oncorhynchus gorbuscha*), which were spawned, the eggs hatched at the station, and in February the fry planted in the McCloud River.

During the summer run of the salmon, there were taken 1,117 males and 1,345 females, of which latter 651 were ripe; in the fall run, 435 males and 286 females, of which latter 62 were ripe.

The following table presents the spawning operations:

Date.	Females spawned.	Number of eggs.	Date.	Females spawned.	Number of eggs.
Aug. 31	33	164,500	Sept. 12	31	144,000
Sept. 1	17	69,500	Sept. 14	62	271,000
Sept. 2	18	74,000	Sept. 15	24	114,000
Sept. 3	24	97,000	Sept. 16	31	140,000
Sept. 4	38	147,250	Sept. 17	31	145,000
Sept. 5	31	142,750	Sept. 18	36	179,000
Sept. 6	38	165,000	Sept. 19	22	105,000
Sept. 7	44	204,000	Oct. 30	16	84,000
Sept. 8	50	222,000	Nov. 4	26	140,000
Sept. 9	49	190,000	Nov. 10	29	126,000
Sept. 10	58	268,000			
Sept. 11	41	184,000		749	3,376,000

Of the take of eggs, 2,852,250 were sent to the Sisson hatchery of the California Fish Commission; 50,000 to the Mexican Government at the City of Mexico; 25,500 were hatched and the fry liberated at the station; and 448,250, or about 13.25 per cent, were lost in developing.

FORT GASTON STATION, CALIFORNIA (CAPT. F. H. EDMUNDS, U. S. A., IN CHARGE).

The conduct of this station and its auxiliary at Redwood has continued under the direction of Capt. Frank H. Edmunds, U. S. Army.

In July the ponds for young salmon and breeding trout were completed and the extension of the hatchery building so as to contain 40 troughs was begun, being completed by October. Arrangements were made in August for the construction of a small hatchery, 14 feet square, with a capacity of 8 troughs, at Redwood, which was completed in October. In November a water-supply tank was built for the Redwood hatchery.

The first salmon eggs collected at the Redwood hatchery were taken December 3, and their gathering was continued to March 10, the total yield being 300,000, of which 150,000 were transferred to the Fort Gaston Station and 150,000 retained for hatching at Redwood. Of those taken to Fort Gaston 2,000 died during transfer. The remainder began to hatch February 9, and were all hatched by March 10. The loss in fry was about 400. On May 30 and 31, 147,600 young salmon were turned into Supply Creek, a branch of the Trinity River, and distant from the station about a quarter of a mile. The eggs retained at the Redwood hatchery commenced hatching March 12. These eggs were taken February 2, and the period of their incubation was much shorter than heretofore, the usual time being sixty to ninety days. The unusually mild weather prevailing during the winter was undoubtedly the cause. The hatching was completed by April 30, producing 142,500 fry, which were released through a sluice, on May 1, into Minor Creek, a tributary of Redwood Creek. During August 25,000 young salmon reared at the station were turned into Supply Creek.

The rainbow trout taken during the previous season, and held in the station ponds for breeders, were spawned February 24 to 27, yielding about 9,000 eggs, and a further gathering of 12,000 eggs was made between March 1 and 19, making a total collection of 21,000. Hatching commenced April 10, and was completed May 29, producing 18,450 fry.

On January 30, 1892, 20,000 eggs of the eastern brook trout purchased of Mr. J. Annin, jr., of Caledonia, N. Y., were received at the station. On unpacking, the number of dead eggs was 225, and the subsequent loss was 9,393. The remainder began hatching February 5, and nearly 80 per cent were hatched by the close of the month. The loss in fry was a little over 500, mainly occurring during April.

The 25,000 eggs of the Von Behr trout shipped from the Northville Station January 22 were received February 2 in excellent condition, on unpacking but 10 eggs being found dead. The subsequent loss in eggs was 113. Hatching commenced February 18 and was finished February 26, the number of fry produced being 24,877. At the close of the year there were at the station—

Rainbow trout (breeders)	300
Rainbow trout (fry)	18,450
Von Behr trout (fry)	24,856
Brook trout (fry)	9,854

On July 1 the reservation was turned over to the Interior Department for Indian school purposes, in accordance with the act of July 31, 1892, and Capt. Edmunds and his command transferred to Benicia Barracks, Cal. In this connection the Commissioner takes pleasure in acknowledging the hearty and efficient aid extended by Capt. Edmunds in the conduct of the Commission's work at Fort Gaston and Redwood.

Clackamas Station, Oregon (Waldo F. Hubbard, Superintendent).

The work of this station consists in the propagation of the quinnat salmon. On August 25, 1891, the work of clearing the fishing-grounds and building the traps was begun. Some distance below the rack, which was built at the end of the previous year, were two channels, in each of which a trap was placed. Between the rack and the traps all the large rocks were removed from the river, which left a bed of fine gravel where the salmon came to spawn and thence were driven into the traps. A second fishing-place, further down the river, was made. Here the fish were caught by a net and put in pens, where they were kept till stripped of their spawn.

On September 8 the first eggs were taken from four salmon caught in one of the traps. It soon became evident, however, that but few fish could be caught at the station, owing to the existence, about five miles below, of a dam across the river which in low water prevented the ascent of the salmon. As a good many fish were seen below this dam a temporary collecting-station was there established September 21. A large tent, to serve as a hatchery, was placed on a small island below the dam, from which, by means of a flume, water was led into the hatching troughs. Two spawn-takers were left at this station, the parent fish being purchased from the fishermen in the vicinity.

Eggs were obtained daily during October, the total amount gathered being 1,185,000. The number of eggs taken at the regular station during the season, from September 8 to October 31, was 851,500. The total take of eggs was 2,036,500. The number of salmon spawned at the station was 198, and at the tent 247. The average number of eggs to the full-roed fish was about 5,000. Eye-spots began showing in the eggs taken at the temporary hatchery about October 24, when 90,000 eggs packed in boxes, on canton-flannel trays, were transferred to the station without loss.

Experiments were made in transferring eggs of different ages, but the loss among those not showing eye-spots was very great. The eggs at the temporary station were transferred in installment, up to November 3, when a heavy rise in the river, which washed away the flume and floated some of the troughs, necessitated the immediate removal of the remainder. It was found that eggs 16 to 18 days old could be transferred with but little loss; when younger than that the loss was very great, while those under 10 days were all killed. About 500,000 eggs were lost by transfer. The balance of the eggs hatched, with a loss of about 10 per cent. The loss among the fry during the time they were held in the hatching troughs was small, with the exception of about 50,000 which were diseased at the time of hatching, some living but a few days and others two or three weeks. The fry were all placed in the Clackamas River and Clear Creek, near the station, between December 1, 1891, and February 27, 1892.

On September 28, 25,000 eggs were placed on exhibition at the Portland Industrial Exposition. The water supply here was very poor, sometimes stopping altogether, and the majority of the eggs were killed. The few fry produced were afterwards brought back to the station.

On March 16, 1892, 20,000 eggs of the landlocked salmon were received from the Schoodic Station, but they were all dead.

In May, 1892, an attempt was made at the falls of the Willamette River, at Oregon City, to secure some eggs of the steelhead salmon, the effort being based upon statements of the local fishermen that a great many ripe-roed fish were caught there. On May 9 some hatching troughs were taken to Oregon City and placed near a steamboat basin, from which a supply of water was obtainable. Pens were built and placed in the river for holding such fish as might be secured through the fishermen. Just before preparations were completed the fishermen were catching a good many fish, but few, however, were ripe; after all arrangements were ready no more fish were caught. At this time occurred an unusual rise in the river, which permitted the fish to clear the fall and ascend the river. In ordinary seasons the river is low and the fish can not get above the falls, below which they remain till they spawn. A spawn-taker was kept at the place for twelve days in the hope that eggs could be obtained, but none being secured the attempt was given up and the equipment brought back to the station.

Towards the end of June preparations were commenced for the coming season's work.

AQUARIA AT CENTRAL STATION, WASHINGTON, D. C. (L. G. HARRON, IN CHARGE).

During this year the aquaria were under the charge of Mr. L. G. Harron, who assumed the duty in July, 1891. The aquaria and grotto were thoroughly repaired, and wire-screen covers were made for each aquarium to prevent the escape of specimens and the entrance of any natural enemies.

In the marine aquaria two-thirds of the water used was artificial, being prepared from Turks Island salt. The balance was natural sea water, the supply of which was obtained from Chesapeake Bay, in the vicinity of Old Point Comfort, Va., and brought to the aquaria with the collections secured at that place. The density of water maintained during the year was from 17 to 19, the aim being to keep it at 18, that of the previous year having been 20 to 22. This reduction resulted in greater success in the carrying of the more delicate specimens, both animal and vegetable. For the aëration of the water, dependence was had on the reduced glass jets. The greatest trouble in the management of the aquaria is the regulation of temperature. In the winter it was held between 50° and 60°, which was satisfactory, by attaching a steam drum to the supply pipe; in the summer, however, no economical method for keeping a suitable temperature was discovered, and as a consequence the maintenance of the aquaria during that season was practically abandoned.

The collections were obtained mainly at Old Point Comfort, Va. Instead of detailing our own launches to this work, as in former years, involving much time and expense, arrangements were made with a local agent, by whom specimens were gathered and placed in live cars. As soon as a sufficient quantity was secured advice was sent to Washington and a messenger was directed to proceed by the Norfolk and Washington steamers for them. By this way the collections were received at the aquaria in twelve to twenty-four hours after being taken from the live cars and at a very slight expense. Collections were also received from the Woods Holl Station.

About 250 young shad, the product of fry artificially hatched at Central Station and placed in fish ponds, Monument Lot, on the 26th of the preceding April, were received October 21, 1891. These fish were about five months old and 2 to 3 inches long. At first they were put in brackish water having a density of 1.005, which was increased from day to day for about six days, when it was brought up to 1.018, the general density of the water used in the marine aquaria. At the time these were placed in the brackish water others were placed in fresh water, but all of the latter died within three days. The former, however, began to take food, consisting of chopped oysters, clams, and beef—the preference being for the oysters—in from two to three days. At first they would not take the food from the bottom but would catch it while falling in the water. Later on, however, they began taking it off the plants where it had lodged, and finally from the bottom. Nearly all these remained healthy, plump, and active for six months, some living beyond the end of the fiscal year.

In February, 1892, some of the flounders were found to be in spawning condition. Their eggs were stripped, but none seemed to be fertilized. They were heavy. Two of the blue crabs underwent their shedding in September, 1891. On first coming out they seemed to be healthy and strong, but they died in from three to five days; the cause, however, was not determined.

A number of young oysters obtained from a water tank of the steamer *Fish Hawk*, on which the spat was supposed to have been deposited in August, 1891, were placed in the aquaria in December. These, when received, were from 1 to 1½ inches in diameter. They lived about four months, during which time their growth had increased a half inch in diameter. Whelk eggs sent from Woods Holl hatched out in pod-like envelopes in about three months after their receipt. None of the young, however, lived longer than a few days.

Very successful results were had with the specimens kept in the fresh-water aquaria. But few specimens, however, spawned, probably due to the presence of alum in the water, resulting from the use of the Loomis filter. Owing to this it was found impracticable to place any dependence upon successful results in the growing of plants.

ADDITIONAL FISH-CULTURAL STATIONS.

Montana.—The appropriation providing $1,000 for investigation respecting the advisability of establishing a fish-hatching station in the Rocky Mountain region in the State of Montana or Wyoming being available July 1, 1891, Prof. B. W. Evermann, assistant in the division of inquiry respecting food-fishes, was placed in charge and began his investigations at Helena, Mont., on July 18, 1891, and prosecuted them continuously until August 27.

The establishment of a fish-cultural station in the Rocky Mountain region is advisable, without doubt, since the wide extent of country centering around the Yellowstone National Park has no fish-cultural establishment, and the waters of this region can be stocked only by costly transfers from remote stations, with a great loss of the fish in transit. The character of the fish-cultural operations which may be profitably undertaken in any region varies with climatic conditions, and with the physical, chemical, and biotic features of the water. These facts must be more or less accurately known in order to determine the extent and nature of the fish-cultural installation needed, and to direct advantageously the stocking of the waters, in the interest of which a station is sought to be established.

One of the principal objects of the investigation was for the purpose of determining the best location for fish-cultural operations, and as the station for this region would be largely devoted to the hatching and rearing of various species of trout and other salmonidæ, visits were limited to such places as would furnish a constant supply of pure water of not less than 1,000 gallons per minute, the temperature of which should not exceed 55°, and which should be of sufficient height above the hatchery building to permit a gravity supply. The station should be centrally located with reference to the region to be stocked, and should afford good railroad facilities.

Of the localities examined, Davies Spring, near Bozeman, Mont., seems to be the one most available for the purpose named. A detailed account of the investigation will be found in the Bulletin of the Commission for 1891, pages 1–60.

Gulf States.—On the completion of his investigations in Montana and Wyoming, Prof. Evermann proceeded to Texas, reaching Galveston November 4. In establishing a fish-cultural station for the Gulf States it was desired, if practicable, to secure a site where there existed facilities for work with the salt-water as well as fresh-water species, as also for the investigation and development of the methods of propagation and rearing of the oyster and for the investigation of marine life of the Gulf coast. In carrying out his instructions Prof. Evermann visited Galveston and Corpus Christi on the coast, and Houston, Palestine, San Antonio, New Braunfels, San Marcos, Austin, and Fort Worth in the interior. It was found, however, that the coast afforded no satisfactory conditions for the establishment of the station desired. Of the sites examined for the propagation of the fresh-water species of fishes the most desirable was found to be that at San Marcos, situated at the head of the San Marcos River, a tributary of the Guadalupe. The river has its rise in a number of springs at the foot of a limestone ledge or hill just above the town. All these springs together form a large, deep stream, from the bottom of which, near the upper end, wells up the principal spring. The temperature of the water was found to be about 75°. Many water-plants were found in the river and such species of fish as large-mouth black bass, sunfish, and various species of cyprinoids are abundant. A short way below the spring is a tract of land of some 25 acres, which lies exceedingly well for the establishment of a station. Water can be carried in pipes from the dam, which is some distance below the springs, and which furnishes power for a large mill and for the electric light of the town, to any part of the tract. The slope is sufficient for the easy construction of ponds. San Marcos is also centrally located and has satisfactory railroad facilities. No definite selection, however, was made during the fiscal year. A full report of the investigations can be seen in the Bulletin of the Commission for 1891, pages 61–90.

Vermont.—In the early part of August, 1891, a tour of inspection was made by the Commissioner, accompanied by the engineer of the Commission, Mr. C. E. Gorham, looking to the selection of a suitable site for the establishment of a fish-cultural station in the State of Vermont. Toward the end of the following October the engineer was directed to proceed to Vermont and prepare a report upon such places as from a general examination presented suitable possibilities. Among the places visited were Roxbury, Washington County; Healdville, Forge Flat, Pittsford, and Mendon, Rutland County; Manchester, Bennington County; Williamstown, Orange County; Vergennes, Addison County; and St. Johnsbury, Caledonia County. After a due consideration of the relative merits of these places a site in the vicinity of St. Johnsbury, Vt., and in close proximity to Sleepers River, was fixed upon as more nearly meeting the requirements. It having been learned that the owners of the different pieces of property involved in this site were willing to dispose of them at reasonable prices to the United States, in June, 1892, the engineer of the Commission was directed to proceed to St. Johnsbury and survey the plat of ground which was necessary to be obtained.

The property which it was decided to secure is embraced in four lots—the first two containing 21.31 acres, owned by E. & T. Fairbanks Company; the third, containing 3 acres, immediately south of the Fairbanks property and fronting on Sleepers River for 630 feet. The fourth place belongs to Mr. Asa S. Livingston and includes water rights to the Emerson Falls, on Sleepers River. The land selected is about 2½ miles from the railroad station at St. Johnsbury and about 1½ miles from that at Fairbanks village. It was also deemed desirable to secure rights to the Chickering mill property situated about a mile above the site selected, in order to have full control of the river in the vicinity and for the purpose of erecting a dam for the introduction of a suitable water supply additional to that furnished by the springs. Arrangements were made with the owners of the property by which the site in its entirety was obtained for $2,470. As soon as the proper plat is made, the question of examination of title and preparation of deeds will be referred to the Attorney-General, as required by law.

RAILROAD SERVICE.

The following shows the mileage of cars and detached messengers in the distribution of food-fishes:

Service.	Indigenous fish.	Trout.	Carp.	White-fish.	Pike perch.	Shad.	Miscellaneous.	Miles paid.	Miles free.	Total miles.
Car No. 1	11,271	15,108	2,408	2,193	1,363	1,976	111	9,607	24,823	34,430
Car No. 2	7,215	10,515	3,719			11,906	111	19,252	14,214	33,466
Car No. 3	17,769	13,040	2,524	1,020	2,075	9,459	1,911	24,074	23,724	47,798
Detached messengers.	5,622	25,131	1,676	3,268	2,623	19,166	11,552	62,371	6,665	69,036
Total	41,877	63,794	10,327	6,481	6,059	42,507	13,685	115,304	69,426	184,730

The following table shows the name of railroads and total number of miles of free transportation furnished by the railroad companies, to which the thanks of the Commission are hereby tendered for the aid given:

Name of railroad.	Car No. 1.	Car No. 2.	Car No. 3.	Total.
Atchison, Topeka and Santa Fe		1,657	4,738	6,395
Atlantic and Pacific		712	1,494	2,206
Bennington and Rutland			36	36
Burlington, Cedar Rapids and Northern	684		994	1,678
Chesapeake and Ohio			577	577
Chicago and Northwestern	23		1,707	1,730
Chicago, Burlington and Quincy	2,028	264	1,614	3,906
Chicago, St. Paul, Minn., and Omaha	260			260
Cleveland, Cincinnati, Chicago and St. Louis	1,612	220	2,327	4,159
Colorado Midland		836		836
Cooperstown and Charlotte Valley	32			32
Delaware and Hudson	408		101	509
Detroit, Bay City and Alpena	1,400			1,400
Detroit, Lansing and Northern	300			300
Duluth, South Shore and Atlantic	620			620
Flint and Pere Marquette	2,752			2,752
Grand Rapids and Indiana	438			438
Illinois Central	304		112	416
International and Great Northern		766		766
Iowa Central			332	332
Jacksonville Southeastern	206		220	426
Kansas City, Fort Scott and Memphis			1,182	1,182
Kansas City, Fort Smith and Southern			192	192
Kentucky Central	99			99
Kentucky Midland	16			16
Louisville and Nashville	94		316	410
Michigan Central	6,553			6,553
Milwaukee, Lake Shore and Western	254			254
Minneapolis and St. Louis	120			120
Minn., St. Paul and Sault Ste. Marie	405			405
Missouri. Kansas and Texas		162	2,314	2,476
Missouri Pacific			1,711	1,711
Mobile and Ohio	46			46
New York, Ontario and Western	102			102
Northern Pacific	71	982		1,053
Pecos Valley			178	178
Pittsburg and Western	22			22
Sioux City and Pacific	76			76
Spokane Falls and Northern		80		80
St. Louis and San Francisco			2,210	2,210
Texas and Pacific		954	802	1,756
Union Pacific	1,379	7,016	34	8,429
Wabash	3,284	565	533	4,382
Wisconsin Central	1,235			1,235
Total	24,823	14,214	23,724	62,761

The following table presents the numbers and sizes of each species of fish distributed, and their assignment to the States and Territories:

Distribution and assignment of fish.

States and Territories.	Catfish.	Carp.	Tench.	Golden ide.	Gold-fish.	Shad.		
	Adults and year-lings.	Year-lings.	Year-lings.	Year-lings.	Year-lings.	Eggs.	Fry.	Year-lings.
Alabama		8,350		50	250		3,899,000	
Arkansas		5,860			277			
California	500	60			25			
Colorado		1,485		70	129			
Connecticut		280			60		1,939,000	
Delaware		4,253			152		5,848,000	
District of Columbia		200			6,314			1,000,000
Florida		710		100	277		2,300,000	
Georgia		4,220			321		3,045,000	
Idaho		2,970			12			
Illinois	180	6,900	1,000		832			
Indiana	295	1,460	500	500	735			
Indian Territory		40			36		900,000	
Iowa	440	1,015	3,700		68			
Kansas	300	3,310		69	640			
Kentucky	95	280			180			
Louisiana		7,700		100	388		2,016,000	
Maine		30			6			
Maryland	509	5,640	2,000		1,040		15,223,000	
Massachusetts		800		25	151		1,500,000	
Michigan		1,200			133			
Minnesota		1,830			64			
Mississippi		5,190			54		2,002,000	
Missouri	434	2,100	14,300	25	1,692		930,000	
Montana		1,580			24			
Nebraska		2,720			60			
New Hampshire		130			6			
New Jersey		1,680			552	2,497,000	735,000	
New Mexico	80	280						
New York	100	5,790	2,100	975	736		8,164,000	
North Carolina		5,110	3,000	6	284		785,000	
North Dakota		1,530						
Ohio	375	2,450	1,000	200	466			
Oklahoma		800						
Oregon		120						
Pennsylvania	100	11,230	3,992	51	1,402		9,469,000	
Rhode Island					12			
South Carolina		120			108		1,200,000	
South Dakota		5,640			6			
Tennessee		1,000			432			
Texas	140	17,620	2,000		467			
Utah		6,525			66		1,998,000	
Vermont		200			37			
Virginia		4,385	2,000	15	1,818		4,974,000	
Washington	200	2,060			12			
West Virginia		5,210			221			
Wisconsin		15,030			100			
Wyoming					6			
Foreign countries	578							
Total	4,326	157,093	35,592	2,186	20,651	2,497,000	66,927,000	1,000,000

States and Territories.	Quinnat salmon.			Atlantic salmon.		Landlocked salmon.		
	Eggs.	Fry.	Year-lings.	Eggs.	Year-lings.	Eggs.	Fry.	Year-lings.
California	2,852,000	315,500	25,000			30,000		
Maine					254,232		68,692	148,163
Minnesota						15,000		
Nevada						25,000		
New Hampshire						17,000		
New York			2,400	150,000		65,000		
Oregon		1,332,400						
Pennsylvania				300,000		10,000		
Vermont			3,470			20,000		15,000
Foreign countries	50,000					50,000		
Total	2,902,000	1,647,900	30,870	450,000	254,232	232,000	68,692	163,163

Distribution and assignment of fish—Continued.

States and Territories.	Loch Leven trout.		Rainbow trout.		Von Behr trout.			Black-spotted trout.	Brook trout.	
	Eggs.	Yearlings.	Eggs.	Yearlings.	Eggs.	Fry.	Yearlings.	Yearlings.	Eggs.	Yearlings.
Alabama				1,739						
Arizona							1,200			500
Arkansas			20,000	1,100			700			
California						14,478				
Colorado							38,743	13,000		22,750
Connecticut				1,500			200			
Delaware						2,500				300
Georgia				4,694						
Illinois							50			
Indiana							1,400			
Iowa				5,000			1,980			3,700
Kansas				50			350			
Kentucky		475					1,400			
Maine		10,935		605			743			1,677
Maryland				2,835			623			
Massachusetts				3,100			200			
Michigan	500	1,209			500		3,300		500	10,034
Minnesota						5,000				
Missouri				3,268			970			245
Montana							1,500			
Nebraska	15,000				20,000		1,300			1,000
New Hampshire	25,000									
New Jersey				2,000						
New Mexico							2,350			4,000
New York	20,000			3,252						250
North Carolina				1,000						
Ohio							400			1,890
Pennsylvania		475		4,934			600			1,623
South Dakota							8,050	5,000		10,000
Tennessee				2,900						
Texas				700						
Vermont	30,000		20,000	3,550			476			
Virginia				10,223		5,000	419			
West Virginia	10,000			1,384						
Wisconsin		1,485		900		15,000	2,225			1,000
Wyoming			50,000		30,000					
Foreign countries	10,000		50,000		30,000				10,000	
Total	110,500	14,579	140,000	54,734	80,500	41,978	69,179	18,000	10,500	58,969

States and Territories.	Lake trout.			Lake herring.	Whitefish.		Yellow perch.	Pike perch.		
	Eggs.	Fry.	Yearlings.	Fry.	Eggs.	Fry.	Yearlings.	Eggs.	Fry.	Yearlings.
California							6,980			
Connecticut									1,000,000	
Illinois							2,930			
Indiana			11,962		100,000				16,000,000	
Iowa			1,927							
Kansas							4,600			
Kentucky			500				4,500		10,600,000	100
Maryland							1,487			
Michigan	500		7,900			17,750,000			3,700,000	
Minnesota	50,000	480,000	950			14,727,000		30,000,000		
Missouri							125			
Nebraska	200,000									
New Hampshire	100,000									
New Mexico							350			
New York	300,000		3,425			3,990,000				
Ohio			700	262,500	8,000,000	6,000,000	4,945		18,000,000	
Pennsylvania			7,600		12,500,000			15,000,000		
South Dakota							3,300			
Vermont	100,000		2,000							
Washington							500			
Wisconsin			6,900			2,000,000	233			
Wyoming	150,000									
Foreign countries					200,000					
Total	900,500	480,000	43,864	262,500	20,800,000	44,467,000	29,950	45,000,000	49,300,000	100

Distribution and assignment of fish—Continued.

States and Territories.	Sea bass.	White bass.	Black bass.	Crappie.	Rock bass.	Sunfish.	Pike.
	Fry.	Yearlings.	Yearlings.	Yearlings.	Yearlings.	Yearlings.	Yearlings.
Alabama					500		
Arkansas			50		50		
California			2,610	285	500		500
Connecticut			222	25			
District of Columbia			400				
Georgia					500		
Illinois		600	650	1,780	1,540	2,594	898
Indiana			511	155	325	470	200
Iowa		447	789	240	589	667	190
Kansas		225	1,850	570	100	1,090	70
Kentucky			1,844	1,140	875	1,401	
Maryland		24	2,176		814	168	
Massachusetts	200,000		700		200		
Michigan			55				
Missouri		50	1,430	532	1,262	965	25
New Jersey					350		
New Mexico			67	25	350		
New York			198	211			
North Carolina				50	1,800	152	
Ohio			1,390	150	850	974	83
Pennsylvania			159		2,000		
South Carolina					500		
South Dakota			1,175	390	770		
Tennessee					1,050		
Texas			2,385	80	1,200		
Vermont			600				
Virginia					9,800		
Washington		600	125	270		500	
West Virginia					50		
Wisconsin			367	408	233	285	
Foreign countries						338	
Total	200,000	1,946	19,753	6,311	26,208	9,604	1,966

State.	Scup.	Cod.	Pollock.	Flatfish.		Lobsters.
	Fry.	Fry.	Fry.	Eggs.	Fry.	Fry.
Massachusetts	35,000	52,795,500	2,473,500	2,764,000	3,510,000	5,799,000
Total	35,000	52,795,500	2,473,500	2,764,000	3,510,000	5,799,000

SUMMARY.

States and Territories.	Number.	States and Territories.	Number.
Alabama	3,909,889	Nevada	25,000
Arizona	1,700	New Hampshire	141,136
Arkansas	28,037	New Jersey	3,236,582
California	3,248,438	New Mexico	7,502
Colorado	76,177	New York	12,708,437
Connecticut	2,941,287	North Carolina	796,402
Delaware	5,855,205	North Dakota	1,530
District of Columbia	1,006,914	Ohio	32,278,373
Florida	2,301,087	Oklahoma	800
Georgia	3,054,737	Oregon	1,332,520
Idaho	2,982	Pennsylvania	37,313,166
Illinois	19,954	Rhode Island	12
Indiana	16,118,513	South Carolina	1,200,728
Indian Territory	900,076	South Dakota	34,331
Iowa	20,752	Tennessee	5,382
Kansas	13,224	Texas	24,592
Kentucky	10,612,790	Utah	2,004,591
Louisiana	2,024,188	Vermont	195,333
Maine	485,083	Virginia	5,007,660
Maryland	15,240,316	Washington	4,267
Massachusetts	69,082,176	West Virginia	16,865
Michigan	21,475,831	Wisconsin	2,044,166
Minnesota	45,279,844	Wyoming	230,006
Mississippi	2,007,244	Foreign countries	400,916
Missouri	957,423		
Montana	3,104	Total	305,918,346
Nebraska	240,080		

GENERAL ADMINISTRATION.

Mr. J. J. O'Connor, who had been chief clerk of the Commission from June, 1888, died on May 4, 1892. He was succeeded by Mr. Herbert A. Gill, who had been the disbursing agent of the Commission for many years.

On May 19 Mr. W. P. Titcomb was appointed disbursing agent.

CIVIL SERVICE.

Owing to the increase of the personnel of the Commission and the desirability that faithful employés should have such assurance of permanency of tenure of their positions as is conveyed by the civil-service law, the President was requested to order the classification of the Commission as a part of the classified departmental service. This request was approved, and the executive order issued May 5, 1892.

MENHADEN AND MACKEREL FISHERIES.

During the first session of the Fifty-second Congress much conflicting testimony was had before the House Committee on Merchant Marine and Fisheries relative to the natural history and habits of mackerel and menhaden, as also the influence upon their abundance of certain methods of fishing. On the 21st of March, 1892, the Commissioner was called upon by the chairman of the Senate Committee on Fisheries to make replies to certain interrogatories. Response was made May 9, 1892, which was printed as Senate Miscellaneous Document No. 156, Fifty-second Congress, first session.

PUBLICATIONS AND LIBRARY.

During the year the following papers, forming parts of the reports and bulletins, were issued:

A reconnoissance of the streams and lakes of the Yellowstone National Park, Wyoming, in the interest of the U. S. Fish Commission, by David Starr Jordan. (Bulletin for 1889, pp. 1–40.)

Report upon the pearl fishery of the Gulf of California, by Charles H. Townsend. (Bulletin for 1889, pp. 91–94.)

Report upon certain investigations relating to the planting of oysters in southern California, by Charles H. Gilbert. (Bulletin for 1889, pp. 95–98.)

The embryology of the sea bass (*Serranus atrarius*), by Henry V. Wilson. (Bulletin for 1889, pp. 209–273.)

Report upon the investigations of the fishing grounds off the west coast of Florida, by A. C. Adams and W. C. Kendall. (Bulletin for 1889, pp. 289–312.)

The giant scallop fishery of Maine, by Hugh M. Smith. (Bulletin for 1889, pp. 313–335.)

Notes on the occurrence of protozoan parasites (Psorosperms) on Cyprinoid fishes in Ohio, by Edwin Linton. (Bulletin for 1889, pp. 359–361.)

Notes on the king crab fishery of Delaware Bay, by Hugh M. Smith. (Bulletin for 1889, pp. 363–370.)

Report upon a collection of fishes made in southern Florida during 1889, by James A. Henshall. (Bulletin for 1889, pp. 371–389.)

Notes on the oyster fishery of Connecticut, by J. W. Collins. (Bulletin for 1889, pp. 461–497.)

Report on the work of the U. S. Fish Commission steamer *Albatross*, from January 1, 1887, to June 30, 1888, by Z. L. Tanner. (Report for 1887, pp. 371–435.)

Report upon the construction and equipment of the schooner *Grampus*, by J. W. Collins. (Report for 1887, pp. 436–490.)

Report upon the operations of the U. S. Fish Commission schooner *Grampus*, from March 15, 1887, to June 30, 1888, by J. W. Collins. (Report for 1887, pp. 491–598.)

A review of the labroid fishes of America and Europe, by David Starr Jordan. (Report for 1887, pp. 599–699.)

On some Lake Superior Entomostraca, by S. A. Forbes. (Report for 1887, pp. 701–718.)

Notes on entozoa of marine fishes of New England, with descriptions of several new species, Part II, by Edwin Linton. (Report for 1887, pp. 719–899.)

Report of the Commissioner for 1887, by Marshall McDonald. (Report for 1887, pp. I–LXIII.)

Statistical review of the coast fisheries of the United States, by J. W. Collins. (Report for 1888, pp. 271–378.)

Report on the fisheries of the Pacific coast of the United States, by J. W. Collins. (Report for 1888, pp. 3–269.)

Report on the investigations of the U. S. Fish Commission steamer *Albatross* for the year ending June 30, 1889, by Z. L. Tanner. (Report for 1888, pp. 395–512.)

Report on the operations at the laboratory of the U. S. Fish Commission, Woods Holl, Massachusetts, during the summer of 1888, by John A. Ryder. (Report for 1888, pp. 513–522.)

A preliminary review of the apodal fishes or eels inhabiting the waters of America and Europe, by David Starr Jordan and Bradley Moore Davis. (Report for 1888, pp. 581–677.)

The chemical composition and nutritive values of food-fishes and aquatic invertebrates, by W. O. Atwater. (Report for 1888, pp. 679–868.)

Observations on the aquaria of the U. S. Fish Commission at Central Station, Washington, D. C., by William P. Seal. (Bulletin for 1890, pp. 1–12.)

The fishing vessels and boats of the Pacific coast, by J. W. Collins. (Bulletin for 1890, pp. 13–48.)

Observations upon fishes and fish-culture. (Bulletin for 1890, pp. 49–61.)

Notes on a collection of fishes from the Lower Potomac River, by Hugh M. Smith. (Bulletin for 1890, pp. 63–72.)

A review of the Centrarchidæ or fresh-water sunfishes of North America, by Charles H. Bollman. (Report for 1888, pp. 557–579.)

There was also issued as Senate Miscellaneous Document No. 65, a "Report on the establishment of a fish-cultural station in the Rocky Mountain region and Gulf States" by Marshall McDonald, Commissioner, and Barton W. Evermann, assistant.

The following publications relating to the cruise of the U. S. Fish Commission steamer *Albatross*, under the direction of Prof. Alexander Agassiz, have been published by the Museum of Comparative Zoology:

Three letters from Alexander Agassiz to the Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries, on the dredging operations off the west coast of Central America to the Galapagos, to the west coast of Mexico, and in the Gulf of California, in charge of Alexander Agassiz, carried on by the U. S. Fish Commission steamer *Albatross*, Lieut. Commander Z. L. Tanner, U. S. Navy, commanding. (Bulletin of the Museum of Comparative Zoology at Harvard College, vol. XXI, No. 4.)

General sketch of the expedition of the *Albatross*, from February to May, 1891, by Alexander Agassiz. (Bulletin of the Museum of Comparative Zoology at Harvard College, vol. XXIII, No. 1.)

Calamocrinus Diomedæ, a new stalked Crinoid, with notes on the Apical System and the Homologies of Echinoderms, by Alexander Agassiz. (Memoirs of the Museum of Comparative Zoology at Harvard College, vol. XVII, No. 2.)

Over 2,000 bound copies of the reports and bulletins were distributed to collaborators of the Commission, libraries, and scientific institutions, and about 7,500 pamphlets, copies of papers appearing in these volumes and issued in advance of the full volumes.

The library acquired 713 books, chiefly through gift and exchange for the publications of the Commission. Of those donated we are indebted to the officers of the Government Printing Office for over 100 volumes and to the Société Nationale d'Acclimatation de France for 72 volumes, which were presented by that society in return for eggs of the quinnat salmon sent to it the previous year.

ERECTION OF A FISHWAY AT THE GREAT FALLS OF THE POTOMAC RIVER.

A contract having been entered into June 9, 1891, by the Chief of Engineers, U. S. Army, with Isaac H. Hathaway, of Philadelphia, for the construction of a fishway at Great Falls, in accordance with plans and specifications prepared in this office, work was begun early in July and sections 4, 5, and 6 were completed during the year.

THE WORLD'S COLUMBIAN EXPOSITION.

The preparation of the Commission's exhibit at the World's Columbian Exposition was actively prosecuted under the immediate direction of Mr. J. W. Collins, the representative of the Commission on the Board of Management, U. S. Government Exhibit. As assistants the following special agents were appointed: E. C. Bryan, in charge of administration and of preparation of section of fisheries; W. de C. Ravenel, in charge of section of fish-culture; and W. P. Seal, in charge of construction of aquaria.

The scope of the fisheries section embraces a series of vessel and boat models, and drawings of sail and builders' plans of fishing vessels; specimens and casts of fishes; mounted skins of sea-lions, seals, and birds; fishermen's clothing, nets, and other apparatus used in the fisheries; photographs, cartoons, and water-color illustrations of the fisheries and fishery industries of the United States and Alaska; also a series of the angling appliances manufactured and used in the United States. In the preparation of the cartoons and water-color sketches the Commission availed itself of the services of Mr. Henry W. Elliott; in the drawings of plans of fishing vessels, of the services of Mr. C. B. Hudson, and in the making of casts of fishes, of those of Mr. S. F. Denton.

The representation of the section of fish-culture will be by means of specimens, models, and illustrations (graphic and photographic) of fish-cultural stations (hatcheries, ponds, etc.); cars, vessels, boats, cans, etc., used in the transportation of eggs, fry, and adults of fishes; apparatus used in the artificial propagation of fish; the eggs, fry, and adults of fishes artificially propagated; the methods of fish-cultural work, and of fish-ladders or fishways. The models of the fish-cultural stations were prepared under the direction of Mr. W. P. Sauerhoff, one of the expert fish-culturists of the Commission.

By an arrangement made with the executive board, the Exposition authorities constructed a suitable building and arranged for proper aquaria for the exhibition of fresh-water and marine life, the furnishing of the specimens and the general maintenance of the exhibit to be by the Fish Commission. Plans for the necessary water mains, pumps, etc., required for the supply of both fresh and salt water, and its circulation, were prepared by W. B. Bayley, U. S. Navy, the engineer of the Commission. The plans for the aquaria were likewise furnished by the Commission, and Mr. W. P. Seal, superintendent of the Commission's aquaria, was detailed in August, 1891, to superintend their construction.

STATE FISH COMMISSIONS.

The coöperation of the Commission with the various State fish commissions in their fish-cultural work is indicated by the following table:

Statement showing the kinds and number of eggs and fish furnished to State fish commissions during the fiscal year ending June 30, 1892.

State.	Species.	Eggs.	Fish.
California	Quinnat salmon	2,852,000	
	Landlocked salmon	30,000	
Delaware	Carp		1,500
	Shad		†1,800,000
	Von Behr trout		†2,500
	Brook trout		300
Georgia	Carp		2,500
Illinois	Catfish		*180
	Carp		5,000
	Yellow perch		*2,930
	White bass		*600
	Crappie		*1,780
	Rock bass		*1,540
	Sunfish		*2,594
Indiana	Whitefish	100,000	
Minnesota	Carp		1,500
	Landlocked salmon	15,000	
	Lake trout	50,000	
Missouri	Catfish		240
	Tench		5,000
	Rainbow trout		12
	Brook trout		12
Nebraska	Loch Leven trout	15,000	
	Von Behr trout	20,000	
	Lake trout	200,000	
Nevada	Landlocked salmon	25,000	
New Hampshire	do	17,000	
	Loch Leven trout	25,000	
	Lake trout	100,000	
New York	Carp		5,000
	Tench		2,100
	Golden ide		975
	Atlantic salmon	150,000	
	Landlocked salmon	15,000	
	Lake trout	300,000	
Ohio	Whitefish	8,000,000	
	Yellow perch		2,750
	Black bass		175
	Crappie		25
	Sunfish		376

* Deposited by U. S. Fish Commission in waters designated by State commissioners. † Fry.

Statement showing the kinds and number of eggs and fish furnished to State fish commissions during the fiscal year ending June 30, 1892—Continued.

State.	Species.	Eggs.	Fish.
Pennsylvania	Carp		4,000
	Shad		*2,348,750
	Atlantic salmon	300,000	
	Whitefish	12,500,000	
	Pike perch	15,000,000	
Utah	Carp		2,000
Vermont	Landlocked salmon	20,000	
	Loch Leven trout	30,000	
	Rainbow trout	20,000	
	Von Behr trout		290
	Lake trout	100,000	
West Virginia	Loch Leven trout	10,000	
Wisconsin	Carp		15,000
Wyoming	Rainbow trout	20,000	
	Von Behr trout	10,000	
	Lake trout	100,000	

*Fry.

COURTESIES EXTENDED AND RECEIVED.

RELATIONS WITH OTHER GOVERNMENT DEPARTMENTS.

Acknowledgments are due the Coast and Geodetic Survey for charts and sounding books and the loan of instruments.

The War Department, through Maj. C. E. L. B. Davis, in charge of the improvement of the Potomac River, for the use of scows to transfer buildings and equipment from Fort Washington to Bryan Point.

The Interior Department for continuing the authority issued by the War Department for the use of a portion of the reservation at Fort Gaston, Cal., as a fish-cultural station.

The Navy Department for the extension of the facilities of the navy-yards for the outfit and repair of the Commission's ships. Passed Assistant Engineer W. B. Bayley was detached April 1, 1892, as consulting engineer, and Passed Assistant Engineer I. S. K. Reeves detailed in his stead. The steamer *Albatross* was transferred to the Navy Department for use in making a survey for a telegraphic cable between the United States and the Hawaiian Islands.

By direction of the President the steamer *Albatross* was detailed to convey to Bering Sea Drs. T. C. Mendenhall and C. Hart Merriam, agents of the State Department to investigate the seal fisheries of Alaska.

At the request of the Superintendent of the Eleventh Census the appointment of Dr. H. M. Smith as special agent of the census in charge of fish and fisheries was sanctioned.

The steam launch *Blue Wing* was lent to the Commissioners of the District of Columbia while the police boat was being repaired.

For use during the shad-hatching season at Bryan Point, loan of tents and equipment was made by Gen. Albert Ordway, commanding the District of Columbia militia.

RELATIONS WITH FOREIGN COUNTRIES.

Canada.—Eggs of the landlocked salmon were furnished Mr. W. P. Greenough, Portneuf, Quebec.

Mexico.—Eggs of the Von Behr trout, landlocked salmon, and quinnat salmon were furnished the Mexican Fish Commission.

United States of Colombia.—Through Lieut. H. R. Lemly the Government of the United States of Colombia was supplied with eggs of the brook, Loch Leven, Von Behr, and rainbow trout. The shipment resulted in entire loss.

Great Britain.—At the request of U. S. Minister Robert T. Lincoln, a shipment of landlocked salmon eggs was made to Bridgeworth, England. In March, 1892, 100,000 eggs of the whitefish were forwarded to the Midland Counties Fish Culture Establishment. Report was made December 30, 1891, that the consignment made during the previous season had successfully hatched and that many of the fish had attained a length of 8 inches.

Germany.—On October 25, 1891, a quantity of catfish, sunfish, and calico bass were furnished Dr. Charles von dem Borne for his father, the eminent German fish-culturist, Mr. Max. von dem Borne, of Berneuchen. A small consignment of whitefish was also sent in April, 1892. During the year there were received from Mr. von dem Borne eggs of the Von Behr trout, brook trout, lake trout, and whitefish.

France.—Eggs of the rainbow trout were sent to Mr. Le Conteula de Caumont, Oise.

Belgium.—In compliance with request of the Belgium Commission of Pisciculture, about 500 catfish were collected at Quincy, Ill., and forwarded to Antwerp in December, 1891.

Switzerland.—In February, 1892, 100,000 eggs of the common whitefish were sent to Mr. E. Covelle, Geneva.

MARSHALL McDONALD,
U. S. Commissioner of Fish and Fisheries.

Details of distribution, 1891-92.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Catfish (*Ictalurus punctatus*, chiefly):			
Deer Creek, Bel Air, Md			509
Private ponds in Pennsylvania			100
New York			100
Max von dem Borne, Berneuchen, Germany			76
Belgium, Government of			502
Lake Cuyamaca, San Diego, Cal			250
Feather River, Gridley, Cal			250
Illinois River, La Salle, Ill			100
Meredosia, Ill			(250,000)
Private ponds in Illinois			80
Flat Rock River, Flat Rock, Ind			295
Upper Iowa River, Decorah, Iowa			50
Wall Lake, Lake View, Iowa			195
Mineral Park Lake, Dow City, Iowa			195
Lake Evelyn, Bonner Springs, Kans			300
Cumberland River, Williamsburg, Ky			20
Spring Lake, Madisonville, Ky			25
Reinecke Lake, Madisonville, Ky			25
Loch Mony Lake, Earlington, Ky			25
Salisbury fish ponds, Salisbury, Mo			65
City reservoir, Moberly, Mo			75
Missouri Fish Commission, St. Joseph, Mo			240
Cockrell Lake, Independence, Mo			27
Private ponds in New Mexico			80
Brady Lake, Ravenna, Ohio			200
Lake Lakemere, Kenton, Ohio			15
Private ponds in Ohio			160
Private ponds in Texas			140
Liberty Lake, Spokane Falls, Wash			50
Loon Lake, Loon Lake, Wash			150
Private ponds in Missouri			27
Carp (*Cyprinus carpio*):			
Private ponds in Alabama			850
Larapee Creek, Chehaw, Ala			2,500
Tombigbee River, near Demopolis, Ala			2,500
Alabama River, near Selma, Ala			2,500
Private ponds in Arkansas			860
Washita River, Arkadelphia, Ark			5,000
Private ponds in California			60
Colorado			1,485
Connecticut			280
Delaware Fish Commission			1,500
Nanticoke River, Seaford, Del			2,753
Private ponds in District of Columbia			200
Florida			710
Georgia			1,720
Georgia Fish Commission			2,500
Private ponds in Idaho			970
Mud Lake, near Paris, Idaho			2,000
Private ponds in Illinois			150
Illinois River, Meredosia, Ill			(5,000)
Fox River, near Elgin, Ill			500
Embarras River, near Greenup, Ill			1,250
Illinois Fish Commission			5,000
Private ponds in Indiana			210
Wabash River, Terre Haute, Ind			1,250
Private ponds in Indian Territory			40
Iowa			715
Fifteen-acre lake, near Dow City, Iowa			300
Private ponds in Kansas			3,310
Kentucky			280
Louisiana			200
Crocodile River, near Bunkie, La			2,500
Bayou Scie, near Robeline, La			2,500
Cypre Bayou, near Stonewall, La			2,500
Private ponds in Maine			30
Maryland			640
Big Pool, Hagerstown, Md			1,000
Tuckahoe Creek, Queen Anne, Md			3,000
Deer Creek, Bel Air, Md			1,000
Private ponds in Massachusetts			800
Michigan			1,200
Minnesota			330
Minnesota Fish Commission			1,500
Private ponds in Mississippi			190
Chunkey River, Chunkey's Station, Miss			2,500
Bayou Chitto near Johnston's Station, Miss			2,500
Private ponds in Missouri			600
Shoal Creek, near Neosho, Mo			1,000
Tributary of Spring River, near Seneca, Mo			500

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Carp (*Cyprinus carpio*)—Continued:			
Private ponds in Montana			1,580
Nebraska			2,720
New Hampshire			130
New Jersey			1,680
New Mexico			280
New York			790
New York Fish Commission			5,000
Private ponds in North Carolina			2,110
Mayo and Dan rivers in North Carolina			3,000
Private ponds in North Dakota			1,530
Ohio			300
Licking River, Newark, Ohio			1,250
Stillwater River, Bradford Junction, Ohio			900
Private ponds in Oklahoma			800
Oregon			120
Pennsylvania			2,230
Tulpehocken Creek, Stouchsburg, Pa			5,000
Pennsylvania Fish Commission			4,000
Private ponds in South Carolina			120
South Dakota			840
Vermillion River, Vermillion, S. Dak			4,700
Small lake, near Forestburg, S. Dak			100
Private ponds in Tennessee			1,000
Texas			1,020
Red River, near Dawn, Tex			1,000
Texas and Pacific R. R. Co.'s pond, near Westbrook, Tex			600
Sabin River, near Mineola, Tex			2,500
Neches River, near Prices, Tex			2,500
Navasota River between Lake and Dean, Tex			2,500
Trinity River, near Dallas, Tex			2,500
San Marcos River, near San Marcos, Tex			2,500
Nueces River, near Cotulla, Tex			2,500
Private ponds in Utah			3,830
Streams near Tooele, Utah			300
in Emery County, Utah			395
Utah Fish Commission			2,000
Private ponds in Vermont			200
Virginia			3,330
Mill pond tributary to Reed Creek, near Wytheville, Va			55
Pohick Run, near Springman, Va			1,000
Private ponds in Washington			420
Small lake near Clear Lake, Wash			300
Seattle, Wash			540
Sedalia, Wash			300
Houghton, Wash			500
Private ponds in West Virginia			210
West Virginia Fish Commission			5,000
Wisconsin Fish Commission			15,000
Private pond in Wisconsin			30
Tench (*Tinca tinca*):			
Big Darby Creek, near Plain City, Ohio			500
Spring Creek, near Urbana, Ohio			500
Whitewater River, near Richmond, Ind			500
Current River, near Chilton, Mo			2,300
Private pond in Missouri			200
Texas and Pacific R. R. Co.'s pond, Arlington, Tex			500
Texas and Pacific R. R. Co.'s pond, Loraine, Tex			1,500
Hickory Creek, Martinsville, Ill			500
Kaskaskia River, Vandalia, Ill			500
Brandywine River, near Chadds Ford, Pa			992
Deer Creek, near Bel Air, Md			1,000
Big Pool, near Hagerstown, Md			1,000
Tulpehocken River, near Reading, Pa			1,500
Ontelaunee River, near Reading, Pa			1,500
Missouri Fish Commission			5,000
Hickory Creek, near Neosho, Mo			1,100
Shoal Creek, near Boyden, Mo			2,000
New York Fish Commission			2,100
Appomattox River, near Petersburg, Va			2,000
Grand River, Chillicothe, Mo			3,700
Des Moines River, Ottumwa, Iowa			3,700
Mayo and Dan rivers, near Reidsville, N. C			3,000
Golden ide (*Idus melanotus*):			
Applicants in Alabama			50
Colorado			70
Florida			100
Indiana			500
Kansas			69
Louisiana			100
Massachusetts			25
Missouri			25

Details of distribution, 1891-92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Golden ide (*Idus melanotus*)—Continued:			
New York Fish Commission			975
Applicants in North Carolina			6
Ohio			200
Pennsylvania			51
Virginia			15
Goldfish (*Carassius auratus*):			
Applicants in Alabama			250
Arkansas			277
California			25
Colorado			129
Connecticut			60
Delaware			152
District of Columbia			6,314
Florida			277
Georgia			321
Idaho			12
Illinois			832
Indiana			735
Indian Territory			36
Iowa			68
Kansas			640
Kentucky			180
Louisiana			388
Maine			6
Maryland			1,040
Massachusetts			151
Michigan			133
Minnesota			64
Mississippi			53
Missouri			1,435
Hearrell Branch, near Neosho, Mo			257
Applicants in Montana			24
Nebraska			60
New Hampshire			6
New Jersey			552
New York			736
North Carolina			284
Ohio			466
Pennsylvania			1,402
Rhode Island			12
South Carolina			108
South Dakota			6
Tennessee			432
Texas			467
Utah			66
Virginia			1,818
Vermont			37
Washington			12
West Virginia			221
Wyoming			6
Wisconsin			100
Buffalo (*Ictiobus*, sp.):			
Illinois River, Meredosia, Ill			(20,000)
Shad (*Clupea sapidissima*):			
Alabama River, Montgomery, Ala		2,499,000	
Dog River, near Mobile, Ala		1,400,000	
Connecticut River, Warehouse Point, Conn		1,939,000	
Nanticoke River, Seaford, Del		1,798,000	
Brandywine Creek, Wilmington, Del		2,250,000	
Black Bird Creek, Middletown, Del		120,000	
Appoquinimink Creek, near Middletown, Del		120,000	
Little Duck Creek, Clayton, Del		240,000	
Jones River, Dover, Del		300,000	
Murderkill Creek, Felton, Del		240,000	
Mispillion Creek, Milford, Del		180,000	
Duck Creek, Ellendale, Del		90,000	
Indian River, Millsboro, Del		510,000	
Potomac River, Washington, D. C			*a* 1,000,000
Tomoka River, Daytona, Fla		750,000	
Suwanee River, New Bradford, Fla		750,000	
St. Johns River, Buffalo Bluffs, Fla		800,000	
U. S. Fish Ponds, Washington, D. C		*b*(1,989,000)	
Chattahoochee River, West Point, Ga		925,000	
Savannah River, Augusta, Ga		1,220,000	
Ocmulgee River, Macon, Ga		900,000	
Grand River, Shawnee, Ind. T		900,000	
Atchafalaya River, Melville, La		669,000	

a Estimated product of 2,054,000 fry deposited in April, 1891.
b Deposited for rearing and distribution in fall of 1892.

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Shad (*Clupea sapidissima*)—Continued:			
Crocodile River, near Bunkie, La		672,000	
Vermilion River, near Lafayette, La		675,000	
North-East River, North-East, Md		1,800,000	
Gunpowder River, Gunpowder Station, Md		2,250,000	
Elk River, Elkton, Md		2,680,000	
Bush River, Bush River Station, Md		2,250,000	
Wicomico River, Salisbury, Md		1,349,000	
Tuckahoe Creek, Queen Anne, Md		1,320,000	
Patapsco River, Relay House, Md		448,000	
Susquehanna River, near Havre de Grace, Md		1,025,000	
Peach Bottom, Pa		1,800,000	
Fites Eddy, Pa		1,800,000	
Columbia, Pa		1,200,000	
Back River, near Back River Station, Md		450,000	
Patuxent River, Laurel, Md		301,000	
Chester River, Chestertown, Md		1,350,000	
Taunton River, Dighton, Mass		1,500,000	
Jordan River, near Bay St. Louis, Miss		500,500	
Wolf River, near Bay St. Louis, Miss		500,500	
Bayou de Lisle, near Bay St. Louis, Miss		500,500	
Rotten Bayou, near Bay St. Louis, Miss		500,500	
James River, Springfield, Mo		180,000	
U. S. Fish Commission Station, Neosho, Mo		*a* (700,000)	
St. Francis River, Knob Lick, Mo		750,000	
Timber Creek, Gloucester, N. J	2,497,000	261,000	
Woodbury Creek, near Gloucester, N. J		24,000	
Delaware River, Lambertville, N. J		450,000	
Callicoon, N. Y		1,450,000	
Port Jervis, N. Y		1,515,000	
Lackawaxen, Pa		2,069,000	
Delaware Water Gap, Pa		2,600,000	
Hudson River, Albany, N. Y		2,524,000	
West Point, N. Y		1,350,000	
Newburg, N. Y		1,325,000	
Catawba River, near Morganton, N. C		260,000	
Neuse River, Goldsboro, N. C		275,000	
Yadkin River, Salisbury, N. C		250,000	
Congaree River, Columbia, S. C		1,200,000	
Bear River, Cache Junction, Utah		1,998,000	
Chappawausie Creek, Quantico, Va		474,000	
Elizabeth River, Norfolk, Va		429,000	
Otter River, Evington, Va		361,000	
Rapidan River, Rapidan, Va		594,000	
Stony Creek, Stony Creek, Va		379,000	
Tye River, Tye River Station, Va		688,000	
Meherrin River, Belfield, Va		396,000	
Cedar Run, Catlett, Va		437,000	
Little River, Taylorsville, Va		421,000	
Rockfish River, Rockfish Station, Va		395,000	
Machipongo Creek, Machipongo, Va		400,000	
Quinnat salmon (*Oncorhynchus chouicha*):			
California Fish Commission	2,852,000		
E. Cházari for Mexican Government	50,000		
McCloud River, Baird, Cal		25,500	
Clackamas River, Clackamas, Oreg		1,332,400	
Tributaries of Trinity River, near Fort Gaston, Cal		140,000	
Redmond Creek, near Fort Gaston, Cal		150,000	
Supply Creek, near Fort Gaston, Cal			25,000
Nissequogue River, near Smithtown, Long Island, N. J			2,400
Green River, near Arlington, Vt			1,500
Benedict Brook, near Arlington, Vt			1,000
Madison Brook, near Arlington, Vt			485
Denning Brook, near Arlington, Vt			485
Atlantic salmon (*Salmo salar*):			
Pennsylvania Fish Commission	300,000		
New York Fish Commission	150,000		
Tributaries of Penobscot River, Maine			254,200
Alamoosook Lake, near Craig Brook Station, Maine			32
Landlocked salmon (*Salmo salar*, var. *sebago*):			
Toddy Pond, near Orland, Me			8,421
Burnt Land Pond, near Deer Isle, Me			1,499
Craig Pond, near Orland, Me			59
Winooski River, near Waterbury, Vt			5,000
Browns River, near Essex Junction, Vt			5,000
Indian Brook, near Essex Junction, Vt			2,000
Malletts Creek, near Essex Junction, Vt			2,000
Sunderland Hollow Brook, near Essex Junction, Vt			1,000
Patten Pond, near Green Lake, Me			20,000
Green Lake and tributaries, near Green Lake, Me			76,000

a Deposited for rearing and distribution.

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Landlocked salmon (*Salmo salar*, var. *sebago*)—Continued:			
Grand Lake and Grand Lake Stream, near Schoodic Station, Me			42,184
Do		68,692	
H. B. W. Whitmore, Bridgeworth, England	15,000		
California Fish Commission	30,000		
Blooming Grove Park Association, Glen Eyre, Pa	10,000		
New York Fish Commission	15,000		
Wilmurt Club, Newton Corners, N. Y	30,000		
Tuxedo Club, Tuxedo, N. Y	10,000		
A. N. Cheney, Glens Falls, N. Y	10,000		
Minnesota Fish Commission	15,000		
Nevada Fish Commission	25,000		
Vermont Fish Commission	20,000		
New Hampshire Fish Commission	17,000		
E. Cházari, for Mexican Government	25,000		
W. P. Greenough, Lachevrotiere, Canada	10,000		
Loch Leven trout (*Salmo levenensis*):			
University of Michigan, Ann Arbor, Mich	500		
New Hampshire Fish Commission	25,000		
Vermont Fish Commission	30,000		
West Virginia Fish Commission	10,000		
Nebraska Fish Commission	15,000		
A. N. Cheney, Glens Falls, N. Y	20,000		
Lieut. H. R. Lemly, Colombia, S. A	10,000		
Toddy Pond, near Craig Brook Station, Me			10,935
University of Michigan, Ann Arbor, Mich			9
Nolin Creek, White Mills, Ky			475
Tonches Creek, near Traverse City, Mich			500
Goodwin Creek, Vassar, Mich			500
Private pond in Michigan			200
Alder Run, Kylertown, Pa			275
Private pond in Pennsylvania			200
Knights Creek, Menominee, Wis			1,485
Rainbow trout (*Salmo irideus*):			
Vermont Fish Commission	20,000		
Wyoming Fish Commission	20,000		
John H. Gordon, South Bend, Wyo	20,000		
Otto Gramm, Laramie, Wyo	10,000		
E. M. Robinson, Mammoth Springs, Ark	20,000		
Le Conteula de Caumont, Havre, France	30,000		
Lieut. H. R. Lemly, Colombia, S. A	20,000		
Heart Pond, near Orland, Me			105
Coosa River, Leesburg, Ala			700
Little River, Fort Payne, Ala			489
Cypress Creek, Florence, Ala			300
Private ponds in Alabama			250
Arkansas			1,100
Lake Pocotopong, near East Hampton, Conn			1,000
Private ponds in Connecticut			500
Crawfish Springs, near Chickamauga, Ga			3,000
Raccoon Creek, Rome, Ga			800
Line Creek, Palmetto, Ga			94
Private ponds in Georgia			800
Bloody Run, Dubuque, Iowa			5,000
Private pond in Kansas			50
Little Cold River, Fryeburg, Me			500
Mill Pond, Barton, Md			95
Tributaries of Gunpowder River, near Loch Raven and Parkton, Md			550
Cowlers Creek, near Loch Raven, Md			250
Jenifer Branch, near Lock Raven, Md			250
Tributary of Deer Creek, near Belair, Md			500
Bynum Run, near Belair, Md			100
Sideling Hill Creek, in Washington County, Md			500
Private ponds in Maryland			590
Pelham Brook, Lowell, Mass			700
Browns Brook, Northfield, Mass			700
Twelve-acre lake, near Bellingham, Mass			1,000
Private ponds in Massachusetts			700
Current River, near Chilton, Mo			1,500
Shoal Creek, in Newton County, Mo			1,256
Missouri Fish Commission			12
Private ponds in Missouri			500
Malapardis Brook, near Morristown, N. J			500
Sam Spring Brook, near Morristown, N. J			500
Quail Run, Island Heights, N. J			300
Private ponds in New Jersey			700
Otsego Creek, Oneonta, N. Y			972
Dam of New City Mills, Conger, N. Y			1,000
Skanandoa Creek, Vernon, N. Y			480

Details of distribution, 1891-92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Rainbow trout (*Salmo irideus*)—Continued:			
Bouchor Creek, near Lordville, N. Y			500
Private ponds in New York			300
Flat Creek, Black Mountain, N. C			1,000
Wyalusing Creek, South Montrose, Pa			500
Metcalf Dam, Shippensburg, Pa			200
Stony Creek, Penn Haven Junction, Pa			300
Garlick Run, Coatesville, Pa			250
Big Spring Creek, Newville, Pa			200
Tributaries of Tioga River, Troy, Pa			1,000
Rock Run, Coatesville, Pa			250
Iron Mine Run, Middletown, Pa			200
Canons Run, Dickinson, Pa			500
Trout, Scott, and other runs, near Marysville, Pa			500
Doe Run, near Coatesville, Pa			100
Hensinger Run, Jordan, Pa			500
Private ponds in Pennsylvania			434
Horse Creek, Bethel, Tenn			493
Indian Creek, Harrogate, Tenn			500
Lick Creek, near Franklin, Tenn			100
Harfith Creek, near Franklin, Tenn			200
Flint River, Fayetteville, Tenn			500
Doe River, Knoxville, Tenn			357
Doe and Watauga rivers, near Elizabethton, Tenn			500
Private ponds in Tennessee			250
Texas			700
Happy Creek, Front Royal, Va			100
Holston River, Rich Valley, Va			100
Saltville, Va			500
Bradford, Va			500
Big Spring Branch, Leesburg, Va			500
Mountain stream, near Delaplane, Va			300
Holmes Creek, Dunn Loring, Va			300
Beaver Dam Creek, Hamilton, Va			495
Wolf Creek, Abingdon, Va			500
Clear Creek, Ramsey, Va			500
Roaring Run, Rocky Mount, Va			496
Thorn Spring, Newbern, Va			300
Cedar Creek, Natural Bridge, Va			1,000
Cleveland, Va			300
Augusta Springs Pond, Augusta Springs, Va			498
Reed Creek, Wytheville, Va			115
Private ponds in Virginia			3,719
Roaring Brook, Stamford, Vt			500
Menden Brook, Rutland, Vt			1,600
Metcalf Pond, E. Fairfield, Vt			500
Meadow Brook, Berlin, Vt			200
Private ponds in Vermont			750
Elkhorn Creek, Powhatan, W. Va			300
Elk River, Charleston, W. Va			987
Private ponds in West Virginia			97
Kinnickinnick River, River Falls, Wis			900
Von Behr or brown trout (*Salmo fario*):			
University of Michigan, Ann Arbor, Mich	500		
John H. Gordon, South Bend, Wyo	20,000		
Wyoming Fish Commission	10,000		
Nebraska Fish Commission	20,000		
E. Cházari, for Mexican Government	20,000		
Lieut. H. R. Lemly, Colombia, S. A	10,000		
Delaware Fish Commission		2,500	
Augusta Springs Lake, Augusta Springs, Va		5,000	
Rock Creek, Rock Creek National Park, District of Columbia		14,478	
Streams near Amberg Station, Wis		15,000	
Baptism River, Lake County, Minn		5,000	
Private ponds in Arizona			1,200
Arkansas			700
South Clear Creek, Georgetown, Colo			1,500
South Fork of White River, Glenwood, Colo			1,250
Beauty Lake, Morrison, Colo			500
Grape Creek and tributaries in Fremont County, Colo			2,000
Old Curtis Lake, Aspen, Colo			2,000
Boulder Creek, Niederland, Colo			2,000
Mammoth Creek, Griffin County, Colo			3,000
South Boulder Creek, Griffin County, Col			3,000
Platt River, Grant, Colo			1,500
Slaghts, Colo			1,500
Estabrook, Colo			1,500
Pine Grove, Colo			1,500
Dome Rock, Colo			1,500
Lake Creek, in Lake County, Colo			1,500

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Von Behr or brown trout (*Salmo fario*)—Continued:			
Rock Creek, in Lake County, Colo			5,500
Arkansas River, near Boulevard, Colo			5,000
Lower Evergreen Lakes, near Evergreen, Colo			2,000
Private ponds in Colorado			1,993
Kent Hollow, Melford, Conn			200
Private ponds in Illinois			50
Tippecanoe River, Monticello, Ind			500
Hartman Creek, South Bend, Ind			300
McCarty Creek, South Bend, Ind			200
Private ponds in Indiana			400
Canoe Creek, Decorah, Iowa			1,000
Spring Branch, Strawberry Point, Iowa			980
Private ponds in Kansas			350
Blue Lick Creek, near Louisville, Ky			200
Strait Creek, near Pineville, Ky			500
Clear Creek, near Pineville, Ky			500
Private pond in Kentucky			200
Toddy Pond, near Orland, Me			743
Sideling Hill Creek, in Washington County, Md			423
Private ponds in Maryland			200
Smith Brook, near Hoosic Tunnel, Mass			200
Texas Creek, near Kalamazoo, Mich			425
Crystal Spring Lake, near Lawton, Mich			400
Birch Lake, near Williamsville, Mich			50
Monroe Creek, near Maple Ridge, Mich			400
Van Etten Creek, near Mikado, Mich			400
Centennial Mill Creek, near Daily, Mich			425
Houghton Creek, near Vassar, Mich			200
Cass River, near Vassar, Mich			200
Pine River, near Alma, Mich			800
Private ponds in Missouri			970
Little Blackfoot River, Elliston, Mont			1,000
Private ponds in Montana			500
Otter Creek, Ogallala, Nebr			1,000
Private ponds in Nebraska			300
Dark Canyon Stream, Eddy, N. Mex			1,000
Private ponds in New Mexico			1,350
Rockwell's Mill Creek, Bellevue, Ohio			300
Private ponds in Ohio			100
Mass Hope Creek, White Mills, Pa			300
Moose Creek, Clearfield, Pa			300
Crystal Lake, Spearfish, S. Dak			250
Turkey Creek, near Yankton, S. Dak			7,800
Cowardin Run, near Warm Springs, Va			419
Small brooks near Bennington, Vt			186
Vermont Fish Commission			290
Eighteen-mile Creek, near Pratt, Wis			250
Lost Creek, near Maiden Rock, Wis			1,975
Black-spotted trout (*Salmo mykiss*):			
Mammoth Lake, in Griffin County, Colo			6,000
Lake Creek, in Lake County, Colo			1,000
Mammoth Creek, in Griffin County, Colo			4,000
Rock Creek, in Lake County, Colo			2,000
French Creek, in Custer County, S. Dak			1,000
Squaw Creek, in Custer County, S. Dak			200
Iron Creek, in Custer County, S. Dak			300
Robin Creek, in Custer County, S. Dak			200
Spring Creek, in Pennington, S. Dak			700
Castle Creek, in Pennington, S. Dak			800
Rapid Creek, in Pennington, S. Dak			500
Spearfish Creek, in Lawrence, S. Dak			1,000
Whitewood Creek, in Deadwood, S. Dak			300
Brook trout (*Salvelinus fontinalis*):			
University of Michigan, Ann Arbor, Mich	500		
Lieut. H. R. Lemly, Colombia, S. A	10,000		
Private ponds in Arizona			500
South Clear Creek, near Georgetown, Colo			1,500
South Fork of White River, near Glenwood, Colo			1,250
Woody Lake, near Woody, Colo			1,000
Grape Creek, in Fremont County, Colo			3,000
South Boulder Creek, in Griffin County, Colo			4,000
Platte River, near Grant, Colo			1,500
Slaghts, Colo			1,500
Estabrook, Colo			1,500
Pine Grove, Colo			1,500
Dome Rock, Colo			1,500
Lake Creek, in Lake County, Colo			1,500
Rock Creek, in Lake County, Colo			3,000
Delaware Fish Commission			300
Baldwin Creek, near Cresco, Iowa			700

Details of distribution, 1891-92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Brook trout (*Salvelinus fontinalis*)—Continued:			
Streams in Dubuque County, Iowa			3,000
Craig Pond, near Orland, Me			1,479
Alamoosook Lake, near East Orland, Me			198
Streams in Wayne County, Mich			10,000
University of Michigan, Ann Arbor, Mich			34
Missouri Fish Commission			12
Bolen Pond, near Jasper, Mo			233
Otter Creek, near Ogallala, Nebr			1,000
Gallinas River, near E. Las Vegas, N. Mex			1,000
Santa Fe River, near Santa Fe, N. Mex			3,000
Lovejoy Creek, near Clyde, N. Y			250
Cold Creek, near Castalia, Ohio			1,890
Chester Creek, near Green Hill, Pa			375
Paradise Run, near Leaman Place, Pa			250
Starrucco Creek, near Thompson, Pa			375
Branch Creek, near Pocono, Pa			373
Private ponds in Pennsylvania			250
Turkey Creek, near Wakonda, S. Dak			5,000
French Creek, in Custer County, S. Dak			500
Squaw Creek, in Custer County, S. Dak			300
Iron Creek, in Custer County, S. Dak			200
Robin Creek, in Custer County, S. Dak			300
Spring Creek, in Pennington County, S. Dak			800
Castle Creek, in Pennington County, S. Dak			700
Rapid Creek, in Pennington County, S. Dak			500
Spearfish Creek, in Lawrence County, S. Dak			1,500
Whitewood Creek near Deadwood S. Dak			200
Kinnickinnick River, near River Falls, Wis			1,000
Lake trout (*Salvelinus namaycush*):			
University of Michigan, Ann Arbor, Mich	500		
John H. Gordon, South Bend, Wyo	50,000		
Wyoming Fish Commission	100,000		
Minnesota Fish Commission	50,000		
Vermont Fish Commission	100,000		
New Hampshire Fish Commission	100,000		
Nebraska Fish Commission	200,000		
New York Fish Commission	300,000		
Lake Superior, off mouth of Lester River, near Duluth, Minn		420,000	
Lake Superior, near Grand Marais, Minn		10,000	
Mackletts Channel, Minn		50,000	
Weager Creek, near South Bend, Ind			100
Turkey Lake, near Cedar Beach, Ind			2,531
Lake Maxinkuckee, near Marmont, Ind			2,531
Stanfield Lake, near South Bend, Ind			2,000
Twin Lakes, near Lima, Ind			2,000
Twin Lakes, near Garner, Iowa			1,427
Pilot Mound Lake, Garner, Iowa			500
Hickman Creek, near Lexington, Ky			200
Private pond in Kentucky			300
Lake Esau, near Bell, Mich			500
Walnut Lake, near Franklin, Mich			500
Boon Lake, near Franklin, Mich			500
Zukey Lake, near Hamburg Junction, Mich			2,000
Pickerel Lake, near Newayga, Mich			1,000
Mill Creek, near Wingleton, Mich			3,400
Pleasant Lake, near Annandale, Minn			950
Otsego Lake, near Cooperstown, N. Y			1,950
Johnson Creek, near North Ridgeway, N. Y			1,475
Paint Creek, near Chillicothe, Ohio			200
Lake in Franklin Park, Columbus, Ohio			500
Letort Spring, near Carlisle, Pa			3,700
Lake Underwood, near Como, Ind			2,800
Upper Twin Lake, near Preston Park, Pa			3,900
Forest Stream Pond, near Wilmington, Vt			2,000
Pike River, near Kirton, Wis			2,900
Long Lake, near Spooner, Wis			2,000
Toscobia Lake, near Rice Lake, Wis			2,000
Lake herring (*Coregonus artedi*):			
Lake Erie, near Bass Islands		262,500	
Whitefish (*Coregonus clupeiformis*):			
Indiana Fish Commission	100,000		
Midland Counties Fish Culture Association, England	100,000		
Switzerland, Government of	100,000		
Pennsylvania Fish Commission	12,500,000		
Ohio Fish Commission	8,000,000		
Lake Superior, off mouth of Lester River, near Duluth, Minn		11,727,000	
Lake Superior, off mouth of ship canal, near Duluth, Minn		3,000,000	

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Whitefish (*Coregonus clupeiformis*)—Continued:			
Lake Superior, near Whitefish Point, Mich		2,000,000	
Lake St. Croix, off mouth of St. Croix River, in Wisconsin		2,000,000	
Lake Erie, near North Bass Island		1,000,000	
Rattlesnake Island		750,000	
Middle Bass Island		1,000,000	
Kelley Island		1,000,000	
Put-in-Bay Island		1,000,000	
Ballast Island		1,250,000	
Thunder Bay, near Alpena, Mich		2,250,000	
Lake Huron, near Alpena, Mich		1,500,000	
East Tawas, Mich		2,000,000	
Harrisville, Mich		2,000,000	
Au Sable, Mich		2,000,000	
Lake Michigan, near Naubinway, Mich		2,000,000	
Epoufette, Mich		2,000,000	
Whitefish Lake, near Corinne, Mich		2,000,000	
Lake Ontario, near Sacketts Harbor, N. Y		2,000,000	
Oswego, N. Y		801,000	
Scriba, N. Y		875,000	
Otsego Lake, near Cooperstown, N. Y		314,000	
Yellow perch (*Perca flavescens*):			
Feather River, near Gridley, Cal			3,000
Lake Cuyamaca, San Diego, Cal			3,980
Private ponds in Illinois			750
Glenwood Lake, near Galesburg, Ill			300
Rock River, near Milan, Ill			1,230
Sni Ecarte Lake, near East Hannibal, Ill			300
Illinois River, near La Salle, Ill			50
Meredosia, Ill			(25,000)
Kankakee River, near Kankakee, Ill			200
Island Pond, near Waterloo, Ill			34
Gilmore Lake, near Columbia, Ill			33
Sucker State Pond, near Carlisle, Ill			33
Private ponds in Kansas			650
Lake Evelyn, near Bonner Springs, Kans			2,250
Elm Creek, near Sawyer, Kans			1,700
Private ponds in Kentucky			4,500
Big Pool, near Hagerstown, Md			1,487
Private ponds in Missouri			50
Salisbury Fish Pond, Salisbury, Mo			25
City reservoir, near Moberly, Mo			50
Private ponds in New Mexico			250
Blue Water, near Blue Water, N. Mex			100
Private ponds in Ohio			333
Lake Mere, near Kenton, Ohio			1,862
Ohio Fish Commission			2,750
Nixon River, near Faulkton, S. Dak			516
James River, near Huron, S. Dak			518
Turtle Creek, near Redfield, S. Dak			516
Lake Kampeska, near Pierre, S. Dak			1,750
Loon Lake, near Spokane Falls, Wash			500
Camp Lake, Camp Lake, Wis			33
Silver Lake, Silver Lake, Wis			33
Cedar Lake, near Schleisingerville, Wis			33
Browne Lake, near Burlington, Wis			33
Phantom Lake, near Mukwonago, Wis			33
Crooked Lake, near Mukwonago, Wis			33
Chain of Lakes, near Waupaca, Wis			35
Pike perch (*Stizostedion vitreum*):			
Pennsylvania Fish Commission	15,000,000		
Pike River, in Minnesota	15,000,000		
St. Louis River, in Minnesota	10,000,000		
Lake Superior, in Minnesota	5,000,000		
Lake Erie, near Put-in-Bay Island		2,500,000	
North Bass Island		1,500,000	
North Bass and Middle Bass Islands		2,000,000	
West Sister Island		6,000,000	
Quinnebaug River, near Putnam, Conn		1,000,000	
Wild Cat River, near Kokomo, Ind		1,500,000	
Salmonia River, near Warren, Ind		1,500,000	
Mississenewa River, near Marion, Ind		1,500,000	
Iroquois River, near Rensselaer, Ind		1,500,000	
Cedar Lake, near Lima, Ind		4,700,000	
Twin Lakes, near Lima, Ind		4,700,000	
Diamond Lake, near Ligonier, Ind		50,000	
Chain Lake, near South Bend, Ind		100,000	
Stone and Pine Lake, near La Porte, Ind		200,000	
Pike, Eagle, and Chapman lakes, near Warsaw, Ind		200,000	
Cedar Lake, near Ora, Ind		50,000	
Little Clam Lake, near Cadillac, Mich		1,850,000	

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Pike perch (*Stizostedion vitreum*)—Continued:			
Big Clam Lake, near Cadillac, Mich		1,850,000	
Scioto River, near Kenton, Ohio		1,000,000	
Grand Reservoir, near Carthagena, Ohio		1,000,000	
Maumee River, near Cecil, Ohio		1,000,000	
Tuscarawas River, near Zoar, Ohio		1,000,000	
Maumee River, near Toledo, Ohio		500,000	
Grand Reservoir, near Celina, Ohio		500,000	
Blanchard River, near Ottawa, Ohio		1,000,000	
Litchfield Creek, near Winchester, Ky		1,000,000	
North fork of Kentucky River, near Ford, Ky		2,000,000	
Silver Creek, near Slate Lick, Ky		1,000,000	
Rockcastle River, near Livingston, Ky		2,000,000	
Cumberland River, near Pineville, Ky		3,000,000	
Salt River, near Sheperdsville, Ky		400,000	
Elizabethton, Ky		400,000	
Nolin Creek, near Nolin, Ky		400,000	
Big Barren River, near Bowling Green, Ky		400,000	
Private ponds in Kentucky			100
Sea bass (*Serranus atrarius*):			
Vineyard Sound, Massachusetts coast		200,000	
White bass (*Roccus chrysops*):			
Private ponds in Illinois			75
Sni Ecarte, near East Hannibal, Ill			400
Illinois River, near La Salle, Ill			100
Meredosia, Ill			(15,000)
Kankakee River, near Kankakee, Ill			25
Upper Iowa River, near Decorah, Iowa			447
Private ponds in Kansas			25
Little Blue River, near Hanover, Kans			200
Big Pool, near Hagerstown, Md			24
Pertle Spring, near Warrensburg, Mo			50
Loon Lake, near Spokane Falls, Wash			500
Liberty Lake, near Spokane Falls, Wash			100
Black bass (*Micropterus salmoides* and *M. dolomieu*):			
Private pond in Arkansas			50
Lake Cuyamaca, near San Diego, Cal			1,990
Feather River, near Gridley, Cal			620
Private pond in Connecticut			222
District of Columbia			400
Private ponds in Illinois			150
Du Page River, near Burlington Park, Ill			50
Glenwood Lake, near Galesburg, Ill			50
Rock River, near Milan, Ill			175
Sni Ecarte Lake, near East Hannibal, Ill			25
Illinois River, near La Salle, Ill			25
Kankakee River, near Kankakee, Ill			25
Island Pond, near Waterloo, Ill			50
Gilmore Lake, near Columbia, Ill			50
Sucker State Pond, near Carlisle, Ill			50
Flat Rock River, near Flat Rock, Ind			300
White River, near Indianapolis, Ind			211
Wall Lake, near Lake View, Iowa			247
Mineral Park Lake, near Dow City, Iowa			248
Upper Iowa River, near Decorah, Iowa			294
Private ponds in Kansas			175
Lake Evelyn, near Bonner Springs, Kans			900
Little Blue River, near Hanover, Kans			425
Elm Creek, near Sawyer, Kans			350
Private ponds in Kentucky			1,000
Sherman Lake, near Williamstown, Ky			15
Cumberland River, near Williamsburg, Ky			15
Reinecke Lake, near Madisonville, Ky			50
Spring Lake, near Versailles, Ky			14
Madisonville, Ky			50
Loch Mony Lake, near Madisonville, Ky			50
Licking River, near Covington, Ky			150
Drennen Creek, near Eminence, Ky			25
Elk Horn Creek, near Switzer, Ky			425
Lexington, Ky			50
Private applicants in Maryland			107
Big Pool, near Hagerstown, Md			34
Potomac River, near Woodmont Club House, Washington County, Md			2,035
Prospect Pond, near Taunton, Mass			200
Nine Mile Lake, near Centreville, Mass			500
Private pond in Michigan			55
Missouri			50
Lake Contrary, near St. Joseph, Mo			130
Miller Lake, near Moberly, Mo			50
Pertle Springs, near Warrensburg, Mo			100

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Black bass (*Micropterus salmoides and M. dolomieu*)—Cont'd:			
Salisbury Fish Pond, near Salisbury, Mo			50
City Reservoir, Moberly, Mo			50
McNutt Pond, near Indian Creek, Mo			1,000
Private pond in New York			48
Wildmere Lake, near Copake Iron Works, N. Y			150
Private ponds in New Mexico			67
Ohio			213
Muzzy Lake, near Ravenna, Ohio			100
Bass Lake, near Chardon, Ohio			350
Lake Mere, near Kenton, Ohio			502
Brady Lake, near Chardon, Ohio			50
Ohio Fish Commission			175
Private ponds in Pennsylvania			159
Nixon River, near Faulkton, S. Dak			225
James River, near Huron, S. Dak			225
Turtle Creek, near Redfield, S. Dak			225
Lake Kampeska, near Watertown, S. Dak			500
Private ponds in Texas			1,280
Texas and Pacific R. R. Company's pond, near Iatan, Texas			1,105
Hosmore Pond, near North Craftsbury, Vt			600
Loon Lake, near Spokane Falls, Wash			100
Liberty Lake, near Spokane Falls, Wash			25
Camp Lake, near Camp Lake, Wis			33
Silver Lake, near Silver Lake, Wis			33
Cedar Lake, near Schleisingerville, Wis			33
Browne Lake, near Burlington, Wis			66
Phantom Lake, near Mukwonago, Wis			66
Crooked Lake, near Mukwonago, Wis			66
Chain of Lakes, near Waupaca, Wis			70
Crappie (*Pomoxis annularis* and *P. sparoides*):			
Lake Cuyamaca, near San Diego, Cal			285
Private ponds in Connecticut			25
Private ponds in Illinois			230
Du Page River, near Burlington Park, Ill			50
Glenwood Lake, near Galesburg, Ill			50
Rock River, near Milan, Ill			75
Sni Ecarte Lake, near East Hannibal, Ill			500
Illinois River, near La Salle, Ill			300
Meredosia, Ill			(5,000)
Kankakee River, near Kankakee, Ill			75
Island Pond, near Waterloo, Ill			168
Gilmore Lake, near Columbia, Ill			166
Sucker State Pond, near Carlyle, Ill			166
Flat Rock River, near Flat Rock, Ind			150
White River, near Indianapolis, Ind			5
Wall Lake, near Lake View, Iowa			95
Mineral Park Lake, near Dow City, Iowa			95
Upper Iowa River, near Decorah, Iowa			50
Private ponds in Kansas			150
Little Blue River, near Hanover, Kans			370
Elm Creek, near Sawyer, Kans			50
Private ponds in Kentucky			355
Sherman Lake, near Williamstown, Ky			30
Cumberland River, near Williamsburg, Ky			30
Reinecke Lake, near Madisonville, Ky			25
Spring Lake, near Madisonville, Ky			25
Loch Mony Lake, near Madisonville, Ky			25
Licking River, near Covington, Ky			150
Drennen Creek, near Eminence, Ky			25
Elk Horn Creek, near Switzer, Ky			425
Lexington, Ky			50
Lake Contrary, near St. Joseph, Mo			150
Miller Lake, near Moberly, Mo			50
Pertle Springs, near Warrensburg, Mo			75
Salisbury Fish Pond, near Salisbury, Mo			75
City Reservoir, near Moberly, Mo			75
McNutt Pond, near Indian Creek, Mo			95
Hickory Creek, near Neosho, Mo			12
Susquehanna River, near Oneonta, N. Y			211
Private ponds in New Mexico			25
North Carolina			50
Ohio			75
Lake Mere, near Kenton, Ohio			50
Ohio Fish Commission			25
Nixon River, near Faulkton, S. Dak			63
James River, near Huron, S. Dak			64
Turtle Creek, near Redfield, S. Dak			63
Lake Kampeska, near Pierre, S. Dak			200
Private ponds in Texas			80
Loon Lake, near Spokane Falls, Wash			220

Details of distribution, 1891–92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Crappie (*Pomoxis annularis and P. sparoides*)—Continued:			
Liberty Lake, near Spokane Falls, Wash			50
Camp Lake, near Camp Lake, Wis			58
Silver Lake, near Silver Lake, Wis			58
Cedar Lake, near Schleisingerville, Wis			58
Browne Lake, near Burlington, Wis			58
Phantom Lake, near Mukwonago, Wis			58
Crooked Lake, near Mukwonago, Wis			58
Chain of Lakes, near Waupaca, Wis			60
Rock bass (*Ambloplites rupestris*):			
Private ponds in Alabama			500
Arkansas			50
Feather River, near Gridley, Cal			100
Lake Cuyamaca, near San Diego, Cal			400
Private ponds in Georgia			500
Illinois			400
Du Page River, near Burlington, Ill			240
Glenwood Lake, near Galesburg, Ill			50
Rock River, near Milan, Ill			75
Illinois River, near La Salle, Ill			650
Kankakee River, near Kankakee, Ill			25
Island Pond, near Waterloo, Ill			34
Gilmore Lake, near Columbia, Ill			33
Sucker State Pond, near Carlyle, Ill			33
Flat Rock River, near Flat Rock, Ind			200
White River, near Indianapolis, Ind			125
Wall Lake, near Lake View, Iowa			269
Mineral Park Lake, near Dow City, Iowa			270
Upper Iowa River, near Decorah, Iowa			50
Private ponds in Kansas			100
Kentucky			200
Clear Creek, near Shelbyville, Ky			480
Reinecke Lake, near Madisonville, Ky			65
Spring Lake, near Madisonville, Ky			65
Loch Mony Lake, near Madisonville, Ky			65
Private ponds in Maryland			690
Big Pool, near Hagerstown, Md			124
Scadings Pond, near Taunton, Mass			200
Miller Lake, near Moberly, Mo			150
Indian Creek, McDonald County, Mo			1,000
Hickory Creek, near Neosho, Mo			112
Private ponds in New Jersey			350
New Mexico			350
North Carolina			1,800
Ohio			650
Muzzy Lake, near Ravenna, Ohio			50
Bass Lake, near Chardon, Ohio			50
Brady Lake, near Chardon, Ohio			100
Private ponds in Pennsylvania			500
Connoduquinet Creek, near Mechanicsburg, Pa			1,500
Private ponds in South Carolina			500
Nixon River, near Faulkton, S. Dak			256
James River, near Huron, S. Dak			258
Turtle Creek, near Redfield, S. Dak			256
Private ponds in Tennessee			1,050
Texas			200
T. and P. R. R. Co.'s pond, near Iatan, Tex			1,000
Private ponds in Virginia			9,800
West Virginia			50
Camp Lake, near Camp Lake, Wis			33
Silver Lake, near Silver Lake, Wis			33
Cedar Lake, near Schleisingerville, Wis			33
Browne Lake, near Burlington, Wis			33
Phantom Lake, near Mukwonago, Wis			33
Crooked Lake, near Mukwonago, Wis			33
Chain of lakes, near Waupaca, Wis			35
Sunfish (*Lepomis*, sp.):			
Max von dem Borne, Berneuchen, Germany			338
Private ponds in Illinois			1,030
Du Page River, near Burlington Park, Illinois			314
Glenwood Lake, near Galesburg, Ill			25
Sni Ecarte Lake, near East Hannibal, Ill			675
Kankakee River, near Kankakee, Ill			200
Island Pond, near Waterloo, Ill			118
Gilmore Lake, near Columbia, Ill			116
Sucker State Pond, near Carlyle, Ill			116
Flat Rock River, near Flat Rock, Ind			470
Wall Lake, near Lake View, Iowa			50
Mineral Park Lake, near Dow City, Iowa			50
Upper Iowa River, near Decorah, Iowa			567
Private ponds in Kansas			200

Details of distribution, 1891-92—Continued.

Species and disposition.	Eggs.	Fry.	Adults and yearlings.
Sunfish (*Lepomis*, sp.)—Continued:			
Lake Evelyn, near Bonner Springs, Kans			300
Little Blue River, near Hanover, Kans			90
Elm Creek, near Sawyer, Kans			500
Private ponds in Kentucky			925
Sherman Lake, near Williamstown, Ky			35
Cumberland River, near Williamsburg, Ky			225
Spring Lake, near Versailles, Ky			16
Drennen Creek, near Eminence, Ky			25
Elk Horn Creek, near Switzer, Ky			150
Lexington, Ky			25
Big Pool, near Hagerstown, Md			86
Deer Creek, near Bel Air, Md			82
Private ponds in Missouri			50
Lake Contrary, near St. Joseph, Mo			250
Miller Lake, near Moberly, Mo			25
Pertle Springs, near Warrensburg, Mo			75
Salisbury Fish Pond, near Salisbury, Mo			65
City reservoir, near Moberly, Mo			500
Private ponds in Ohio			223
Muzzy Lake, near Ravenna, Ohio			150
Lake Mere, near Kenton, Ohio			75
Brady Lake, near Chardon, Ohio			150
Ohio Fish Commission			376
Private ponds in North Carolina			152
Loon Lake, near Spokane Falls, Wash			350
Liberty Lake, near Spokane Falls, Wash			150
Camp Lake, near Camp Lake, Wis			47
Silver Lake, near Silver Lake, Wis			47
Cedar Lake, near Schleisingerville, Wis			47
Phantom Lake, near Mukwonago, Wis			47
Crooked Lake, near Mukwonago, Wis			47
Chain of lakes, near Waupaca, Wis			50
Pike (*Lucius lucius*):			
Feather River, near Gridley, Cal			100
Lake Cuyamaca, near San Diego, Cal			400
Private ponds in Illinois			148
Du Page River, near Burlington Park, Ill			725
Glenwood Lake, near Galesburg, Ill			25
Flat Rock River, near Flat Rock, Ind			200
Wall Lake, near Lake View, Iowa			95
Mineral Park Lake, near Dow City, Iowa			95
Elm Creek, near Sawyer, Kans			70
Miller Lake, near Moberly, Mo			25
Private ponds in Ohio			8
Brady Lake, near Chardon, Ohio			75
Scup (*Stenotomus chrysops*):			
Buzzards Bay, off Massachusetts coast		35,000	
Cod (*Gadus morrhua*):			
Buzzards Bay, off Massachusetts coast		25,671,000	
Massachusetts Bay, off Massachusetts coast		27,124,500	
Pollock (*Pollachius virens*):			
Massachusetts Bay, off Massachusetts coast		2,473,500	
Flatfish (*Pseudopleuronectes americanus*):			
Buzzards Bay, off Massachusetts coast	2,764,000	3,510,000	
Lobster (*Homarus americanus*):			
Buzzards Bay, off Massachusetts coast		5,799,000	
Totals	75,887,000	228,008,070	2,023,276

Figures inclosed in parenthesis are not included in summations.

REPORT UPON THE INQUIRY RESPECTING FOOD-FISHES AND THE FISHING-GROUNDS.

By Richard Rathbun, *Assistant in charge.*

NORTH PACIFIC OCEAN AND BERING SEA.

The principal investigations conducted under this division during the past year have related to the fur seal in the North Pacific Ocean and Bering Sea, the oyster-grounds and other fishery matters along the Atlantic seacoast, and the requirements for fish-culture in the Rocky Mountain region and the Gulf States.

The steamer *Albatross* has been much more actively employed than during any previous year, if the amount of work accomplished be measured by the time spent at sea and the total distance sailed, but only a very short period was given specially to that class of fishery inquiries with which this ship has hitherto been chiefly occupied. Early in the fall a brief reconnaissance was made of the Strait of Juan de Fuca, which served to make known its principal resources, and to point out the difficulties which must be encountered in prosecuting extensive fisheries in that deep arm of the sea. During the balance of the year, however, fishing and dredging trials were only incidental features of the work. From September 18, 1891, until March 12, 1892, the *Albatross* was engaged, under the direction of the Secretary of the Navy, in running two lines of deep-sea soundings between the coast of California and the Hawaiian Islands, with the object of determining if a practicable route exists across that part of the Pacific Ocean for the laying of a telegraphic cable, a task which was successfully accomplished, notwithstanding the unfavorable season chosen for that purpose and the inclement weather met with during most of the cruise.

Aside from this purely hydrographic survey and the short stay made in the Strait of Juan de Fuca, the operations of the *Albatross* have related exclusively to the fur-seal inquiries in connection with the preparation of the Bering Sea case for the proposed tribunal of arbitration at Paris. During the summer of 1891, this ship acted simply as a transport for the Bering Sea commissioners, Dr. Mendenhall and Dr. Merriam, conveying them to and from the Pribilof Islands, but on March 15, 1892, she entered directly into the investigations which were then begun to settle some of the main points in controversy respecting the habits of the fur seals and the effects of pelagic sealing.

The habits of these animals during the period of their residence on the Pribilof Islands have been studied with considerable care, and upon the knowledge thus obtained has been based a judicious system of regulations, not entirely perfect, perhaps, but which, if properly carried out, could not fail to insure the perpetuation of the herd. Whatever abuses may have been practiced on those islands, they could have produced little or no effect upon the main or breeding parts of the rookeries, as the supply of skins was drawn entirely from the so-called hauling-grounds, which are occupied solely by the bachelors or non-breeding males. The marked decrease on the breeding-grounds, beginning only a few years ago, was evidently due to some influence from without, and its cause was not difficult to discover. An interference of this character with the seal fishery had never been anticipated by the Government of the United States, and no steps had been taken, therefore, to investigate the conditions associated with the movements of this highly prized species during its long wanderings in the open sea. Whether the possession of such information would have helped to avert the injury which is now being done or not, it would at least have greatly strengthened this Government in its efforts to obtain a just recognition of its claims, and it is therefore greatly to be deplored that the work was left until its urgency was demonstrated by force of circumstances.

In view of the material interests involved, a somewhat heated controversy could not be avoided between the two countries whose subjects claimed protection in what they regarded, on each side, as their respective rights. On the one side there was a long-established industry, whose continuity need not be broken except by unwise administration, while on the other there was a young and enterprising fishery, gaining strength every season, and bound eventually not only to sap its own resources, but to destroy the rookeries as well. This was practically the status of the fur-seal question when arbitration was suggested and agreed upon, a *modus vivendi* prohibiting pelagic sealing in Bering Sea being arranged for at the same time. It was now too late to begin a systematic and thorough study of the entire subject, which, under suitable conditions, would have been productive of much more satisfactory and convincing results, and provision was made for investigating only the more salient features of the problem, on which there was a wide diversity of opinion between the British and American representatives.

Three vessels were assigned to this duty, the Fish Commission steamer *Albatross* and the revenue steamers *Corwin* and *Bear*. The cruising-ground of the *Albatross*, up to the close of the fiscal year, was mainly off the southern side of the Alaska Peninsula and along the Aleutian chain, from Prince William Sound, in the east, to Attu Island and to the Commander Islands, off the Siberian coast. The representations made on the part of Great Britain that the eastern body of fur seals has other hauling-grounds than the Pribilof Islands were disproved, and the entire weight of the evidence obtained tends to show that the American and Asiatic herds do not mingle, each being quite independent of the other.

Another important discovery was made by Mr. Charles H. Townsend, the naturalist of the steamer *Albatross*, who was sent to Guadeloupe Island, off the coast of Lower California, where the Alaskan fur seal was said to haul out regularly during the period of its southern distribution in the winter. Specimens obtained there and brought to Washington proved to belong not only to a different species than the northern form, but to represent as well a totally distinct genus. The investigations of the *Albatross* were still in progress at the end of the year.

Further assistance was rendered to the agent of the United States in preparing the Bering Sea case by the assistant in charge of this division, who was called upon to present a review of the principal ocean fisheries of the world, together with a compilation of all foreign laws for the protection of marine products and the regulation of the industries pertaining thereto. This work, which required several months for its completion, served to bring out many interesting features of legislation, some of the most conspicuous in respect to the disregard of the traditional 3-mile zone being afforded by the British colonies in the southern hemisphere. As an illustration may be noted the regulations of New Zealand, which, by provisions as stringent as those of the *modus vivendi* now in force in Bering Sea, seek to protect the fur seals, once so abundant in that region, over an area measuring 20° in latitude by 25° in longitude, the greatest width of water in that area, measured from the coast of the middle island of New Zealand, being 700 miles. On the western side of the island of Ceylon, moreover, along a strip of water frontage exceeding 20 miles in width, any vessel "anchoring or hovering and not proceeding to her proper destination" during certain months is subject to seizure and confiscation as a menace to the pearl fishing banks. These laws and many others of equal novelty which might be quoted are probably entirely justifiable, but if the right to enforce them is recognized in respect to one country, the exercise of such right may be justly claimed in all analogous cases.

The steamer *Fish Hawk* has spent a large part of the year in delineating the oyster-grounds in different parts of Chesapeake Bay, and in determining their condition by careful and detailed investigations. The work accomplished has proved of great practical value in bringing forcibly to the attention of the governments of Maryland and Virginia the necessity of affording greater protection to their oyster territory, and the advantages offered by those waters for greatly increasing the production of this mollusk. Virginia has already taken steps to profit by this information and will seek to encourage private oyster-culture as a means of utilizing large tracts of bottom which are well adapted to oyster growth, but yield no returns at the present time. In some countries of Europe, and notably in France, the cultivation of the oyster has been brought to a high state of perfection. While it is not expected that the methods there employed can be advantageously introduced into this country, it was thought that a study of the subject could not fail to furnish many valuable suggestions which would be appreciated by American oyster-growers. Arrangements were accordingly made with Dr. Bashford Dean, of Columbia College, New York, who went to Europe in the summer of 1891 on private business, to undertake this work, which he has already completed with respect to France, Spain, and Portugal, and his report upon the methods practiced in the first-mentioned country has been received and published.

The physical inquiries respecting the waters off the southern New England coast, begun in 1889 by the schooner *Grampus* and conducted the next year by the same vessel in conjunction with the Coast Survey steamer *Blake*, were continued during the summer of 1891 by the *Grampus* alone. The work was carried on, as in previous years, under the direction of Prof. William Libbey, jr., of Princeton College. Just before the close of the fiscal year the schooner *Grampus* was detailed to commence upon a systematic investigation relative to the bottom fishes in the lower part of Chesapeake Bay and the adjacent waters of the ocean, which it was proposed to continue during a large part of the summer.

Although the attendance at the Woods Holl laboratory during the summer of 1891 was not as large as usual, much effective work was accomplished, and very important results were also obtained through the efforts of Mr. V. N. Edwards, who has been the resident collector at that place since 1871. The most noteworthy of his observations have been those respecting the breeding habits of the menhaden, which, it seems now to be quite definitely decided, spawns in the coastal waters instead of at sea, as was originally supposed.

The practical utility of the inland or fresh-water investigations, first systematically taken up in 1888, was well demonstrated during the past year, when this division was called upon to determine, under a special act of Congress, the advisability of establishing hatching-stations in the Rocky Mountain region of Montana and Wyoming and in the Gulf States. Although only a small amount of money was available for this purpose, yet entirely satisfactory results were accomplished, owing in large part to information acquired through previous inquiries conducted partly in the same region and partly in other waters having corresponding features. It is expected that in the course of not many years these researches will have covered the different parts of the United States so completely as to furnish the groundwork for a more thoroughly comprehensive system of fish-culture than it has been possible to establish hitherto. The conduct of the inland work has been mainly under the immediate direction of Prof. B. W. Evermann, the principal assistant in this division. His inquiries in Montana were supplemented by Prof. S. A. Forbes, director of the Illinois State Laboratory of Natural History. Investigations on a smaller scale were also carried on in the States of Kentucky, Tennessee, North Carolina, Indiana, Ohio, and New York.

The studies and experiments relative to the propagation of the Spanish mackerel in Chesapeake Bay begun in June, 1891, were completed later in the same summer, and although the number of eggs obtained and hatched was relatively small, sufficient information was secured to indicate the proper methods to pursue in case it should be deemed advisable to increase the abundance of this important food-fish by artificial means. The great falling off in the supply of this species which has taken place during recent years would seem to justify such action.

A case of river pollution brought to the attention of the Fish Commission has been thoroughly investigated, and although the results obtained were not entirely conclusive, advantage was taken of the opportunity to conduct a very interesting series of observations. The source of pollution is a wood-pulp paper mill situated on the banks of the Susquehanna River, the waste liquor from which finds its way directly into the stream. The harmful influence of the sulphurous acid thus discharged was practically demonstrated upon fishes held in confinement, but it yet remains to be decided whether the volume of water in the river at the site of the mill is sufficient to overcome the pernicious effects of the acid or not. In smaller streams there could be no question as to the harm produced from such a cause.

Studies upon the diseases of fishes, a subject which has been very generally neglected, notwithstanding its important relation to the welfare of fishes in general and to successful fish-culture in particular, have been carried on at intervals during the year by Dr. R. R. Gurley, who has been mainly occupied in bringing together the literature on the subject and in preparing a monograph on one of the most extensive groups of injurious parasites, the Myxosporidia. Several special cases of disease have also been made the subject of inquiry.

CRUISE WITH THE BERING SEA COMMISSIONERS.

At the beginning of the fiscal year the steamer *Albatross* was at San Francisco, Cal., prepared to start upon a trip of investigation to the Alaskan coast, where it was proposed to continue the survey of the fishing-banks in Bering Sea, begun the previous summer.

During the season of 1890 the work had been confined mainly to the extreme southeastern part of that sea, including Bristol Bay as far up as the mouth of the Nushagak River, but exceedingly important results had been obtained in the development of Baird and Slime banks, the former of very large size and both comparatively little known as regards either their hydrography or fishery resources. The narrow stretch of shallow water along the northern side of Unalaska Island was also explored at the same time, and several lines of deep-sea soundings served to define the approximate outer limits of the continental platform as far north as latitude 58° 43′ N., or about 168 miles northwesterly from St. Paul Island, of the Pribilof group.

It had been intended the present year to extend the surveys in a westerly and northerly direction as far as circumstances would permit, and judging from the success obtained in 1890 it was expected that additional fishing-grounds of great value would be discovered and marked out. Other and more urgent requirements of the public service, which arose at this time, however, made it necessary to abandon these plans, and to dispatch the *Albatross* on a special mission.

In connection with the controversy respecting pelagic sealing in the North Pacific Ocean and Bering Sea, between Great Britain and the United States, commissioners had been appointed by both Governments to investigate the conditions of seal life in those regions, and, no other suitable vessel being available, the *Albatross* was, by direction of the President, placed at the service of the two representatives on the part of the United States, Prof. T. C. Mendenhall and Dr. C. Hart Merriam. Instructions announcing this change of detail were telegraphed to the commander of the *Albatross* on July 9, and on the 16th of that month, both commissioners having arrived on board, the ship set sail directly for Unalaska, where she arrived on the 25th. The steamer *Danube*, conveying the British commissioners, Sir George Baden-Powell and Dr. George M. Dawson, reached Unalaska on the same day.

After coaling, the *Albatross* proceeded to St. George Island, the more southern of the two Seal Islands, remaining there a part of one day, and thence going to St. Paul Island on the afternoon of July 28. On the following day the commissioners took up their residence on shore, owing to the difficulty and, at times, uncertainty of making a landing from the ship. There are no protected harbors on either of the Pribilof Islands, and anchorages have to be changed with the shifting of the winds whenever the latter are strong, but, according to Lieut. Commander Tanner, an able steamer may lay safely at anchor long after communication with the shore has become impracticable. The officers of the *Albatross* did not participate directly in the seal investigation, but rendered such assistance as was requested of them by the Bering Sea commissioners. Visits were paid, however, to some of the rookeries and killing-grounds, and many incidental observations were recorded. On July 29 the ship was called upon by the Treasury agent at the islands to aid in capturing a schooner which had been detected in killing seals with rifles off Northeast Point rookery, but the poacher had been seized by the revenue-cutter *Corwin* before the *Albatross* arrived upon the spot.

On August 3 a fishing and dredging trip was made off the southern and western sides of St. Paul Island, the beam trawl being used at five stations, in depths of 20 to 51 fathoms. The bottom was found to consist of fine gray or black sand and shells, with scattered pebbles and traces of black mud in some places. A great variety of invertebrate life was obtained, but not many specimens of any group, except starfishes and sea-cucumbers, which were very abundant. Only a small number of fishes were taken in the beam trawl, among them being young cod, pollock, and flounders, and nothing was secured by means of hand lines, although they were tried in several places. Later in the same day a series of hydrographic soundings was made off the western extremity of St. Paul Island. According to Lieut. Commander Tanner:

The natives report that cod and halibut frequent the waters about the Pribilof Islands during the winter and early spring, but the former disappear soon after the seals arrive and only a few of the latter remain during the summer. Neither of these species is ever taken in large numbers. It is a well-known fact that feeding seals go farther from the islands in search of food as the season advances, until in the latter part of July they reach the vicinity of the 100-fathom line south and west of the Pribilofs, from 50 to 100 miles and more from their rookeries.

A number of sea-lion skins, prepared for use as museum specimens, were procured on August 4, and two days later a fishing party, sent out in small boats, covered considerable ground, but returned with only three halibut and five small cod. The *Albatross* left the Pribilof Islands on August 10, bound south, and the following morning anchored off Bogoslof Volcano, on which the Bering Sea commissioners and several officers of the ship were landed for the purpose of making observations. The following interesting notes based upon this visit are from the report of Lieut. Commander Tanner:

We noted many changes since our visit the previous year. New Bogoslof was still active, smoke and steam escaping through numberless crevices throughout the whole mass from the water's edge to the summit. It was at least 100 feet lower, and was otherwise changed in outline; what had been the rocky pinnacle was now lying in huge masses strewn down the steep incline, even to the surface of the sea.

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The old and new volcanoes are about a mile apart and were, a year ago, connected by a narrow isthmus but little above the level of the sea, composed of fine volcanic cinders. Now, however, there is an open passage through it several hundred feet in width near the new cone, the remainder of the spit extending from Old Bogoslof having been removed bodily to the westward with a broad sweep. A bar or middle ground was found a few hundred yards to the eastward of a line drawn between the cones. * * * The beaches, the banks above mentioned, and the isthmus formerly connecting the two cones are composed of fine cinders, ashes, etc., lighter than sand or gravel, and are, in consequence, washed back and forth with every heavy gale. * * * A sea-lion rookery referred to in former reports, near the base of Old Bogoslof, was occupied as usual. This colony is notable for the unusual size of some of the old bulls. They seemed quite tame, permitting several of the shore party to approach close to them before showing signs of fear; their location being remote from the usual routes in Bering Sea, they are seldom disturbed.

Unalaska was reached in the evening of August 11, and on the 13th the ship passed out into the North Pacific Ocean, through Unalga Pass, bound for the northern end of Vancouver Island. Thence the inland passage was taken to Tacoma, Wash., stops being made at Alert Bay, Departure Bay, and Port Townsend. At Alert Bay the salmon cannery and Indian village were visited, and a collection of the native hunting and fishing implements was made for the World's Columbian Exposition. The commissioners left the ship at Tacoma on August 22.

STRAIT OF JUAN DE FUCA.

As the season was too far advanced when the *Albatross* reached Tacoma from the special trip to Bering Sea to justify her returning north for the purpose of continuing the fishery investigations in the Alaskan region, instructions were issued to make a thorough study of the fishing-grounds in the Straits of Juan de Fuca and Puget Sound, where practically no work of this character had hitherto been undertaken. Scarcely more than a week elapsed, however, after starting upon this inquiry before it was interrupted, and very little was accomplished, therefore, beyond running a few lines of dredgings and fishing trials through a part of the Straits of Juan de Fuca.

The investigations were taken up on August 27 and terminated on September 4, having been carried through the strait from the longitude of New Dungeness to the vicinity of Cape Flattery. A large amount of life was obtained through the agency of the beam trawl, and a change in the character of the bottom fauna was observed as the mouth of the strait was approached, deep-sea types forming a more conspicuous feature of each haul. The surface, however, was found to be almost barren of life at this season, a few small crustaceans being about the only forms taken in the tow nets during the day, although large numbers of jelly-fishes came to the surface after dark. On August 28, between Neah Bay and Cape Flattery, a single specimen of the true cod (*Gadus morrhua*) was secured in the beam trawl, the first example of this species taken by the *Albatross* south of the Alaskan coast. The fishing trials were of great interest, but unfortunately they were not continued long enough to permit of entirely satisfactory conclusions respecting the extent of the fishery resources of this sheet of water. The work accomplished may be briefly summarized as follows:

On the first day the beam trawl was used from off New Dungeness to the neighborhood of Race Rocks in depths of 80 to 100 fathoms, and on August 28 six dredging stations were occupied in depths of 98 to 151 fathoms between Neah Bay and Cape Flattery. Two cod and two halibut trawl lines were also set on the latter date off Neah Bay in 80 to 100 fathoms of water, hand lines being employed at the same time. The currents proved too strong, however, for the successful use of either, and in the course of a few minutes the trawl buoys disappeared beneath the surface; they were not seen again. The weather was fine all day and the sea smooth, but during the dredging trials strong and erratic currents swept the ship about in the most extraordinary manner. Notwithstanding this fact, however, many flounders of excellent quality, together with other edible fishes and an abundance of shrimps and crabs, were taken in the beam trawl.

Greater precautions were taken with the fishing trials on August 29, and better success was obtained. One trawl line was first set in 140 fathoms, gravelly bottom, off Neah Bay, both ends being provided with heavy grapnels and double buoys, and one end being also secured to a boat. The buoys were carried under by the current as on the previous day, but 100 hooks from the end attached to the boat were recovered, bringing with them three black-cod, the largest weighing 28 pounds. On a second trial in the same locality, both ends of the trawl line being secured to boats, the entire gear was recovered, the catch this time amounting to 14 black cod, averaging 12½ pounds each in weight. Two dredging stations were made the same day in depths of 120 and 125 fathoms. The ship was then obliged to proceed to Victoria, British Columbia, in order to replenish the stock of fishing gear, but returned again to Neah Bay on the 31st.

The following day four sets with the trawl lines and four hauls of the beam trawl were made between Neah Bay and the Vancouver shore on the opposite side of the strait in depths of 136 to 152 fathoms. A cultus-cod weighing 29 pounds was captured in the beam trawl, the catch with the trawl lines comprising a few black cod, red rockfish, and dogfish, but in some places the currents were so strong that nearly all the hooks were stripped of their bait. Only a few dogfish were taken on the trawl lines during September 2 between Neah Bay and Pillar Point, but the beam trawl used in four positions, in 53 to 123 fathoms, secured an abundance of edible flounders and a dozen young cod. On the 3d three sets with trawl lines were made between Pillar Point and Port Angeles in 64 to 95 fathoms, taking only a few dogfish, and one dredging station was occupied in 92 fathoms. Flounders, herring, perch, butter-fish, sculpins, a salmon trout, and other species were secured by seining on the beach at the latter place.

The following day, the last one of the trip, was utilized in running a line of dredging and hand-line fishing stations diagonally across the strait from off Port Angeles to the vicinity of Victoria, the depths ranging from 40 to 46 fathoms. Nothing at all was taken with the hand lines, the currents being so strong that it was quite impossible to keep the hooks on or near the bottom, except close to land. Lieut. Commander Tanner concludes his account of this investigation as follows:

> We have demonstrated the existence of several species of sea fishes in the open waters of the Straits of Fuca, and have also shown the impracticability of taking them in paying quantities by the usual methods. Should the black-cod ever take the place it deserves in the market, means will doubtless be devised for its capture, even in the straits. In the vicinity of Cape Flattery the currents reach the bottom with strong scouring effect, and the state of tides on the surface is no indication of their condition at the bottom. A heavy, confused swell will also be encountered, even in the calmest weather. Of course, this soon becomes modified after passing up the straits.

SURVEY FOR A CABLE ROUTE BETWEEN CALIFORNIA AND THE HAWAIIAN ISLANDS.

By an act of Congress approved March 2, 1891, special provision was made "To enable the President to cause careful soundings to be made between San Francisco, Cal., and Honolulu, in the Kingdom of the Hawaiian Islands, for the purpose of determining the practicability of the laying of a telegraphic cable between those points." This survey was placed under the direction of the Secretary of the Navy, but a suitable naval vessel not being available for the work, the services of the *Albatross* were requested, and by instruction of the President she was accordingly detailed for that purpose. While it was regarded as unfortunate that this steamer should so soon again be diverted from her legitimate fishery inquiries, there was cause for congratulation in the fact that so favorable an opportunity was thus presented to demonstrate once more her eminent fitness for this class of hydrographic investigations, similar surveys having previously been executed for the Navy Department by the same ship in the Caribbean Sea and about the Bahama Islands. In the field of work for which the *Albatross* was specially constructed, means for taking accurate soundings in all depths of water constitute one of the principal requirements in locating and defining the fishing-grounds, and to this end the most approved appliances have always been provided. In fact, no other vessel afloat is so perfectly equipped in respect to all inquiries relative to the physical and the natural-history features of the sea, and none has been more effectively employed, thanks to the untiring energy of her accomplished commanding officer.

Upon arriving at San Francisco from the Strait of Juan de Fuca the only material alteration required in preparation for the cruise was in the direction of increasing the coal capacity, which was readily accomplished by changing the laboratory storeroom into a temporary bunker. The ship was placed at the disposal of the Secretary of the Navy on September 18, but owing to delays, mainly caused by the necessity for awaiting supplies, the work was not actually taken up until October 9, 1891. Two lines of soundings were run, one toward the Hawaiian Islands, the other on the return trip, which was completed January 15 following. The results of the survey have been published in the form of a report to Congress by the Secretary of the Navy,* in which, doubtless through inadvertence, no credit is given to the Fish Commission for its participation in the work. A more detailed account of the cruise will be found in the report of Lieut. Commander Tanner, printed in the appendix to this volume.

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*Report of the results of the survey for the purpose of determining the practicability of laying a telegraphic cable between the United States and the Hawaiian Islands, Fifty-second Congress, first session, Senate Ex. Doc. No. 153, 1892. 28 pp., and several charts, diagrams, and photographic reproductions.

A number of years previously the U. S. S. *Tuscarora* had run a line of soundings between San Francisco and the Hawaiian Islands, and it was proposed that the new line be made to the northward of the course taken by that ship, with stops for soundings at intervals of 10 and 2 miles. The plan finally adopted and carried out was suggested by Lieut. Commander Tanner, namely, to begin the line off Salinas Landing, in Monterey Bay, carry it thence through the deep gully which approaches the land very closely at that place, and having reached the open sea, to proceed practically along the arc of a great circle to the eastern end of Oahu Island, passing about 40 miles to the northward of the *Tuscarora's* submarine mountain, an elevation of about 1,400 feet above the surrounding ocean bed. The survey at the eastern shore end was first completed, and subsequently, with a full supply of coal, the main part of the line was run between the dates of November 7 and 21. From 10 to 12 soundings were generally made each day, the depths, outside of the continental platform at each end, ranging from 2,000 to over 3,000 fathoms, except in a few instances. The ship remained about the Oahu Island until December 11, surveying a route for the shore end of the cable, making some needed repairs, and conducting natural-history investigations by means of the beam trawl and tangles. The naturalists also took advantage of the opportunity to secure a large and fine collection of the shore fishes.

Realizing the importance of obtaining still further information respecting the contour of the ocean bottom between the two countries, and having no instructions to the contrary, Lieut. Commander Tanner, on leaving the Hawaiian Islands, carried a second line of soundings eastward along a rhumb line which intercepted the great-circle line about 35 miles off Salinas Landing. On neither of these lines did the ship encounter the submarine elevation discovered by the *Tuscarora*.

Stormy weather was met with during both trips, and it was especially severe during the second one. The completion of the survey was greatly delayed in consequence, and the ship was subjected to unusual strain and wear, but escaped any severe damage. After reaching San Francisco orders were issued to make preparations for a third sounding trip, this time between Point Conception and Hilo, on the island of Hawaii, and the necessary repairs were at once begun, but by the time they had been completed the ship was required for other service. The U. S. S. *Thetis* was therefore substituted in her place, and the *Albatross* was returned to the Fish Commission on March 12, 1892.

During the cable survey, in addition to the ordinary sounding work, the samples of the bottom brought up in the cup were examined microscopically; the temperature of the water at the surface and bottom was constantly observed, series of intermediate temperatures were taken occasionally, and the density of the surface water was frequently determined. The rhumb line run by the *Albatross* has been considered to have developed the most favorable conditions for a cable route.

FUR-SEAL INVESTIGATIONS.

On March 15 the *Albatross* was detailed to assist in securing information required in preparing the case of the United States respecting the fur-seal fishery of the North Pacific Ocean and Bering Sea, to be submitted to the Paris Tribunal of Arbitration, for which arrangements were then in progress. This work continued until the end of the fiscal year and was under the nominal direction of the Secretary of the Treasury, although the instructions relative to the investigations emanated from the State Department and the Fish Commission. The ship left San Francisco on March 20, proceeding first to Port Townsend, where she was joined by Prof. B. W. Evermann, as chief naturalist, and Mr. Joseph Murray, special Treasury agent. The services of an interpreter for the Alaskan dialects and of two seal-hunters were also secured. Mr. C. H. Townsend, naturalist of the *Albatross*, and Mr. A. B. Alexander, fishery expert, were attached during a part of the season to the revenue steamers *Corwin* and *Bear*, both of which vessels had been dispatched upon similar missions.

The principal objects sought to be attained through the agency of the *Albatross* were to ascertain if the fur seal has other hauling-grounds than the Pribilof Islands on the Alaskan coast; to determine what, if any, relations exist between the American and Asiatic herds, and to learn as much as possible regarding the habits and movements of these animals during their migrations northward. The necessity of moving rapidly from place to place, however, prevented satisfactory observations relative to the pelagic habits of the seals, but in other respects the duties assigned to the ship were successfully accomplished.

Starting from Port Townsend on March 31, a course was set to carry the ship over the usual sealing-grounds at this season off Vancouver Island, but owing to stormy weather only occasional seals were seen, either singly or in groups of two and three. Cook Inlet, Kadiak, and Prince William Sound were visited in the order named, and the experienced native hunters and few white inhabitants were interrogated at each place. In regard to Cook Inlet, Lieut. Commander Tanner makes the following statement, which applies also to the other places mentioned:

> The question as to whether fur seals were ever known to haul out in or near Cook Inlet was among the many interesting subjects presented for solution. Inquiries were made among men who have passed their lives in hunting over the region under discussion, and the fact that none of them ever saw a seal hauled out would seem to settle the question conclusively. The fur seals pass along the shores, and sometimes enter Cook Inlet in small numbers when they are on their way to Bering Sea; they sometimes loiter about a few days, and then an occasional one is killed, providing there are no sea otter about; but should the presence of the latter be suspected, the seals will remain undisturbed by the otter hunters.

The past winter had been the most severe one known for many years, causing much suffering, and this was subsequently found to be the case at all places in Alaska visited by the *Albatross*. During one day hand-line fishing was tried on a bank several miles off Soldovoi, at the mouth of Cook Inlet, where, according to tradition, cod and halibut are exceedingly abundant. The bottom indications proved favorable for those species, but no fish were taken, and if they resort to this locality it is probably at some other time of the year. The region is worthy of further examination, especially in view of the proximity of good harbors, native settlements, and supplies of wood, coal, and fresh water.

About Port Etches, Prince William Sound, cod and herring were found to be abundant, the former species being taken by the natives. Specimens were caught from the deck of the *Albatross* by means of hand lines, and, although rather small in size, they were of good quality. Herring were also captured in considerable numbers by seining along the shores. The pursuit of the sea otter has been the principal occupation of the natives at this place, as in Cook Inlet and along most of the coast and islands further westward.

Before starting on the return trip to Port Townsend, a short time was spent in investigating the positions of several dangers to navigation which have been reported to exist in this region. Hydrographic office chart No. 527 shows a rock in latitude 59° 31′ N., longitude 144° 43′ W., where, however, the *Albatross* failed to discover it. In 1888 the *Albatross* also disproved the occurrence of Pamplona Rocks in one of the positions assigned to them, namely, latitude 59° 03′ N., longitude 142° 40′ W., and it now proceeded to run a careful series of soundings with respect to the other position given, in latitude 59° 35′ N., longitude 143° 04′ W. In this locality, however, the least depth observed was 114 fathoms, the greatest being 504 fathoms. The results of the survey are thus described by Lieut. Commander Tanner:

> The various courses during the day practically paralleled those of 1888, when the *Albatross* made her first search for the rocks, and, both days being clear during the time of search, the masthead lookout would have noted anything above water at least 10 miles on either hand; hence we may conclude that these vigias do not exist within the belt 40 miles in width and 100 in length, over which our reconnoissance extends.

A brief stop only was made at Port Townsend, the ship proceeding thence, on May 10, directly to Unalaska, which was reached on the 18th. On the 22d of the same month the *Albatross* left the latter place for a cruise to the westward among the Aleutian Islands and as far as the Commander Islands off the Siberian coast, during which much important information was gathered regarding the fur seals and the fishes along that route. The settlement at Nazan Bay was reached while the hunters, who follow the sea otter among the Andreanof and Kryci (Rat) islands, were still at home. The Atka mackerel (*Pleurogrammus monopterygius*), an excellent food-fish, is here taken to a limited extent and constitutes an important item in the native food supply. It appears on the shores of the Aleutian Islands, from Atka westward, in the spring, in large schools, which hover closely about the kelp beds, especially favoring the passes or exposed points where strong currents prevail. This habit would preclude the use of purse seines for their capture, but they can readily be taken by other methods. With respect to seals, Lieut. Commander Tanner states:

The agent and several of the older and most intelligent hunters testified regarding the movements of fur seals, and were unanimous in the opinion that the herds do not use the passes between Amukta and Great Kiska islands in their migrations to and from Bering Sea. Only scattering seals have been seen by them in the Andreanof and Kryci islands, and they were mostly gray pups, which appear from September to November, usually after northerly gales; they are never seen during the winter. They are captured whenever opportunity offers, and the flesh used for food, it being considered a great delicacy; the skins are either used for domestic purposes or sold to the company. A dozen seals a year would probably be a fair average for the Atka hunters.

Attu Island was next visited. The occupation of the natives is the same here as at Nazan, the hunting-grounds embracing their own island, Agattu, and the Semichi group. This was formerly a rich station, but the sea otters have been steadily decreasing in abundance, and are now scarce. Halibut are taken in small quantities in the spring, while cod are present at all seasons. The Atka mackerel is abundant from April to September and forms an important article of food. The condition of the people at this place, especially the women and children, was so deplorable from the lack of proper food, owing to the severe winter, that sufficient rations were issued to them from the *Albatross* to relieve their wants until the arrival of the supply vessel. The native hunters, according to Lieut. Commander Tanner, were practically unanimous on the following points:

Fur seals are seldom seen about Attu, Agattu, and the Semichi Islands, and they have never been known to haul out except when wounded; two or three instances are remembered of wounded seals having been shot while hauled out to rest. Twenty-five or thirty years ago the older hunters recollected seeing them in small squads about the kelp beds, during the month of June, feeding on Atka mackerel. They never saw any seals east of the Semichis, nor had they ever seen any about during the winter season.

It will be remembered that the Atka hunters did not believe that the Pribilof herd used the passes west of Amukta Island; the Attu men never saw fur seals east of the Semichi group, and the *Albatross* experience in traversing the whole length of the Aleutian Archipelago from Unalaska to Attu without seeing even a single individual seems to confirm the native belief that the Commander Islands herd do not enter or leave the sea east of Attu and the Pribilof herd do not enter or leave west of the Four Mountain Pass.

A line of soundings was run May 29 and 30 across the wide entrance into Bering Sea from Attu Island, the westernmost of the Aleutian chain, to Copper Island, of the Commander group. Only deep water was found in this space, the maximum depth discovered being 1,996 fathoms, about 30 miles off Copper Island. The Commander Islands are located at the eastern edge of the continental platform off the Kamchatkan coast, and apparently have no direct connection with the Aleutian chain.

On May 31 the *Albatross* reached Nikolski, on Bering Island, the residence of the governor, Col. N. A. Grebnitzky, who had been advised by his government of the mission of the ship, and who did everything in his power to render it successful. The experienced native hunters on these islands are convinced that the seals which resort to the Pribilof and Commander islands do not mingle, and that those on the western side spend the winter along the Kurile Islands of Japan. The authorities also stated that the fur seals were fast decreasing on the rookeries of the Commander Islands, which fact they attribute to the indiscriminate slaughter of all ages and sexes by the pelagic sealers. Specimens were obtained from one of the rookeries on Bering Island for comparison with others from the eastern herds. The naturalists secured from one of the natives a very nearly perfect skeleton of the extinct Arctic sea cow (*Rhytina stelleri*), which is now in possession of the U. S. National Museum in Washington. A partial survey of Nikolski Bay was likewise made by the *Albatross*. The ship proceeded on June 3 to Copper Island, where observations were made on Polatka rookery, and some additional seal specimens were obtained.

The population of the Commander Islands at the time of the visit of the *Albatross* was 656, 20 being whites and the remainder natives. The management of affairs here is excellent and constant employment is given to the inhabitants, all of the able-bodied men and larger boys being occupied on the rookeries during the sealing season and in hunting the blue fox in the winter. Protection for the rookeries is provided in the following manner:

A small guard is maintained for watching over the rookeries. The privates are selected from the native youths between the ages of 15 and 21; they serve three years without further compensation than their share of the family fund. The non-commissioned officers are Russians. While the guards are stationed at the rookeries they occupy barabaras, usually situated on the bluffs overlooking the beaches, and are not allowed to approach a rookery except to repel poachers. It is their first duty to give the alarm in case boats are seen approaching and warn them off. If the warning is not heeded, they are to drive the seals into the water, and if the poachers still persist in landing or do not depart, they are to fire upon them, using sufficient force to drive them away.

The regulations enforced on the seal rookeries of the Commander Islands are more stringent than those relating to the Pribilof group, and the same is also true with respect to sea-otter hunting as compared with the waters within the jurisdiction of the United States. There is a close season for sea otters extending from June 1 to February 1 of each year (according to the Russian calendar), and during the open season the number which may be taken is prescribed. On and about the sea-otter rookeries only spears and nets are allowed to be used, firearms being permitted only at distances of 5 or more versts from the rookeries. Females and yearling pups caught in the nets must be set free. All persons are forbidden to go on or near the sea-otter rookeries during the breeding season; neither shall they make a camp on or near a rookery during the same period, nor build a fire, or be the cause of any kind of smoke.

Fifteen reindeer introduced on the islands in 1881 have increased to about 300, and the herd is still protected. The natives also have small herds of Siberian cattle, which are hardy and find ample subsistence the year round. Lieut. Commander Tanner suggests that the same breed of cattle might advantageously be introduced on the inhabited islands of the Aleutian chain, where the rapid extinction of the fur-bearing animals will soon make it difficult for the natives to obtain food. This important matter deserves prompt consideration.

From Copper Island the *Albatross* returned to Port Townsend by way of Unalaska, and on June 30 she left Departure Bay, British Columbia, where she had been coaling, on another cruise to Bering Sea.

Between July 1, 1891, and the same date in 1892 the *Albatross* was at sea 206 days, during which time she steamed 24,991 knots and made 601 soundings, mostly in the deep sea, 39 dredgings, and 30 tow-net stations, the intermediate tow net being employed at many of the latter in considerable depths of water.

ATLANTIC COAST.

OYSTER INVESTIGATIONS IN CHESAPEAKE BAY.

Tangier and Pocomoke sounds.—The survey of this important oyster region begun on May 15, 1891, was continued until November 28 following, when, owing to inclement weather and the presence of many fishing boats upon the grounds, it was closed for the year, although the dredging trials had not been entirely completed. It is proposed to finish the latter during the summer of 1892. The scope of this investigation and the plans adopted for carrying on the work were described in the last annual report. Similar inquiries had been conducted in the same waters by Lieut. Francis Winslow in 1878 and 1879 and by Dr. W. K. Brooks a few years later, and it was expected that by repeating the examinations conclusions might be reached of more than local significance.

The work was carried on by means of the steamer *Fish Hawk*, Lieut. Robert Platt, U. S. Navy, commanding, and the steam launch *Petrel*, the latter replacing the *Fish Hawk* during its temporary absence in connection with the experiments relative to the hatching of the Spanish mackerel, and subsequently remaining on the grounds until the end of the season, being required for the examination of the shallow-water areas which could not be reached by the larger vessel. In many places, moreover, it became necessary to resort to the use of small flat-bottomed boats, especially near the shores and between the islands. Mr. John D. Battle acted as chief assistant in the hydrographic work and also had charge of the observations upon the material secured by dredging. He was aided by Mr. J. Percy Moore, of the University of Pennsylvania, until September 1; by Mr. B. L. Hardin and by Mr. W. C. Kendall after the middle of July. In addition to his other duties Mr. Moore spent considerable time in conducting special researches respecting the biology of the oyster. A person well acquainted with the oyster-grounds of the region was also employed as an oyster pilot.

Owing to the fact that nearly all the original triangulation points established by the Coast and Geodetic Survey had disappeared and that the coast lines had been materially altered by currents since the construction of the charts now in use, some delays occurred in the placing of new signal stations, which it was necessary should be located with much care to insure accuracy in the positions of all dredging and sounding stations. The region was divided into three sections, to be investigated in succession, the instructions being to complete the work in one before beginning upon another. The southern half of Tangier Sound, between its mouth and latitude 38° N., was first taken up and the hydrographic observations relating to it were practically completed by July 18. Between that date and August 1 the examinations were carried over the very shoal area between Tangier and Smith islands; some time was spent in studying the advantages of the region for the establishment of an experimental oyster station, which is much needed; and lines of density observations were run back and forth across the sound at different times of the tide. The *Fish Hawk* having returned by this time, the dredging investigations were started August 3 and were completed on the 28th of the same month.

Beginning then in the northern part of Tangier Sound, the inquiry was continued there until October 22, the hydrographic and density observations as far north as Clay Island light-house, and including also Manokin and Great Annemessex rivers, being completed by that date, as well as some of the dredging lines. The regular oyster-fishing season, however, had opened in the meantime and hundreds of dredging boats were at work, making it impossible to carry on the investigation in a continuous and satisfactory manner. It was also considered that the thorough raking which the grounds were then receiving would render the results to be obtained by the dredgings of the *Fish Hawk* of little value for comparison, so the vessel proceeded to Pocomoke Sound, where the month of November was spent in delineating the oyster beds. In this shallow area of water the *Fish Hawk* was only useful as a base of operations, the work being entirely carried on by means of the steam launches and rowboats. No dredging was attempted.

By the methods employed in conducting this investigation the outlines of the oyster-grounds, the areas of rank and scattered oyster growth, and the barren grounds were all determined and marked out as a part of the sounding work, the dredge being used to supplement the results thus obtained, to ascertain the actual proportion of living oysters to dead shells, the relative number of each size, the amount of spat, and the general condition of the grounds. The proportions were calculated to the square yard, the dredge employed having a width of exactly 3 feet in the opening of the mouth and the distance over which it was dragged each time being accurately determined. As this branch of the work was completed in the southern half of Tangier Sound just before the opening of the oyster season, the information obtained can be relied upon to show the true condition of the grounds in that region during the latter part of the customary period of rest which is allowed them every year.

A final report upon this survey has not yet been prepared for publication, but the principal results obtained, including maps illustrating the outlines of the oyster beds and the relative abundance of oysters in different parts of the two sounds, have been communicated to the governors of Maryland and Virginia, both of which States are now considering measures for the improvement of their oyster fisheries.

In addition to his regular duties in recording the character and condition of the material obtained by dredging, Mr. Moore made many interesting observations upon the younger stages of oysters following their fixation and until their shells had attained a diameter of three-quarters of an inch. He also succeeded in rearing the embryo oysters as far as the larval-shell period, when they all suddenly disappeared, as they did in the experiments made by Prof. John A. Ryder and Lieut. Francis Winslow. No light was thrown upon the causes of this disappearance.

Mobjack Bay.—During the last of May, 1892, an oyster survey, identical in its purposes and methods with that conducted the previous year in Tangier and Pocomoke sounds, was begun in Mobjack Bay, Virginia, the launch *Petrel* being detailed to make the delineation of the oyster beds and adjacent bottom, over which it was intended to run dredging lines later in the season by means of the steamer *Fish Hawk*. This investigation was still in progress at the close of the fiscal year, at which time the sounding operations in the bay proper were well under way, but it was expected that some time would be required to finish the survey in the tributary creeks, which contain beds of considerable importance. The work was in charge of Mr. John D. Battle, assisted by Mr. W. F. Hill and Mr. B. L. Hardin.

Delineation of public oyster-grounds by Virginia.—During the spring of 1892, under an act of the State legislature, arrangements were completed by the governor of Virginia looking to the delineation or marking off of the natural oyster beds in the waters of that State by right lines, with the ultimate object of retaining the areas so inclosed as public grounds and of granting the use of any suitable bottoms outside of those limits to individuals for oyster cultural or planting purposes. The benefits to be derived by fixing the outlines of all grounds held open to the public, so that their boundaries may readily be determined at any time by bearings from the shore or by sextant angles, unless, in fact, they be actually buoyed out, and by establishing their status permanently through legislative enactment to avoid constant interference through the courts, will be thoroughly appreciated by everyone who feels a genuine interest in the advancement of this important fishing industry.

The State is to be congratulated on having at last taken the initial step toward restoring, on a proper basis, those extensive resources which have been so rapidly depleted and which, by judicious management, can be made to yield the State a large revenue. State officers will be selected to act in conjunction with an engineer, who is to be detailed by the Superintendent of the U. S. Coast and Geodetic Survey, in running the necessary lines and preparing the maps required. The careful investigations now being made by the U. S. Fish Commission relative to the oyster-grounds of Chesapeake Bay have been accepted as the basis for the proposed delineations, so far as they apply to the waters of Virginia, and may be finished in time to serve the purposes of the State. Arrangements have also been made to allow the State authorities the use of one of the Fish Commission launches during the summer of 1892.

The food of oysters.—With the object of obtaining some needed information concerning the food of oysters, and the relations of oysters to their environment in that respect, the services have been secured of Dr. John P. Lotsy, of Johns Hopkins University, who will spend the months of July, August, and September in making a study of this subject in the vicinity of Hampton, Va. Dr. Lotsy is a native of the Netherlands, where he had considerable experience in connection with oyster-cultural experiments before coming to this country. Questions relative to the feeding of the oyster have, however, already received much attention from employés of the Fish Commission, and several important contributions bearing upon this subject will be found in its publications.

THE PRODUCTION OF SEED OYSTERS.

Before the close of the fiscal year arrangements had been made with Dr. John A. Ryder to continue some novel experiments respecting the collecting of oyster spat by a new system, which had been given a partial trial during the previous summer at the marine biological laboratory of the University of Pennsylvania, located at Sea Isle City, N. J. The system in question consists in distributing oyster shells or other materials suitable for the fixation of the spat over horizontally placed wire screens, supported on posts near the surface of the water in close proximity to beds of oysters. The advantages claimed for this method are, the more favorable position given to the collecting surfaces and the fact that areas of muddy bottom not suitable for oyster planting can also be utilized for this purpose. In case natural oyster beds are not properly situated for supplying the spat desired, artificial beds can be arranged on similar platforms, at a lower level than the collecting surfaces, during the spawning season. The cost of the plant is comparatively little, and the success met with in 1891 encourages the hope that the experiments may lead to results of practical importance.

FISHERY INVESTIGATIONS IN CHESAPEAKE BAY AND ADJACENT WATERS.

In the latter part of June, 1892, the schooner *Grampus* was detailed to conduct investigations in the lower part of Chesapeake Bay and in the adjacent waters of the open ocean, with the special object of determining the distribution and abundance of fishes throughout that region. The inquiry was in charge of Capt. A. C. Adams, commanding the *Grampus*, with Mr. W. C. Kendall as naturalist, and it was continued into the next fiscal year. The vessel has been fitted out with dredges, beam trawls, trawl and hand lines, and with the necessary instruments for observing the temperature and density of the waters. Being without steam power, however, it is not expected that very effective work can be accomplished by dredging, and collecting will chiefly be carried on by the ordinary methods of the fishermen. Scarcely anything has hitherto been done in the region indicated in the way of studying the bottom fishes, although the field is one of great importance in view of the extensive commercial fisheries which it has supported for a long period. Occasional dredgings were made some years ago within the limits of the bay by the steamer *Fish Hawk*, and on the ocean bottom outside by the steamer *Albatross*, but those investigations contributed little information of direct practical importance.

PHYSICAL INQUIRIES.

The physical inquiries which had been carried on off the southern coast of New England during the previous two summers, under the direction of Prof. William Libbey, jr., of Princeton College, were continued during the season of 1891, from June 30 until September 1. As the Coast Survey steamer *Blake* could not be spared again for this work, the lines of observing stations were run exclusively by the schooner *Grampus*, the light-ship on Nantucket New South Shoal being also utilized as before, through the courtesy of the Light-House Board, for the taking of supplementary observations. Prof. Libbey remained in charge of operations, and was assisted by Prof. M. McNeill, Prof. C. G. Rockwood, Prof. H. B. Thomson, Mr. S. T. Dodd, Mr. L. S. Mudge, and Mr. W. H. Dodd.

The work was conducted on essentially the same plan as in 1889 and 1890, but as only one vessel was employed the scope of the observations was materially less than in the latter year. A complete account of the methods pursued will be found in the last annual report. The principal object of the investigation is to determine the physical characteristics of the belt of water bordering the coast through which many important fishes pass during their seasonal migrations north and south, the changes occurring therein, and the causes producing such changes. To accomplish this purpose it is necessary to obtain at different times of the season many parallel series of surface and intermediate temperature observations at right angles to the shore line, together with corresponding meteorological observations for comparison with them. It is expected that Prof. Libbey will soon be ready to announce the results of the work so far completed.

The Light-House Board and the Southern Pacific Railroad Company have continued to coöperate with the Fish Commission in securing continuous series of water-temperature observations at many places along the Atlantic seacoast and on some of the Western rivers. This service is rendered gratuitously, and in the case of the light-house keepers at least at their own personal volition, not being regarded as a part of their regular or official duties. The records now on hand cover a period of many years, and are of great value in connection with the study of the migratory habits of our food-fishes. Mr. H. R. Center is now engaged in making reductions of the daily observations to averages of ten-day periods for publication in tabular form. The places at which observations were made during the past year are as follows:

Temperature stations on the Atlantic coast.

Stations of the Light-House Service:
- Coast of Maine: Petit Manan Island, Mount Desert Rock, Matinicus Rock, Seguin Island, Boon Island.
- Coast of Massachusetts: Race Point, Pollock Rip light-ship, Great Round Shoal light-ship, Nantucket New South Shoal light-ship, Cross Rip light-ship, Vineyard Sound light-ship.
- Coast of Rhode Island: Brenton Reef light-ship, Block Island southeast light.
- Long Island Sound: Bartlett Reef light-ship, Stratford Shoal light-ship.
- Coast of New York: Sandy Hook light-ship.
- Coast of New Jersey: Absecon Inlet light, Five-Fathom Bank light-ship.
- Delaware Bay: Fourteen-Foot Bank light-ship.
- Coast of Virginia: Winter Quarter Shoal light-ship.
- Chesapeake Bay: Windmill Point, Stingray Point, Wolf Trap Bar, York Spit.
- Coast of North Carolina: Bodys Island, Cape Lookout, Frying Pan Shoals light-ship.
- Coast of South Carolina: Rattlesnake Shoals light-ship, Martin's Industry Shoal light-ship.
- Coast of Florida; Fowey Rocks, Carysfort Reef, Dry Tortugas.

Stations of the Fish Commission:
- Gloucester and Woods Holl, Mass.
- Fort Washington and Bryan Point, Potomac River, Maryland.
- Washington, D. C.

Temperature stations of the Pacific Slope.

Stations of the Southern Pacific Company:
- Sacramento River, at Tahama and Yolo Bridges and Kings Landing, Cal.
- Feather River, at railroad crossing, near Marysville, Cal.
- American River, at railroad crossing, California.
- Mokelumne River, at Lodi, Cal.
- Tuolumne River, at Modesto, Cal.
- San Joaquin River, at the upper and lower railroad crossings, California.
- King River, at Kingsbury, Cal.
- Colorado River, at Yuma, Ariz.

The Fish Commission is under obligations to the U. S. Weather Bureau for the comparison with standards of a series of Negretti and Zambra deep-sea thermometers, and for information supplied for the use of Prof. Libbey in connection with the physical investigations of the schooner *Grampus.*

WOODS HOLL LABORATORY.

The laboratory at the Woods Holl Station of the Fish Commission was opened as usual for the summer season on July 1, 1891, but several persons arrived there and began their studies during the previous month. The biologists in attendance were Dr. H. V. Wilson, assistant in charge of the laboratory; Prof. F. H. Herrick, of Adelbert College, Cleveland, Ohio; Prof. William Patten, of the University of North Dakota; Dr. James L. Kellogg and Dr. E. J. Conklin, fellows of Johns Hopkins University; Dr. W. McM. Woodworth, instructor in Harvard University; and Prof. H. T. Fernald, of the State College of Pennsylvania. The Commissioner and Dr. T. H. Bean, ichthyologist of the Commission, were also present during most of the summer, and Prof. William Libbey, jr., with his assistants on the schooner *Grampus,* were at the station from time to time.

Dr. Wilson, who has been employed at the laboratory continuously since May, 1888, was engaged chiefly in the study of the embryology of certain sponges, preparatory to a visit to the coast of Florida, which it was proposed to make the following winter, with the object of investigating the development of the commercial sponges and of conducting experiments relative to their artificial propagation. On August 31, however, he resigned his position on the Commission to accept the chair of biology in the University of North Carolina, much to the regret of his associates. Prof. Herrick continued his researches on the life-history of the lobster, paying most attention to the phenomena which accompany the metamorphoses of the younger stages. Prof. Patten was chiefly occupied with observations respecting the variety of ways in which the embryo of Limulus, or the horseshoe crab, develops, finding the number of abnormal embryos and the grades of abnormality to be unusually large with this peculiar species. Messrs. Kellogg and Conklin were at work upon the anatomy, embryology, and habits of several edible and harmful mollusks, important species in connection with the commercial fisheries of the Atlantic coast. Their inquiries in this direction had been taken up previous to this summer, and were continued later in the year at the laboratory of Johns Hopkins University.* Prof. Fernald made a study of the development of several crabs, and Mr. Woodworth continued for a few weeks his researches on the life-history of the parasitic planarian which infests the gills of Limulus.

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*A contribution to our knowledge of the morphology of Lamellibranchiate mollusks. By James L. Kellogg, PH. D. Bull. U. S. Fish. Comm., X, for 1890, pp. 389–436, plates LXXIX–XCIV.

Mr. Vinal N. Edwards, who has been attached to the Woods Hole Station since it was first established in 1871, continued during the entire year his observations upon the natural history and temperature of the waters in this region, in addition to the assistance which he rendered in connection with the fish-cultural work. His duties in the line of scientific inquiry consist in keeping a daily record of all fishes present in this neighborhood, so far as the same can be determined by observing the catches made by the fishermen, and by making frequent collecting trips with seines, gill nets, tow nets, etc., to all parts of Vineyard Sound, Buzzards Bay, and other neighboring waters.

One of the most important and significant discoveries which he has made in recent years relates to the spawning habits of the menhaden. The very young of this species abound during the entire summer in the brackish waters of several creeks or small rivers which empty into Buzzards Bay, such as the Acushnet River and the Wareham River, and their incredible numbers, taken in connection with their small size, precludes their having entered these streams from the sea. The adult menhaden come into these waters to spawn in the spring, but what has diverted attention from this habit is the fact that they do not school at the surface at that season, and consequently their early movements have generally escaped the notice of the fishermen. Since Mr. Edwards first made known these observations information has been received that the young have been found just as abundantly in similar situations on the coast of New Jersey and in Chesapeake Bay, and a careful search would undoubtedly disclose their presence along the entire range of coast to which the menhaden resort. Whether or not the spawning takes place exclusively in the spring has not been determined, but nearly ripe menhaden have been captured in the fall, and it is possible that the season is different on different parts of the coast. Observations relative to this very interesting problem will be actively prosecuted during next year.

Before the end of June, 1892, a number of naturalists had already arrived at the Fish Commission laboratory, and work was actively in progress in advance of the regular opening day for the next season, July 1. Dr. James L. Kellogg had been employed temporarily to take charge of the laboratory during the summer of 1892, and reached there on June 3. Others present before the close of the fiscal year were Prof. F. H. Herrick, Prof. William Patten, Dr. H. V. Wilson, and Mr. Maynard M. Metcalf, of Johns Hopkins University.

Many additions made to the laboratory during the past year in the way of appliances for research, books of reference, etc., have greatly increased the facilities for work. Numerous courtesies have been extended to the Marine Biological Laboratory, which is adjacent to the Fish Commission station, and many favors in return are to be acknowledged.

INVESTIGATION OF INTERIOR WATERS.

MONTANA AND WYOMING.

Extensive investigations were conducted in Montana and Wyoming by Prof. B. W. Evermann during July and August, 1891, in compliance with a provision of the sundry civil appropriation bill for the fiscal year 1891–92, with the object of determining the advisability of establishing a fish-hatching station in the Rocky Mountain region in one or other of the States mentioned and of making observations relative to the selection of a proper site for such a purpose. From a previous knowledge of the region it was decided that the best conditions for such a station as had been contemplated would be found either in the western part of Montana or the northwestern part of Wyoming, and the examinations were therefore limited to the area so defined, which is drained by the head waters of both the Columbia and Missouri rivers, having their origin on the great continental divide. Prof. Evermann was assisted in his field work by Prof. O. P. Jenkins, of the Leland Stanford, jr., University, and Mr. Burnside Clapham, of Monroeville, Ind. Supplemental inquiries, having reference mainly to the lower forms of life living in the same waters, were also carried on by Prof. S. A. Forbes, of Illinois, later in the season.

In order to comply fully with the requirements of the case, it was necessary to conduct this survey on a somewhat more comprehensive basis than had been usual in the past, comprising a careful study of the physical features of all the important lakes and water-courses and of the different fishes which inhabit them, whether useful or otherwise, together with the conditions of environment now existing or essential to their welfare, as also to that of other species which it might be deemed advisable to introduce, and, likewise, the detailed examination of all places which might appear suitable for fish-cultural operations of the character proposed.

The following account of the water systems of this region is extracted from the report of Prof. Evermann:*

By far the greater part of Montana, nearly all that portion lying east of the meridian of 112° 30′, lies within the Missouri drainage area. In the northwest portion of the State the divide lies more than a degree farther west, and in the southwest the Missouri drainage extends westward to the Idaho State line. The Missouri also drains all of northwest Wyoming, excepting the southwest portion of the National Park and part of the region south of the Park. This part of Wyoming belongs to the Columbia River basin, being drained directly by the Snake River and its tributaries. In general it may be said that the streams of the Missouri system flow in

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*A Reconnaissance of the Streams and Lakes of Western Montana and Northwestern Wyoming, by Barton W. Evermann, PH. D. Published first as a Congressional document in Report of the Commissioner of Fish and Fisheries respecting the establishment of fish-cultural stations in the Rocky Mountain region and Gulf States, 1892 (Fifty-second Congress, first session, Senate Mis. Doc. No. 65, 58 pages, 27 plates), and reprinted in the U. S. Fish Comm. Bull., vol. XI, for 1891, pp. 3–60, plates 1–27.

a northeast or northerly direction. Those tributary to the Clarke Fork of the Columbia flow to the northwest, while the drainage into the Snake River or Lewis Fork of the Columbia is to the southwest.

Nearly all of these rivers and creeks are, of course, swift mountain streams; most of them have their rise in small lakes of clear, cold water, high up in the mountains—lakes which as yet are difficult of access and but little known. Many of these lakes are known, however, to be well supplied with trout, while others are wholly without any fish life whatever. From these mountain lakes the swiftly-flowing, turbulent streams make their descent through rocky gorges and canyons to the valleys below. Ordinarily the beds of the streams are very rocky, but now and then are found more quiet reaches where the streams have sand or gravel beds as they flow through small mountain meadows. Then, at other places, there are rapids and cascades, and in many of the streams are found considerable waterfalls. The best illustrations of this are in the numerous magnificent falls found in the streams flowing from the great volcanic plateau constituting the larger part of the Yellowstone National Park. As the streams leave this immense sheet of rhyolite they do so in great falls, such as those of the Yellowstone, Gibbon, and Lewis rivers. Others of the same nature are to be found in the country lying to the east of the National Park, in the Clarke Fork of the Yellowstone, and other streams of that region. These falls, of course, serve as more or less effective barriers to the distribution of fish, and as a result many of the mountain lakes, though of the most suitable character, so far as temperature, purity, and abundance of food supply are concerned, are wholly barren of fish life of any kind. The larger streams are, as a rule, less swift, and have more sandy and gravelly beds. There are few, if any, sluggish streams in this region, and all are clear, unless contaminated by mining operations.

In the Columbia River basin twenty-four lakes and streams tributary to the Clarke Fork and nine tributary to the Lewis Fork were examined by Prof. Evermann; in the Missouri River basin the examinations extended to twenty-six tributaries of the Yellowstone River and Lake, the Madison, Gallatin, and Jefferson rivers, and Prickly Pear Creek. Descriptions are given of the principal features characteristic of each of these waters, and their fishes are discussed.

One of the most interesting incidents of the expedition was a trip to Two-Ocean Pass, where the waters of the Columbia and Missouri rivers virtually meet and provide a limited passageway for fishes from one to the other. Visits had previously been paid to this locality, which is situated just south of the southern border of the Yellowstone National Park, by a few travelers who have given accounts of its peculiarities, but although Prof. Evermann was there only a short time his observations have enabled him to explain its features more completely and accurately than any of his predecessors, whose descriptions of the place are greatly at variance with one another. His report contains a plan and sketch illustrating the true relations existing between the several streams.

According to Prof. Evermann—

Two-Ocean Pass is a nearly level piece of meadow land, surrounded by rather high hills except where the narrow valleys of Atlantic and Pacific creeks open out from it. Running back from the hills to the northward are two small canyons; on the opposite side is another canyon of the same character. Down these canyons come the three main streams which flow through the pass. The extreme length of the pass from east to west can not be much less than a mile, while the width from north to south is perhaps three-fourths of a mile.

After describing the creeks and the character of their connections in detail, he adds:

Pacific Creek is a strong stream long before reaching the pass, and its course through the meadow is well fixed, but not so with Atlantic Creek. The west bank of each fork [of Atlantic Creek] is liable to break through almost anywhere, and thus send a part of its water across to Pacific Creek. It is probably true that one or more branches connect the two creeks under ordinary conditions, and that in times of high water a very much greater portion of Atlantic Creek flows across to the other. At any rate, it is certain that there has been, and usually is, a free waterway through Two-Ocean Pass of such a character as to permit fishes to pass easily and readily from the Snake River over to the Yellowstone—or in the opposite direction. Indeed, it is possible, barring certain falls, for a fish so inclined to start at the mouth of the Columbia, travel up that great river to its principal tributary, the Snake, continue on up the long, tortuous course of that stream, and, under the shadows of the Grand Tetons, enter the cold waters of Pacific Creek, by which it could journey on up to the very crest of the Great Continental Divide, to Two-Ocean Pass. Through this pass it may have a choice of two routes to Atlantic Creek, where it begins the journey down stream. Soon it reaches the Yellowstone River, down which it continues through Yellowstone Lake, then through the Lower Yellowstone out into the turbid waters of the Missouri.

Small trout of the species belonging on the western slope (*Salmo mykiss*) were abundant in both Pacific and Atlantic creeks, but the blob, or miller's thumb, which occurs in the former, was not observed in the latter, nor in the waters into which it flows lower down. The high falls in the Lower Yellowstone River, however, preclude the ascent of fishes from the Missouri River basin, and the Upper Yellowstone River, together with the lake of the same name, was evidently stocked from the west, and almost certainly by way of Two-Ocean Pass.

By diligent collecting at the various places visited by the party a fair representation of the fish fauna was undoubtedly obtained, but owing to the mountainous character of the region and the clear, cold waters and rapid currents of most of the streams it was not to be expected that a great variety of forms would be found. Only sixteen indigenous species were secured, besides four species which had been introduced by the Fish Commission. The former comprised four species of the genus *Catostomus*, or suckers, six of *Cyprinidæ*, or chubs and dace, four of *Salmonidæ*, the *Lota maculosa*, or ling, and the blob. The *Salmonidæ* were as follows: *Coregonus williamsoni*, or whitefish, taken in both the Columbia and Missouri River basin; *Thymallus signifer*, or grayling, in the Missouri basin; *Salmo mykiss*, or Rocky Mountain trout, very abundant on both sides of the Divide; and *Salvelinus malma*, or Dolly Varden trout, in the upper waters of the Columbia River, in Montana. Specimens of the last-mentioned species have been said to attain a weight of 12 to 14 pounds.

During the years 1889 and 1890 seven species of *Salmonidæ* were planted by the Fish Commission in eight different rivers and lakes of the Yellowstone National Park, each of which constituted a more or less isolated minor basin, as described in previous reports. Only two or possibly three of these basins had previously contained fish of any kind, and the new-comers were so distributed that only one or two species were placed in each basin. An examination of these waters by Prof. Evermann showed conclusively that at least five of the introduced forms were doing well, two, if not more, having spawned; the white-fish (*Coregonus williamsoni*), however, had not survived the change, but as to the seventh species there was no reason to doubt that it was still living in its new home, although no specimens were observed. There are several falls in the park which are of such a nature that they could readily be provided with fishways; and Prof. Evermann suggests that this matter will merit consideration when the species planted by the Fish Commission have had sufficient time to become thoroughly established. By this means several native species which occur abundantly in some of the lower courses would be given the opportunity to disseminate themselves throughout the upper waters.

Great care was exercised in making the examinations relative to the selection of a suitable site for a hatching station, in order to be advised in case Congress should direct its establishment. Three places were found to present better advantages for this purpose than any others, and they are fully described in Prof. Evermann's report. They are Horsethief Springs, in Gallatin County; Botteler Springs, 3 miles south Fridley; and Davies Springs, 4 miles from Bozeman, all in Montana. In transmitting this information to Congress the Commissioner recommended the establishment of a trout-breeding station at one of the above-named localities, and the same has received favorable consideration. Davies Spring was subsequently selected for the purpose, as offering, in all respects, the best facilities.

The inquiries by Prof. Forbes, previously referred to, were begun on August 10 and were completed on September 13, 1891. They related to the lower classes of organisms which constitute the food of many fishes at different periods in their life-history, and to the physical characteristics of the waters examined. Owing to the difficulty in the way of making comprehensive collections of these smaller and more widely disseminated forms and of observing the conditions of their surroundings rendering progress much slower than with the fishes, the investigations were necessarily confined to fewer localities than had been visited by Prof. Evermann, but the region of the Yellowstone National Park had already been covered by Prof. Forbes's expedition of the previous summer, described in the last annual report.

The work of 1891 was mostly limited to the Flathead region of western Montana, with visits to Davies Springs, on Bridger Creek near Bozeman, and to Botteler Springs near Fridley, two sites suggested for the proposed new hatching station. The waters examined in the Flathead system were Flathead and Swan lakes, Flathead, Swan, and Cœur d'Alene rivers, and the Jocko River at Ravalli. A preliminary paper by Prof. Forbes* gives the general results accomplished during

*A preliminary report on the aquatic invertebrate fauna of the Yellowstone National Park, Wyoming, and of the Flathead region of Montana. By S. A. Forbes, Bull. U. S. Fish Comm., vol. XI, for 1891, pp. 207–258, plates 37–42.

both years, and contains descriptions of the principal features, physical and biological, of each of the basins studied by him, namely, the Snake River system, Yellowstone River system, Gardiner River system, Madison River system, and Flathead River system. Many of the organisms obtained are also described in detail.

As no topographical surveys have been made about Flathead Lake, its outlines and dimensions are still matters of conjecture, but it is said to be about 24 miles long and from 12 to 17 miles wide. Its principal characteristics, as compared with those of Yellowstone Lake, are thus described by Prof. Forbes:

Although this lake stands in some respects in decided contrast to Yellowstone Lake, these differences tend largely to neutralize each other. Flathead Lake is over 200 miles farther northward than Yellowstone, but the latter is 4,775 feet the higher above the level of the sea. These lakes lie on opposite continental slopes, their waters passing respectively into the Gulf of Mexico and the Pacific Ocean, but neither is more than a few miles from the relatively low continental divide, easily passable by most of the plant and animal forms likely to occur in such waters. Both lakes lie in the course of streams of considerable size, but these streams flow in opposite directions, the inlet of Flathead Lake coming southward from the British possessions, and its outlet running first to the south and then to the west as Flathead River, a branch of the Columbia, while Yellowstone River, rising about 150 miles from the lake, runs northward more than a degree below it before swinging to the east to join the Missouri. Nevertheless, the headwaters of the two river systems interlace almost inextricably through interlocking mountain valleys along several hundred miles of the main Rocky Mountain range. Both lakes lie among the mountains, from whose rugged gulches the snow never wholly disappears, and both are bordered by forest broken by park-like openings on the lower slopes; but the geological structure of the surrounding country and the chemical composition of the rocks which form their shores and beds differ widely for the two, and the forests, all pine and fir and other conifers around Yellowstone Lake, are largely deciduous trees about Flathead.

The lakes are similar in size and are both deep enough to give a deep-water character to their interior fauna, but Flathead has much the more uniform shore line and contains—if I may judge from the parts of it which we examined—a larger extent of shallow and weedy water. It is divided, in fact, by a chain of islands stretching across its lower third, into unlike parts, the northern deep and clear, and the southern shallow and easily stirred up to its clayey bottom by the winds. * * * The principal tributaries are the Flathead, a still, broad river, larger than the Yellowstone at the lake, running from Demersville, most of the way between flat, low banks; the Big Fork or Swan River, a rocky stream, whose course from Swan Lake to the Flathead is an oft-repeated alternation of wild rapids and comparatively quiet reaches; and Dayton Creek on the west, which I did not see. The outlet (Flathead River) flows rapidly away from the lake between bluffy blanks which presently become a canyon.

TEXAS.

The act of Congress relative to investigations in the Rocky Mountain region also provided for similar inquiries with respect to the Gulf States. As the appropriation made for this purpose did not permit of extensive explorations, they were limited to the State of Texas, where it was expected a convenient location would be found to meet the requirements of a wide territory which has hitherto derived comparatively few benefits from the fish-cultural operations of the Government. The field work was conducted during November and the early part of

December, 1891, by Prof. B. W. Evermann, assisted by Dr. R. R. Gurley, of the Fish Commission; Dr. J. T. Scovell, of Terre Haute, Ind., and Mr. J. A. Singley, of the Texas State Geological Survey. The report of the investigation was transmitted to Congress with that bearing upon the Rocky Mountain region, and the two have been published conjointly.*

While it was of primary importance that the work of propagation in the Gulf region should relate to fresh-water fishes and to pond culture especially, it was considered desirable that provision should also be made for the hatching of marine forms and for experimental studies regarding oyster-culture, providing a suitable location on the seacoast could be found for the building of a composite station. Failing in this, attention was to be turned to the interior of the State, where good facilities for the first-mentioned purpose were known to exist, and the natural history of the different streams was also to be studied, so far as the time would permit.

Examinations were first made in the neighborhood of Galveston and about the bay of the same name, where some time was spent in ascertaining the relations between the salt and fresh waters, and in inspecting all localities which might present any advantages for the combined work. The results, however, were unsatisfactory, as nowhere could a reliable supply of fresh water be obtained without the construction of several artesian wells, and in close proximity to any suitable tract of land the salt water was of too low and variable a density to serve the purposes for which it was desired. A visit made subsequently to Corpus Christi Bay also failed to disclose the required conditions with regard to the fresh-water supply, and as no other places along the coast promised more favorable facilities, it was deemed advisable to abandon the scheme of uniting both stations in one locality.

The cretaceous limestone belt running through the State, near San Antonio, New Braunfels, San Marcos, and Austin, affords numerous very large springs, of which one or more are situated in the immediate vicinity of each of the places mentioned. All of these localities were visited and the conditions at each were found to be so satisfactory that further inquiries were considered unnecessary. The temperature of the water issuing from these several springs seems to be about the same, and does not vary much from 75° F. throughout the year. One group located just outside of the city of San Antonio, and called the San Antonio Springs, gives origin to the river of the same name; it is estimated to have an average flow of not less than 90,000 gallons per minute. Another group, the San Pedro Springs, is within the city limits, and has about half the capacity of the former. Comal Springs, the largest of which is said to supply as much as 50,000 gallons of water a minute, constitute the principal group near New Braunfels.

*A report upon investigations made in Texas in 1891. By Barton W. Evermann, PH. D. Published in conjunction with the report on western Montana and northwestern Wyoming, as cited on p. CXI. Pp. 59-88, Pls. XXVIII-XXXVI. Contains also a supplementary paper, entitled "List of Crustacea collected," by Mary J. Rathbun.

The San Marcos River rises in a number of springs at the foot of a limestone ledge or hill just above the town of the same name. These springs together form a large, deep stream, from the bottom of which, near the upper end, wells up the principal spring with such force and in such quantity as to keep the surface of the river visibly convex above it. Some distance down a dam has been built, and just below the dam, at the edge of the town, is a tract of land about 25 acres in extent, well situated for the purposes of a fish-cultural station, and this will probably furnish the best advantages of any of the sites examined. Just above the city of Austin, Barton Spring helps to form Barton Creek, a good-sized stream, which empties into the Colorado River, and on the banks of which the State had formerly a hatching station. The land here is still suitable for the same purpose, but its extent may be too small.

Prof. Evermann's report contains a full account of the features observed at each of the places examined, together with brief notes on the fishes and crustaceans collected, the preparation of a more complete review of the aquatic fauna of the State having been necessarily deferred until a later time.

KENTUCKY AND TENNESSEE.

The southern tributaries of the Cumberland River between Nashville, Tenn., and the crossing of the Cincinnati Southern Railroad in Whitely County, Ky., a distance of over 150 miles following the main curvatures of the river, were examined during August and September, 1891, by Mr. Philip H. Kirsch, superintendent of schools of Columbia City, Ind. Fishes were collected in 20 different streams, including the following affluents of the Cumberland, together with some of their tributaries, namely: Stone River, Spring Creek, Round Lick, Carey Fork River, Roaring River, Obeys River, Beaver Creek, and the Big South Fork of the Cumberland. In Mr. Kirsch's report* the principal characteristics of the several streams are briefly described, and the fishes of each are enumerated in the form of annotated lists. The largest number of species recorded from any one stream was 39 from the Obeys River. An account of previous investigations in Kentucky by Mr. Kirsch and Mr. A. J. Woolman will be found in the last annual report.

INDIANA.

Mr. Philip H. Kirsch began, on June 13, 1892, an investigation of the fishes of the Eel River basin in Indiana, which was continued into the next fiscal year. This river, with its tributaries, lies between the main branch of the Wabash River and the Tippecanoe River, and extends

*Notes on a collection of fishes from the southern tributaries of the Cumberland River in Kentucky and Tennessee. By Philip H. Kirsch. Bull. U. S. Fish Com., XI, for 1891, pp. 259–268.

from the St. Joseph River basin in the northeastern part of the State to Logansport, where it empties into the Wabash River. It has a total length of 72 miles, the average width of its basin being about 18 miles.

OHIO.

During the summer of 1891, and again in May and June, 1892, Mr. Lewis M. McCormick, assistant in the museum of Oberlin College, acting in the joint interests of that institution and the Fish Commission, made extensive collections of fishes throughout Lorain County, Ohio, in continuation of investigations which had been carried on during the previous three years. In a report upon this work, which has been published by Oberlin College,* 88 species are enumerated as inhabiting the streams and the lake front of that county. Notes are also given respecting their habits and other matters of interest. A complete series of the species collected has been supplied to the Fish Commission. The following account of the main hydrographic features of Lorain County is abstracted from Mr. McCormick's report:

Lorain County is wholly within the lake watershed, all its streams flowing northward into Lake Erie. The streams are all small, the largest being Black River, navigable for about 3 miles, and Vermillion River, having only about a mile of safe water. * * * The land is quite flat, with a gentle slope toward the lake, and the streams are mostly shallow and sluggish, the exceptions being found in the parts that cross the "ridges," or old lake beaches, and a few of the small streams that are tributary to the Vermillion. Some of these are quite brisk and have worn for themselves deep channels in the shale. * * * Lake Erie, where it touches Lorain County, is shallow, reaching a depth of about 55 feet 3 miles from shore, and is free from islands. * * * Pound nets are set in "strings" from perhaps one-half a mile from shore to 3 miles, and it is from these I have obtained most of my lake fishes.

NORTH CAROLINA.

In April, 1892, Dr. Hugh M. Smith, of the Division of Fisheries, made a short trip to the Albemarle region of North Carolina, during which he collected fishes at numerous places in the basins of the Pasquotank and Roanoke rivers and in Edenton Bay, at the mouth of the Chowan River. Owing to the early date at which this investigation was conducted, high, muddy water was generally met with, and the temperature was also still low, causing unfavorable conditions for fieldwork, and making it impossible to obtain nearly as full a representation of the fishes of the region as would have been the case later in the season. Notwithstanding this fact, however, 45 species, belonging to 35 genera and 18 families, were secured. In a paper discussing the results of his expedition, † Dr. Smith describes the features existing

* Descriptive List of the Fishes of Lorain County, Ohio. By Lewis M. McCormick, assistant in the laboratory. Laboratory Bulletin No. 2, Oberlin College, Oberlin, Ohio, 1892, pp. 34. One map of Oberlin County, 14 plates of fishes.

† Report on a collection of fishes from the Albemarle region of North Carolina. By Hugh M. Smith, M. D. Bull. U. S. Fish Comm., vol. XI, for 1891, pp. 185-200.

about each of his collecting stations, and presents a very interesting series of observations relative to the different fishes taken at each place. Speaking of the region in general he states:

Albemarle Sound is said to be the largest coastal body of fresh water in the world, and it is certainly the largest of its kind in the United States. It is 60 miles long from east to west, and has a maximum width of 15 miles and an average width of 6 to 8 miles; its area is 453 square miles. At its eastern extremity it communicates on the north with Currituck Sound, and on the south it merges into Roanoke and Croatan sounds, through which it enters the ocean by means of openings in the sandy "banks" which skirt the ocean front of the State. * * * Viewed from the standpoint of commercial fishing, the Albemarle Sound region is one of the most important in the United States, and there is no other fresh-water basin on the Atlantic coast having such extensive fisheries. The especially prominent fish occurring here are the shad, alewives, striped bass, black bass, and white perch. The seine fisheries for shad and alewives are by far the largest in the country.

During the summer of 1888 the upper waters of the main tributaries of Albemarle Sound were made the subject of an extensive inquiry by Dr. David S. Jordan, but the fishes in the lower part of the basin had never been studied previous to the visit of Dr. Smith.

NEW YORK.

It is appropriate to notice in this connection an important investigation respecting the fishes of Lake Ontario, conducted during August and September, 1891, by Dr. Hugh M. Smith, in view of the fact that the report upon it deals mainly with natural-history subjects.* In describing the results of his expedition, the author has incorporated much material from other sources, and his notes upon the important commercial fishes of the lake contain, in addition to his own observations, an epitome of the principal facts previously made known regarding them. The species treated of are the sturgeon, alewife, shad, Atlantic salmon, lake trout, the common and lesser whitefishes, the pike perches, strawberry bass, and many so-called bait fishes. Special attention is given to a discussion of the sources of introduction into the lake of the alewife, and the possible causes of the great and strange mortality which destroys enormous quantities of them every year; to the history of the Atlantic salmon, once not an uncommon inhabitant of the lake, but now almost entirely exterminated from it; and to the whitefishes, concerning which, aside from the common form, an uncertainty still exists as to the number of species represented and the proper identity of some of them.

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* Report on the Fisheries of Lake Ontario. By Hugh M. Smith, M. D. Bull. U. S. Fish Comm., vol. X, for 1890, pp. 177–215, plates XXI–L.

WISCONSIN.

A physical and biological investigation of Green Lake, Wis., was conducted by Prof. C. Dwight Marsh, of Ripon College, during August, September, and October, 1890, and July, 1891. As assistance was rendered to Prof. Marsh by the Fish Commission to the extent of supplying him with the means of taking deep-water temperatures, we feel justified in referring to some of the results of his inquiries, which have been described in two papers.* They derive additional interest, moreover, from the fact that other lakes in the same state—Geneva and Mendota—have been made the subject of special studies for this Commission by Prof. S. A. Forbes.

The maximum depth recorded for Green Lake, which is situated southeast of the center of the State, is 195 feet. Temperature observations were secured by Prof. Marsh down to a depth of 58 meters. A minimum temperature of 5.28° C. was obtained in the deeper parts of the lake, in July, 1891; in August, 1890, the temperature in corresponding depths was 6.6° C. The author infers that the maximum bottom temperature is reached in August, and remains practically the same during the two following months. The surface temperature is nearly uniform over all the deeper parts of the lake. Prof. Marsh states:

> Because of its depth, Green Lake resembles in the conditions controlling animal life, the larger bodies of water, and might be expected to have a fauna somewhat different from that of the shallower lakes. My collections seem to justify this expectation.

The mollusks obtained were all littoral forms, and in most cases were probably washed in from shallower water. Crustaceans are abundant, although the number of species is small, only 16, including both the pelagic and abyssal forms, having been discovered. "When we compare the deep-water crustacea of Green Lake with those of Lake Michigan and Lake Superior, as shown in the lists published by Prof. Smith and Prof. Forbes, we find a striking similarity. That this should be true of the pelagic fauna is not strange," but the presence of the same abyssal forms which never come to the surface is not so easily explained, as there seems to be no geological evidence of any connection between Green Lake and either the Mississippi Basin or the Great Lakes, by which these deep-water animals could have migrated to their present location.

MEXICO.

Reference may here be made to an expedition into Mexico during the summer of 1891, on which Mr. A. J. Woolman acted as ichthyologist, as his report upon the fishes was accepted for publication by the Fish Commission.† The party traversed the northern and central parts of

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*On the deep-water crustacea of Green Lake. By C. Dwight Marsh. Trans. Wisconsin Academy of Sciences, Arts, and Letters, vol. VIII, pp. 211–213.

Notes on depth and temperature of Green Lake. *Idem*, pp. 215–218, 1 plate.

† Report on a collection of fishes from the rivers of central and northern Mexico. By Albert J. Woolman. Bull. U. S. Fish Comm., XIV, for 1894, pp. 55–66, plate 2.

Mexico on its way south to Mount Orizaba, which was the objective point. According to Mr. Woolman:

In mountainous regions the number of species of fishes is small, and this is especially true in Mexico, where the streams are short, their basins isolated, and their volume of water varies greatly from one season to another.

The total number of species obtained was only 24, of which 6 were new to science, and as the entire collection was made in the head waters of the streams, all of the forms belong strictly to fresh water. Of the species collected south of the Rio Grande, 50 per cent belonged to the *Cyprinidæ* and 30 per cent to the *Cyprinodontidæ*, the remaining 20 per cent representing five other families. The streams visited are as follows: The Rio Grande at El Paso del Norte; Rio de los Conchas at Chihuahua; Rio de Lerma at Salamanca; the lakes and canals about the City of Mexico, and the Rio Blanco at Orizaba. Some of the collections were made at altitudes of 4,000 to 6,000 feet above the level of the sea.

MISCELLANEOUS INQUIRIES.

FRENCH METHODS OF OYSTER-CULTURE.

The marked depletion of oyster-grounds which has taken place on some parts of the Atlantic seacoast of the United States, the difficulty generally encountered in procuring an adequate supply of seed for planting purposes, and the very commendable efforts made or contemplated with respect to the establishment of new oyster-producing areas on both sides of the American continent, have all been fruitful sources of inquiry, calling for information of a thoroughly practical kind. To assist in meeting this demand the U. S. Fish Commission has not only carried on many investigations and experiments relative to the oyster question, but it has also sought to disseminate the experiences acquired in other countries by printing, from time to time, accounts of the methods employed by foreign culturists.

The relative scarcity of oysters in Europe as compared with this country and the high prices there received for them has led to a system of cultivation which at present would be neither expedient nor profitable on our own coasts, and it is sincerely to be hoped that the time is still far distant when this mollusk shall become a luxury to the American people. But, however that may be, much benefit can undoubtedly be derived from a study of the different systems resorted to in Europe, some features of which may prove applicable to our own needs or be at least suggestive. The French Exposition of 1878 was made the occasion for bringing together the literature relative to the history and conditions of oyster-culture in the several European countries where it was then practiced or where experiments had been undertaken regarding it. A comprehensive review of the subject, based upon inquiries made at the same time, was also promised but never completed, and translations only of some of the principal papers were published in the Fish Commission annual report for 1880.

Another opportunity to secure these observations was fortunately presented about a year ago, when Dr. Bashford Dean, of Columbia College, New York, started upon a trip to Europe, intending to be absent for some time. Arrangements were accordingly made with him to visit all of the oyster-producing countries of the old world and to report fully upon the methods there employed, paying especial attention to those matters which might prove of most interest to American oyster-growers. Dr. Dean was well qualified to conduct this investigation, having been connected during several years with the oyster commission of New York State, and having served as naturalist and physicist of the steamer *Fish Hawk* on the oyster survey of South Carolina in 1890-91. During the past fiscal year he completed his studies in France, Spain, and Portugal, and his report relative to the first-mentioned country has been received and published.* It presents a thoroughly comprehensive but concise account of the industry as now carried on, and the illustrations which accompany it, mostly engraved from photographs by the author, emphasize the more essential features of that remarkable system of artificial culture by which the French have maintained their high standard of production.

After explaining the differences existing between the flat, northern, or genuine French oyster and the introduced Portuguese species, and discussing briefly the Government regulations with regard to dredging on the natural beds, the author takes up the different branches of oyster-culture under the following headings: Production, or the raising of seed oysters, and kinds of collectors; elevage, or the growing of oysters for market; claires; special processes, such as "greening" or preparing for transportation. The following remarks are taken in part from the introduction and in part from the concluding chapter of this paper:

When one has carefully examined oyster-culture in France it appears more than ever manifest why the industry at home has been a profitable one. It has certainly required the exercise of but little labor, and all costly methods of cultivation could have proven of little practical value. So great has been our natural supply of oysters that we have always thought far distant the need of replenishment.

If, however, the present condition of our industry must be improved, there are fortunately but few natural obstacles to overcome, and we may well be hopeful. Our oysters are of a hardy and prolific species, our coast is a natural collecting-place for seed, and the conditions of our oyster-bearing grounds are practically as good as ever. We have in no degree the adverse conditions that the French have so successfully encountered. Their coast regions, in the first place, favorable to a natural growth of oysters, are both few and small. Their waters, even in some of the best-known localities, are often turbid, accumulate sediment, and give rise to shiftings of muddy bottoms. Culture has had to bring into use the softest flats and mud banks, crusting them over with gravel and sand; it has had to devise every possible way of protecting its oysters from sediment, mud burial, and enemies. Finally, there are but two points along their entire coast where seed oysters occur in any natural abundance. Skill in culture, however, has enabled Arcachon and Auray to supply readily the great home demand for seed, and even to furnish in large part the parks of the Low Countries and England, a success the more remarkable when

* Report on the Present Methods of Oyster-Culture in France. By Bashford Dean. Bull. U. S. Fish Com., x, for 1890, pp. 363-388, plates 68-78.

we consider how recently was the French coast so depleted that for the first experiments in cultivation the oysters were actually purchased from other countries.

Natural difficulties have caused the French to study division of labor in the industry; to make, for example, one locality furnish the seed, another to raise the oyster to maturity, a third to flavor or color it, and sometimes even a fourth to prepare it for transportation.

Under these conditions the growth of the industry has been especially and almost entirely dependent upon the wise action of the Government. The reservation of the natural grounds as state property and the forbidding of general public dredging is generally regarded as the keystone of French oyster-culture. These grounds, once exhausted, now flourishing, are regarded as the permanent capital of surrounding areas, whose profits in the form of seed oysters are shared by all alike.

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In view of our present needs, what is the most important lesson we are to draw from the studies of the French oyster-culture? The most practical, certainly, seems the action of the Government in reserving oyster-bearing tracts for the purpose of furnishing seed. This prudent restriction has been the safeguard of the entire French industry. Our oyster-grounds are becoming exhausted solely by the enormous drain upon their resources. In general their conditions for culture are as rich as ever. The oysterman has sent to market practically all of his oysters and expects the beds on his neighbor's ground to furnish him with seed. Too often, however, the neighbor has been equally thrifty and has marketed all of his product. The following year both are astonished at the poorness of the set, attributing it to coldness and rain, but they never think that the deficiency might have been caused by the want of a quantity of neighboring oysters sufficient to furnish the spat. Nor is one to blame for not preserving his oysters to furnish seed for everybody. French political economy has assigned to Government the duty of reserving oyster-bearing tracts for the common good, and the Government has studied where these might most judiciously be located so as to profit all alike. The tracts need not be large and would not be of great expense to the state, at any rate as an experiment in a single locality. The grounds would practically take care of themselves; their only expense would be that of a guardian.

If an experimental oyster tract in one locality should prove eminently successful to neighboring seed-culture, a more general legislative action in different States might reasonably follow. The matter would certainly be most heartily seconded by the oystermen themselves. We should not expect seed to be abundant where oysters are lacking. And our industry may, for many years to come, demand nothing more pertinent to its welfare than State spawning-grounds near centers of oyster-culture.

With regard to the production of seed oysters in the United States on some such principle as has been followed by the French, the main question is whether it would pay, in view of the higher price of labor in this country. While not expressing a positive opinion in the matter, Dr. Dean is not inclined to answer the question in the negative, and in respect to this subject he presents many facts which are deserving of careful consideration.

THE SPANISH MACKEREL, SCOMBEROMORUS MACULATUS.

The experiments relative to the hatching of this species, together with the study of its life-history and habits, begun on June 14, 1891, were continued until July 31. The results obtained during the former month have been referred to in the last annual report. The work was conducted in the neighborhood of Cape Charles City, Va., on board the steamer *Fish Hawk*, Lieut. Robert Platt, U. S. Navy, commanding, the biological investigations being carried on by Mr. J. Percy Moore, of the University of Pennsylvania.

The earliest catch of Spanish mackerel at Cape Charles City was reported on May 26, but stormy weather interfering with fishing operations and keeping the water at a relatively low temperature, only small numbers were obtained in the beginning, and, in fact, they were not at all abundant at any time during the season. The first ripe fish were not taken until June 17, but from that date up to July 31 from 1 to 8 mature females were secured on each of twenty-five days, the total number of fish from which eggs and milt were obtained amounting to 97 females and 121 males. From 1,000 to 330,000 eggs were fertilized each day, or a total of 2,494,000 eggs for the season, and an average of 25,711 eggs to each female. Several entire lots of spawn, amounting to 516,000 eggs, died before hatching. From the balance 829,000 embryos were secured, making the proportion of eggs hatched 41.9 per cent. There was considerable variation among the different lots in this respect, however, some yielding only 4 per cent of fry and others as high as 63 per cent; the proportion was seldom less than 25 per cent, and generally above 30 per cent. The period of incubation up to the time when hatching began ranged from 21 to 29½ hours, and for all the lots averaged 24⅖ hours. The rate of development of the embryos was found to be greatly affected by temperature and amount of sunshine, and electrical conditions seemed also to have their influence, but to what extent could not be ascertained.

Temperature and density observations were kept up during the progress of the work, but as corresponding observations for the period just preceding the appearance of the ripe fish are lacking it is not possible to determine what relations the spawning functions bear to changes in the physical condition of the water. The surface-water temperature was subject to considerable and often sudden variation, corresponding to fluctuations in the air temperature, dependent upon the time of day, conditions of weather, etc. Four observations were made daily, namely, at 6 a. m., noon, 6 p. m., and midnight. On June 18 the water temperature at these hours was 77.5°, 80°, 78°, and 78°, respectively. The record for the entire season shows that the temperature at 6 a. m. ranged from 72° to 80°; at noon, from 72° to 82°; at 6 p. m., from 73° to 84°; and at midnight, from 74° to 81°. The densities, corrected to 60° F., ranged from 1.0134 to 1.0186, being, of course, greatly influenced by the tides.

The fish made use of in connection with these experiments were obtained from the different traps distributed between Hungers Wharf and Butlers Hole, the catch from which is mostly marketed at Cape Charles City. Spawn-takers were on hand whenever the traps were hauled, and it is gratifying to acknowledge the hearty coöperation which they received from the fishermen. Mr. Moore always accompanied one of the parties, and was thus enabled to greatly extend the scope of his observations. The following notes are based mainly upon a preliminary report which he has furnished:

The Spanish mackerel were never abundant, and in the beginning the prospects seemed very discouraging, but about June 24 somewhat better runs began. The small amount of spawn taken, however, was not due entirely to the scarcity of fish. The difficulty arose mainly from the fact that the fish appear to spawn chiefly at night or in the early evening, and when the traps were hauled in the morning the ova sacs were generally empty. The great pressure produced by the lifting of the nets and the violent struggles of the fish when they are closely massed together may also be held partly accountable for this result. The experience gained this season in the collecting of the fish leads to the conclusion that the pounds as run for commercial purposes can not be relied upon to furnish a large supply of spawn, and the use of gill nets proved an entire failure, as described in the last report. In the event of extensive operations in the hatching of this species it would, therefore, be greatly to the advantage of the work if one or more pounds could be controlled entirely in this interest, in order that they might be tended and the fish removed at the proper times to insure the retention of the spawn and milt. Such an arrangement could readily be made. The most satisfactory fishing-ground was found at the mouth of Hungers Creek, where there are also excellent facilities for the establishment of an inexpensive hatching station.

The spawn of the Spanish mackerel does not all mature at the same time, and each of the full ovaries examined contained eggs in all stages from the ripe condition down to the minute, nucleated, cell-like eggs of incipient development. Each fish, even under the best conditions, yielded only a comparatively small amount of mature eggs, the greatest number taken from a single individual having been 60,000, and this was far in excess of the usual experience. It is impossible to reconcile this result with the figures given in connection with earlier experiments respecting the Spanish mackerel, made in the same locality, when over a million mature eggs were sometimes credited to a single fish, but this much can be said, that the observations made in 1892 were conducted with great care, and it is considered that they may be entirely relied upon. It is also noticed by Mr. Moore that the two sexes seemed to school more or less separately, and of the specimens secured the males greatly exceeded the females in numbers.

The experiments appeared to indicate that it is immaterial whether a constant current of water is maintained in the hatching apparatus or not, so long as the jars are kept scrupulously clean and are not overcrowded. The good eggs are all hatched before they can be affected by the decomposition of a few dead ones, when the fry can be removed to a place of safety. The jars should be made of glass or at least have enameled surfaces to prevent the rupture of the egg membranes, which are especially delicate in this species. The tidal cod jars were employed with best success on the *Fish Hawk*, not more than 60,000 eggs generally being placed in each. One small lot of eggs treated in a jar of this character, with quiet water, hatched to the extent of 90 per cent.

For the reasons above explained the greatest care must be exercised in taking and handling the spawn. It would be preferable to use filtered water in the hatching work, in order to escape the accumulation of sediment, which settles at the bottom of the jars, and, together with dead organic matter, tends to kill the eggs in water of low density. This probably may be obviated, however, by maintaining a higher density than sometimes occurs in this locality, by which means the eggs are kept floating and out of danger. The best results were accomplished and, in fact, nearly all the hatching was done under the latter conditions, which also insure a ready way of separating the good from the bad eggs, sufficiently accurate for all practical purposes.

In any future experiments it will be advisable to determine if some economical means can not be devised for holding the fry in confinement until they reach a size when they are better able to take care of themselves. This question has been satisfactorily settled with respect to several other species, and the success which may be attained in the propagation of Spanish mackerel will be measured by the extent to which this feature can be carried out. When the fry are deposited in the open waters of Chesapeake Bay their existence is at once threatened by the strong currents and often heavy sediment, and in all places, however much sheltered, they are the prey of multitudes of young fishes which swarm in this region. Even though the utmost care was exercised, however, it was found impossible to keep the fry in an aquarium on board the *Fish Hawk* for more than one week, but in a properly constructed tidal inclosure better success might possibly be obtained. After the fry began feeding in the aquarium their stomachs were observed to contain a few minute green algæ and a mass of material evidently derived through the disintegration of organic substances. The food of the adults during June and July consisted chiefly of young alewives, which were very abundant about the ship, together with various cyprinodonts, silversides, etc. They doubtless devour any small fishes that come in their way.

Some progress was made in the study of morphology and embryology of this species on board the *Fish Hawk*, and material was preserved for the purpose of continuing these researches at a later time.

RIVER POLLUTION.

In February, 1892, the Fish Commission was requested to investigate what was claimed to be a serious case of pollution in the Susquehanna River near the town of Havre de Grace, Md., having its source in a large mill where paper is manufactured from wood pulp. An examination of the conditions existing near the mill was made at once by Prof. Evermann, and careful tests were applied to determine the possible effects produced by the outflow of the waste liquor. The results of the inquiry were not conclusive, and, in fact, the studies have not been entirely completed, but, in view of the widespread interest which attaches to any information bearing upon this much-disputed subject, it seems important to present a brief review of the investigation so far as it has been carried on.

At the mill in question five large digesters are used for converting the wood into pulp, and in each of these from 1,000 to 1,200 gallons of sulphurous acid, or a total of 5,000 to 6,000 gallons, are employed daily. The contents of the digesters are subjected to steam heat for a period of twenty-four hours, after which the acid passes through a trough into the river at a point where a strong current issues from several turbine wheels. The direction of this current is such that it tends to retain the acid for some time along the right shore of the river—that on which the mill is located. The volume of water said to pass the turbine wheels amounts to about 1,000,000 gallons per minute, which is estimated to be not far from one-fifth the average flow of the river at this place. Five minutes are consumed in emptying each digester, during which time 5,000,000 gallons of water would issue at the same point, and in that case the mixture of acid with water would be in the proportion of 1 part of the former to 5,000 parts of the latter; but should all the digesters be emptied at the same time the proportion would change to 1 part of acid to 833 parts of water. This latter occurrence is not probable, however, and, in any event, according to the statement of the manager of the mill, the entire outflow of acid during any twenty-four hours would not exceed their total capacity of 6,000 gallons.

On the part of the fishermen it was claimed that whenever schools of fishes approached the locality occupied by the mill they were driven back and disappeared, and, in fact, that they have come to avoid the neighborhood, greatly to the detriment of the fishing interests. Unfortunately, at the time the examinations were made the season was still too early to observe the direct effects of the polluted water, and although it was arranged that the Commission should be informed as soon as the fish began running no notice to that effect has been received. Samples of the acid, of the waste liquor as it issues from the mill, and of the river water at the time of emptying a digester, at distances of 100 and 400 yards and of $1\frac{1}{8}$ miles below the outlet, were obtained, however, and sent to Washington. None of the samples of river water showed by color or smell any perceptible trace of acid contamination. The waste liquor as it passes out from the digester is a dark-reddish liquor, having a specific gravity of 1.006 at 4° C. and a pungent odor, apparently of sulphurous acid and creosote. The following experiments with this refuse product mixed with water were made by Dr. R. R. Gurley:

A shiner, roach, and young sunfish were placed in such a mixture, beginning with the proportion of 1 part of acid to 250 parts of water and gradually increasing the strength to 4 per cent of acid, during a period of four days, but with no deleterious effect upon the fishes. The odor and taste of the acid first became perceptible when the proportion of the same reached 1.2 per cent. A young sunfish remained alive and apparently without suffering during twenty-four hours in a mixture containing 10 per cent of the waste liquor. A young shad was placed in a solution of 1 per cent strength of acid, which was increased by 1 per cent additions until 10 per cent was reached. The first definite results were obtained with strength of 7 to 8 per cent, and consisted in slight distress, especially in progressive enfeeblement of muscular action. At 10 per cent this was more marked, and after one to two hours the fish died from suffocation, as evidenced by paroxysmal efforts to escape and frequent choking gasps at the surface. One fish similarly immersed, but removed to pure sea water at the first moment that loss of equilibrium was observed, was easily revived. Young shad were subsequently put directly in strong solutions ranging from 10 to 33⅓ per cent of acid, which produced more sudden and acute effects.

Dr. Gurley concludes from his experiments that fish can support for a long period mixtures into which this refuse does not enter in a greater proportion than 10 per cent; that in greater strengths, even up to 25 per cent, the fish would often have time to make its escape before being overwhelmed; and that at about 33 per cent the point is reached where the fish is overwhelmed at once, and his escape would usually not be possible.

In summing up the results, Prof. Evermann remarks that—

> While it does not seem evident from these tests that the fishes of the Lower Susquehanna could be affected as seriously as has been supposed, it should be borne in mind that while the contamination may not be great enough to kill fishes, it might be sufficient to drive them from that part of the river where the mill is located. They began using sulphurous acid at the mill about January 14, 1891. According to the fishermen, the herring fishing began a few days earlier than usual in the spring of 1891, and was fairly good until about April 30, when the fish suddenly disappeared, this being several days earlier than they generally leave. At the same time numerous such fish were seen upon the surface of the water at various places below the mill. Whether these results were due to contamination from the mill can not be certainly stated.

DISEASES AND PARASITES OF FISHES.

Dr. R. R. Gurley has continued his researches respecting the diseases of fishes, a subject which constitutes one of the most important lines of inquiry within the province of this division. While the successful determination of the causes of mortality and especially of epidemics among fishes in their wild state will be exceedingly interesting and possibly productive of much good, it is the fish-culturist who will appreciate most highly the solution of any one of the many perplexing problems of this nature which are associated with his work. The sudden appearance of some unknown disease or rapidly spreading parasite, for which no remedy has been discovered, affecting breeding stock, the eggs or embryos, or the young fishes held in temporary confinement, is a matter of frequent occurrence, and too often results in great destruction. Scarcely a year passes without receiving complaints of serious losses from some such cause, the origin and, in fact, the actual conditions of which have never been accounted for.

During the winter of 1891–92 much trouble was experienced with the eggs of many of the rainbow trout at the Neosho Station, Missouri, which, when extruded from the females, were hard and fully rounded, falling into the receiving pan like shot, and failing to become fertilized by contact with the milt. The same peculiarity had also been observed previously at other stations. Prof. C. E. Riley, of Drury College, Missouri, who examined the eggs while the stripping was still in progress, was inclined to attribute their abnormal condition to the presence of many minute organisms discovered in the fluid which issued with them from the ovarian openings. Dr. Gurley, however, who was prevented from visiting the station at that time, but who was furnished with a series of the eggs preserved in alcohol, discredits this view and has suggested two other possible causes, namely, prematurity on the part of the spawners, which were only twenty months old, and inflammation of the ovaries.

Mr. W. F. Page, superintendent of the Neosho Station, does not consider either of these explanations satisfactory, as rainbow trout from five to nine years old have furnished eggs of the same character in the past, and the fish in question had been stripped this year for the first time, so that inflammation could not have been produced in them from excessive handling.

The solution of this question must, therefore, be left until another opportunity occurs to study specimens affording the hard eggs during the spawning period.

Dr. Gurley has now in course of preparation a complete review of the extensive group of protozoan parasites termed Myxosporidia, which infest fishes and also some other kinds of aquatic animals, and are sometimes the cause of great mortality among them. No systematic revision of the group has yet been published, and the descriptions of the different forms are mainly scattered through the pages of various journals. Such American species as can be obtained will be discussed from a study of the fresh material.

COLLECTIONS, PREPARATION OF REPORTS, ETC.

The quarters assigned to this division for laboratory purposes in the Central Station of the Fish Commission at Washington are no longer adequate to meet the increased requirements of the work, and additional space is much needed. This want is mainly felt in respect to accommodations for special biological and physical inquiries, which are now so poorly provided for as to greatly retard their progress, while, at the same time, the demands for information based upon such studies are becoming more urgent every year. There is also insufficient storage space for the large collections constantly arriving from the several vessels and field parties, which are now performing practically continuous service during all seasons. Although it is not intended to retain from these collections more than a small type series, to serve for the identification of species, yet, owing to the slow progress necessarily made in the elaboration of results by the few assistants now employed, it must be expected that large quantities of material will always remain on hand.

The extensive investigations conducted in the interior of the country have supplied the main part of the natural-history collections received during the past year, much less than usual having been derived from the inquiries of the *Albatross*, in consequence of the almost continuous detail of that vessel to special duties. The dredgings and fishing trials made in the Strait of Juan de Fuca, at the Hawaiian Islands while on the cable survey, and to some extent in Bering Sea and along the Aleutian Islands in connection with the fur-seal expeditions, contributed many things of interest, however, and on the visit paid to the Commander Islands several specimens were obtained of the fur seals belonging on the Asiatic coast.

The fresh-water fishes have been mostly studied by Prof. B. W. Evermann, who has the direct charge of that group. The general collection of marine fishes made by the steamer *Albatross* has been referred to Prof. Charles H. Gilbert, of Leland Stanford Junior University, who has been at work for some time on the earlier collections from the same source, while Prof. O. P. Jenkins, also of the Stanford University, will report upon the special and very interesting series secured at the Hawaiian Islands. The *Albatross* mollusks and higher crustaceans are being attended to at the U. S. National Museum, the former group by Mr. William H. Dall, curator of the department of mollusks, the latter by Mr. James E. Benedict and Miss M. J. Rathbun, of the department of marine invertebrates. To Mr. Benedict has also been assigned the collection of annelids made during the cruise of the steamer *Albatross* from Norfolk to San Francisco in 1887–88. The crayfishes obtained in connection with the interior investigations are being studied by Prof. Walter Faxon, of the Museum of Comparative Zoology.

During the summer of 1891, when Prof. Charles H. Gilbert finally severed his connection with the Indiana University, he returned to Washington all of the *Albatross* fishes on which he had completed his observations, comprising nearly all of the specimens collected in the North Pacific Ocean south of Alaska, and forming a very large collection. The remainder, chiefly from Bering Sea, were forwarded to him at the Stanford University.

The last annual report contains an account of an expedition by the steamer *Albatross* during the early part of the calendar year 1891 off the west coast of Mexico and Central America and to the Galapagos Islands, under the scientific direction of Mr. Alexander Agassiz, director of the Museum of Comparative Zoology of Harvard University, and reference is also made in the same connection to the valuable natural-history results obtained. As Mr. Agassiz offered to provide, at his own expense, for the study of this material and the publication of the reports upon it, the matter was placed entirely under his supervision and will be directed by him from Cambridge, Mass.

The collections were assorted partly in Washington and partly in Cambridge, and during the past year the different groups have been distributed for study among a number of specialists who were selected with reference to their previous acquaintance with the subjects assigned them, several having participated in the working up of the collections obtained during the famous cruise of H. M. S. *Challenger*. Their reports, when they shall have been completed and published, will undoubtedly constitute one of the most important series of contributions ever issued respecting the biology of the deep sea.

The assignments made have been as follows:

The birds, to Mr. Robert Ridgway, U. S. National Museum; reptiles, to Mr. Leonhard Stejneger, U. S. National Museum; fishes, to Mr. Samuel Garman, Museum of Comparative Zoology; phosphorescent organs of fishes, to Dr. R. von Lendenfeld, Innsbruck, Austria; cephalopods, to Prof. William E. Hoyle, Owens College, Manchester, England; gastropod, lamellibranch, and scaphopod mollusks, to Mr. William H. Dall, U. S. National Museum; nudibranch mollusks, to Dr. R. Bergh, Copenhagen, Denmark; pteropods and heteropods, to Dr. P. Schiemenz, Zoological Station, Naples, Italy; ascidians, to Prof. W. A. Herdman, Liverpool, England; salpidæ and doliolidæ, to M. P. A. Traütstedt, Denmark; bryozoans, to C. B. Davenport, Museum of Comparative Zoology; land insects, to Prof. C. V. Riley, Washington, D. C.; halobatidæ, a group of pelagic insects, to Mr. E. P. van Duzee, Buffalo, N. Y.; pycnogonids, to W. Schimkewitch, St. Petersburg, Russia; crustaceans, to Prof. Walter Faxon, Museum of Comparative Zoology; ostracods, to Dr. G. W. Müller, Greifswald, Germany; annelids, to Mr. James E. Benedict, U. S. National Museum; sipunculoid worms, to Mr. H. B. Ward, Troy, N. Y.; sagittæ, to Dr. K. Brandt, Kiel, Germany; planarians, to Mr. W. McM. Woodworth, Museum of Comparative Zoology; holothurians, to Prof. Herbert Ludwig, Bonn am Rhein, Prussia; echini, to Mr. Alexander Agassiz; starfishes, to Mr. W. Percy Sladen, London, England; ophiurans, to Prof. C. F. Lütken, Copenhagen, Denmark; comatulæ to Dr. C. Hartlaub, Göttingen, Germany; stalked crinoids, to Mr. Agassiz; antipathes, to Mr. George Brook, Edinburgh, Scotland; alcyonarians, to Prof. Theodor Studer, Berne, Switzerland; actinarians, to Prof. E. L. Mark, Museum of Comparative Zoology; actinian and hydroid corals, to Dr. G. von Koch, Darmstadt, Germany; hydroids, to Prof. S. F. Clarke and Mr. F. E. Peabody, Williams College, Mass.; acalephs and pelagic fauna generally, to Mr. Agassiz; siphonophores, to Mr. C. Chun, Breslau, Germany; sponges, to Prof. H. V. Wilson, University of North Carolina; foraminifera, to Prof. A. Goës, Stockholm, Sweden; thallasicolæ, to Dr. K. Brandt, Kiel, Germany; nullipores, to Prof. William Farlow, Harvard University; samples of ocean bottom, to Mr. John Murray, Edinburgh, Scotland; geological specimens, to Mr. George Merrill, U. S. National Museum. Mr. John Murray, who directed the preparation of the scientific results of H. M. S. *Challenger* after the death of Sir Wyville Thomson, has also been furnished with a complete series of the bottom samples taken by the steamer *Albatross* during the recent investigations in the North Pacific Ocean and Bering Sea, on which he has promised to prepare a special report.

A very large amount of material in the line of fishes and marine invertebrates, derived mainly from the expeditions of the *Albatross* and the investigations in Montana and Wyoming, has been transferred to the custody of the U. S. National Museum, and also a large series of plants and many bird and mammal skins collected incidentally in Alaska. Sets of duplicate specimens of natural history selected from the collections made by the Fish Commission have been prepared and distributed by the National Museum to the following institutions: Biological School, Avon by the Sea, N. J.; Wells College, Aurora, N. Y.; Trinity University, Durham, N. C.; Fort Worth University, Fort Worth, Tex.; State Normal School, Mankato, Minn.; Iowa State Normal School, Cedar Falls, Iowa; State Normal School, Whitewater, Wis.; Mansfield Memorial Museum, Mansfield, Ohio; Leland Stanford Junior University, Cal.; Pennsylvania State Normal School, Millersville, Pa.; Tulane University, New Orleans, La.; National Deaf-Mute College, Washington, D. C.; The Australian Museum, Sydney, New South Wales; University of Toronto, Canada; Royal Zoological Museum, Copenhagen, Denmark.

In addition to the above, several requests from specialists for material of different kinds, desired for the study of biological problems, have been met directly by the Fish Commission.

Besides the papers referred to on preceding pages, the following, descriptive of Fish Commission materials, either wholly or in part, have been published during the past year:

Fishes collected by William P. Seal in Chesapeake Bay, at Cape Charles City, Va., September 16 to October 3, 1890. By Barton A. Bean. Proc. U. S. Nat. Mus., vol. XIV, pp. 83–94, 1891.

Preliminary descriptions of 37 new species of Hermit Crabs of the genus Eupagurus in the U. S. National Museum. By James E. Benedict. Proc. U. S. Nat. Mus., vol. XV, pp. 1–26, 1892.

The Genus Panopeus. By James E. Benedict and Mary J. Rathbun. Proc. U. S. Nat. Mus., vol. XIV, pp. 355–385, Pls. XIX–XXIV, 1891.

Scientific results of explorations by the U. S. Fish Commission steamer *Albatross*. No. XX. On some new or interesting West American shells obtained from the dredgings of the U. S. Fish Commission steamer *Albatross* in 1888, and from other sources. By William H. Dall. Proc. U. S. Nat. Mus., vol. XIV, pp. 173–191, Pls. V–VII, 1891.

Scientific results of explorations by the U. S. Fish Commission steamer *Albatross*. No. XXI. Descriptions of Apodal fishes from the tropical Pacific. By Charles H. Gilbert. Proc. U. S. Nat. Mus., vol. XIV, pp. 347–352, 1891.

On a peculiar type of arenaceous foraminifera from the American tropical Pacific, *Neusina agassizi*. By A. Goës. Bull. Mus. Comp. Zool., vol. XXIII, No. 5, pp. 195–197, 1 plate.

REPORT ON THE DIVISION OF METHODS AND STATISTICS OF THE FISHERIES.

By Hugh M. Smith, *Acting Assistant in Charge.*

ORGANIZATION AND FUNCTIONS OF THE DIVISION.

The following report, embracing the operations of this division during the fiscal year 1892, is respectfully presented. The administration of the division affairs during this period continued under the nominal direction of Capt. J. W. Collins, who was the assistant in charge. His designation, however, in August, 1890, as representative of the U. S. Commission of Fish and Fisheries on the Government Board of Control of the World's Columbian Exposition, had necessitated the withdrawal of much of his attention from this division, and the supervision of the office duties and field investigations largely devolved upon the writer.

The establishment of a division having for its purpose the consideration of various questions connected with the economic fisheries, but more especially the statistics, methods, and relations of the industry, was achieved at a comparatively recent date in the history of the Commission, although from the outset the subject received such attention as the means would permit and important contributions to a knowledge of the commercial fisheries were brought out during the years preceding the formal organization of this branch of the service. At an early period the necessity for having statistical data was fully appreciated, and Prof. Baird undertook a number of minor inquiries directed to the statistical aspects of special fisheries and regions. The taking of the census of the fisheries in 1880 devolved on the Commission; and, under the direction of Dr. G. Brown Goode, the first reliable and satisfactory census of our fishing industry was then given to the country. From 1880 to 1885 a small sum was annually appropriated by Congress for carrying on statistical work. For the fiscal years 1886, 1887, and 1888 no special allotment was made by Congress, the general appropriations for the Fish Commission being apportioned among the various branches of the work at the discretion of the Commissioner. Under this arrangement the study of the fisheries received more substantial recognition than had previously been accorded. The organization of a separate force for the collection and compilation of statistics and their incorporation in descriptive reports may be said to date from 1886. It was not until the following year, however, that the establishment of a distinct office for this work was consummated, and it was not until 1888 that this division was specially noticed and appropriated for by Congress.

The nature and scope of the work included under the functions of this division may be thus summarized:

(*a*) A general study of the economic ocean, coast, river, and lake fisheries of the United States in their statistical, historical, and other aspects.

(*b*) A study of the vessels, boats, apparatus, and methods employed for the purpose of ascertaining those which are most effectual and economical, of suggesting improvements, and of discouraging the use of forms of apparatus and methods of capture that are unnecessarily destructive.

(*c*) An investigation of the fishing-grounds resorted to by American fishermen, with a view to ascertain their resources, the seasons of abundance of the fish and other water products occurring thereon, and the effects of present and past methods of fishing on the supply.

(*d*) A consideration of the economic and social conditions of the fishing population, their nationality and nativity, wages, disasters, etc.

(*e*) An investigation of the methods of curing, freezing, canning, and otherwise preparing fishery products for market, the offering of suggestions for the utilization of fish and other aquatic animals that are now regarded as of little or no value and are usually thrown away or sold at nominal prices.

(*f*) An inquiry into the condition and extent of the wholesale trades in fishery products, the sources of supply, the principal lines of distribution, and the means and methods of transportation.

(*g*) A consideration of the international relations of the fisheries and the collection of information bearing on questions involving the privileges, movements, treatment, expenditures, etc., of American fishermen in foreign waters and ports.

(*h*) The dissemination among the fishing interests, either by correspondence or printed reports, of information intended to promote the industry; the preparation for State fish commissions or other State officers of special reports illustrating the fishery resources of the States.

(*i*) The determination of the results of artificial propagation and of legislation on the abundance of fishes and other economic products.

While the functions of the division are sufficiently well marked, they nevertheless, in certain lines, necessarily overlap those of the Division of Fish-culture on the one hand and the Division of Scientific Inquiry on the other. The determination of the results of artificial propagation and of the necessity for its inauguration naturally fall to its consideration, and in the investigations of the past and present extent of the fisheries it has always been the aim to bring out these points. In the consideration of the economic resources of the fishing-grounds, of the movements and abundance of food-fishes and other aquatic products, and of other subjects connected with the objects of commercial fisheries, the division approaches the limits of the Division of Scientific Inquiry, but rather supplements than encroaches upon the functions of that branch of the Commission's work.

In the prosecution of its inquiries having in view the collection of data bearing on the foregoing topics the division depends almost wholly on the personal field investigations of its agents. While in a few instances the use of circulars and schedules has been resorted to in the prosecution of minor inquiries by mail, they have generally failed to give satisfaction, and, in the interests of completeness and accuracy, they are utilized only when other methods are especially contra-indicated, by reason of the expense involved, etc.

The prominent feature of the organization of this branch is the corps of agents whose active service in the field constitutes the chief work of the division and affords the principal basis for the preparation of reports on the various phases of the fisheries and furnishes ground for the intelligent comprehension on the part of the Commission of the condition and needs of the industry.

The number of field agents now authorized by Congress is five. By reason of previous practical connection with the fishing industry, and by virtue of lengthy service in their present capacity, the agents are able to bring to bear on their work an invaluable knowledge of the fisheries and of the best methods of conducting the canvass that greatly contributes to the reliability and completeness of the investigations. The repeated personal visits of the agents to fishing communities enables the Commission to maintain close relations with the principal fishermen and fish-dealers of the country, and facilitates the collection of more satisfactory data than would be possible under any other circumstances.

In gauging the work of the division, and in placing a proper estimate on the results accomplished, it is a matter of importance to take into account the small force available for field and office duty and the limited means at hand for carrying on investigations of the extended scope occasioned by the nature of the subject under consideration, as previously outlined. An arrangement intended to place the division on an ideal basis, which would permit an annual or biennial study of the entire fishing interests of the country and the prompt issuance of reports thereon, would require a field force at least four times as large as the present one, a corresponding increase in the number of clerical assistants, and an appropriation of about twice the amount available for the year 1892. The shore line of the States bordering on the coast and the Great Lakes is nearly 30,000 miles in length. The canvass of this extensive territory can, with the present force, be accomplished only once in three or four years, a definite geographical section or special branches of the industry being covered each year until the whole is completed. During the continuance of present conditions the work will necessarily have to be carried on along the same general lines which have heretofore been observed.

It is gratifying to be able to note that the usefulness of the division is being yearly increased, as the working forces become better trained in the field and office duties, and as a result of the accumulation of data that puts the office in position to fully and promptly comply with the demands that are continually made upon it for information concerning the fisheries; so general and comprehensive have been the field inquiries prosecuted, that there are few phases of the commercial fisheries, or few questions that can be propounded regarding them, that are not covered by the office records.

The principal subjects that come up for notice in this report are: A history of the scope and conduct of the field investigations undertaken in 1891–92; a review of the results of those investigations; an account of the reports published by the division during the year; relations with the Eleventh Census; a consideration of the prominent events connected with the commercial fisheries, including the present conditions of the principal branches of the industry, experiments with new types of apparatus, international questions relating to the fisheries, etc.; and recommendations for the future conduct of the work of the division.

INVESTIGATIONS OF THE STATISTICS AND METHODS OF THE FISHERIES.

In planning for the field investigations to be undertaken by the division in 1891–92, the determining consideration in the selection of the regions to be canvassed was the date of the last inquiries in the several sections of the country. The fisheries of the New England and Pacific States had been studied in 1889, and those of the South Atlantic and Gulf States in 1890 and 1891; but no investigation of the Great Lakes had been made since 1885, and the Middle Atlantic States had not been covered since 1888. It was in these regions, therefore, that it was decided to place the field force, although there were other considerations, in addition to time, that prompted the selection of these sections. A minor inquiry was also made in Albemarle Sound and some of its tributaries, in North Carolina, and the regular investigations heretofore carried on by local agents at Boston and Gloucester, Mass., were continued.

THE GREAT LAKES.

When, in 1885, the Fish Commission conducted a comprehensive inquiry into the fisheries of the Great Lakes, it was found that the industry was in a flourishing condition, and the yield was probably greater than in any previous year. The results of that investigation were embodied in a report,* to which recourse should be had for a detailed account of the history, methods, and statistics of these fisheries. In 1891 the time was thought to be opportune for another canvass of this region, which was accordingly undertaken in the first half of the fiscal year. Messrs. W. A. Wilcox and T. M. Cogswell were assigned to Lake Superior; Ansley Hall, E. E. Race, and H. P. Parker to Lake

* Review of the Fisheries of the Great Lakes in 1885. Compiled by Hugh M. Smith and Merwin-Marie Snell. With introduction and description of fishing vessels and boats by J. W. Collins.

Michigan; E. A. Tulian to Lake Huron; W. A. Wilcox to Lake St. Clair and the St. Clair and Detroit rivers; Seymour Bower and C. H. Stevenson to Lake Erie; and H. M. Smith and C. H. Stevenson to Lake Ontario. Mr. Tulian and Mr. Bower, who were detailed from the Division of Fish-culture, had taken part in the investigations of 1885, and the office was fortunate in again securing their services. The preparation of the report covering this inquiry is completed and it is therefore possible at this time to give an accurate summary of the prominent features disclosed.

Since the inception of fish-culture on a large scale in the United States the Great Lakes region has been a favorite and favorable field for carrying on that work. Every State having a frontage on the lakes has appreciated the importance of artificial propagation in maintaining and increasing the supply of food-fishes and has given its appreciation practical form by establishing a board of fish commissioners and founding one or more hatching stations. The General Government has also coöperated with the States in every lake.

The species to which the greatest attention has been given are whitefish (*Coregonus clupeiformis*), lake trout (*Salvelinus namaycush*), and wall-eyed pike (*Stizostedion vitreum*). A knowledge of the present and past abundance of these fishes becomes a matter of great importance, the determination of which naturally falls to the consideration of this division. Besides the fish now propagated there are others of growing importance to which attention should be directed, in view of the probable necessity at an early date of securing their preservation and multiplication by artificial means. Chief among these is the sturgeon.

A comparison of the present and past abundance of the whitefish is not entirely satisfactory and involves some elements of uncertainty. There are at least five species of whitefish of commercial importance occurring in the Great Lakes, viz, the common whitefish (*Coregonus clupeiformis*), the lake herring or cisco (*C. artedi*), the bluefin or blackfin whitefish (*C. nigripinnis*), the Menominee or round whitefish (*C. quadrilateralis*), the whiting, or Musquaw River whitefish (*C. labradoricus*), and the tullibee, or mongrel whitefish (*C. tullibee*). While all of these are not of marked economic value, at least three are taken in considerable numbers, and the others occur in greater or less abundance in some lakes. The superficial differences between some of these are not very pronounced and not always recognized by the fishermen and others. It therefore happens that in making returns of fish taken a fisherman may give a number of species under the general name of whitefish, and being thus recorded an incorrect idea is formed of the abundance of *Coregonus clupeiformis* in a certain lake or place. There is every reason to believe that in 1880 several minor species of *Coregonus* were recorded with the common whitefish; and it is known that in 1885 the same thing was done in some lakes, the species thus combined with *C. clupeiformis* being *C. nigripinnis* and *C. quadrilateralis*.

The improper use of common names of fishes also makes difficult the institution of satisfactory comparisons between the abundance of each fish at different periods; this applies with special force to the wall-eyed pike (*Stizostedion vitreum*), called pike and pickerel, and the true pike (*Lucius lucius*), called by the same names.

The following table shows in condensed form the extent of the fisheries of each of the Great Lakes in 1880, 1885, and 1890. The conditions prevailing in each lake are, as a rule, so distinctive that a general table of this kind conveys only an imperfect idea of the status of the industry and of the nature of the fluctuations. It is seen, however, that in 1890 the lake fisheries were somewhat less important than in 1885, but were much more extensive than in 1880, their rank being determined by the value of the products. The returns for 1890 show that 9,738 persons were employed in various capacities, $5,362,744 was invested, and the value of the catch was $2,471,768. Compared with 1880, an increase has occurred in each of these items; compared with 1885, there are to be noted a slight decrease in the number of fishermen, a substantial gain in the amount of capital invested, and a decline in the value of the catch. The details of these changes will be brought out in the consideration of the fisheries of each lake.

Comparative table showing the extent of the fisheries of the Great Lakes in 1880, 1885, and 1890.

Lakes.	Persons employed.			Capital invested.			Value of products.*		
	1880.	1885.	1890.	1880.	1885.	1890.	1880.	1885.	1890.
Superior	414	914	653	$81,380	$427,933	$366,682	$118,370	$291,523	$220,968
Michigan	1,578	3,378	2,877	551,135	1,757,831	1,437,224	668,400	878,788	830,465
Huron	470	892	726	103,730	385,349	408,858	195,277	276,397	221,067
St. Clair	356	272	611	40,580	251,081	210,145	36,273	40,193	73,577
Erie	1,620	4,298	4,482	515,100	1,562,138	2,816,302	474,880	1,109,096	1,000,905
Ontario	612	600	389	54,050	135,749	123,533	159,700	95,869	124,786
Total	5,050	10,354	9,738	1,345,975	4,520,081	5,362,744	1,652,900	2,691,866	2,471,768

* The value of all secondary products omitted.

The variations in the yield of the principal fishes, considering the entire lake region, may be seen from the following table. The species shown separately are whitefish, lake trout, sturgeon, and lake herring; other important fish, as pike perch and pike, deserve mention, but can not be exhibited in this table, owing to the fact that they were not separately recorded in 1880.

Whitefish, which in 1880 constituted the chief part of the catch, dropped to second place in point of quantity in 1885, and in 1890 were surpassed in this respect by herring and trout. The decrease in the output from 1885 to 1890 was about 30 per cent. Lake trout, which in 1885 exhibited a large increase over 1880, were taken in slightly greater quantities in 1890 than in 1885. Sturgeon have steadily decreased, the catch in the decade in question being reduced over 40 per cent. A prominent feature of the comparison is the largely augmented catch of the lake herring and its assumption of the first position among the lake fishes. The yield in 1890 was three times as great as in 1880 and nearly twice as great as in 1885. The combined production of all other species was about the same in 1885 and 1890, which years showed about double the output of 1880. The decrease in whitefish and sturgeon is more than offset by the increase in herring, so that the total catch in the lake region in 1890 was over 14,000,000 pounds more than in 1885 and about 45,000,000 pounds more than in 1880.

Comparative tabl showing the products of the fisheries of the Great Lakes in 1880, 1885, and 1890.

Species.	1880.	1885.	1890.
	Pounds.	*Pounds.*	*Pounds.*
Whitefish	21, 463, 900	18, 344, 004	12, 401, 335
Lake trout	6, 804, 600	12, 586, 665	12, 890, 441
Sturgeon	7, 557, 383	7, 147, 642	4, 289, 759
Herring	15, 967, 517	25, 869, 458	48, 753, 349
Other fish	16, 948, 600	35, 894, 107	35, 563, 647
Total	68, 742, 000	99, 842, 876	113, 898, 531

LAKE SUPERIOR

The fisheries of this lake are less extensive than those of any other member of the Great Lakes chain with the exception of Lake Ontario. The fishing is practically confined to the taking of whitefish and trout, the catch of all other species being insignificant. The season of 1890 was, on the whole, a satisfactory one, and the output was fully up to the average in recent years. It is therefore a favorable year with which to make comparisons with 1885 and on which to base conclusions.

Considered in the aggregate, a decline is to be noticed in the extent of the fisheries of the American shores of Lake Superior in 1890 as compared with 1885. The decrease was most marked in the items of persons employed and quantity and value of products. The relatively slight decrease in the investment is explained by a large increase in shore and cash property incident upon the establishment of large fish-purchasing houses. An analysis of the returns indicates that the decrease is more apparent than real and does not necessarily represent a scarcity of fish. The decline in the fisheries has been practically confined to Minnesota and has been due to a transfer of American interests to the Canadian side of the lake.

The extent of the fisheries in the American waters of this lake in 1890 is shown in the three following tables:

Persons employed in Lake Superior fisheries.

How engaged.	Number.
Vessel fishing	58
Shore fishing	517
Shore industries	78
Total	653

Apparatus and capital employed in Lake Superior fisheries.

Items.	Number.	Value.
Vessels (tonnage, 256.70)	8	*$61,300
Boats	320	23,975
Gill nets	5,974	63,476
Pound nets	140	34,435
Seines	19	955
Fyke nets	9	415
Dip nets	10	370
Spears	54	265
Lines		1,713
Shore and accessory property		109,878
Cash capital		69,900
Total		366,682

*Includes outfit.

Products of Lake Superior fisheries.

Species.	Pounds.	Value.
Herring, fresh	199,121	$4,616
Pike, fresh and salted	26,362	1,134
Sturgeon, fresh	47,482	1,401
Trout, fresh	2,065,030	72,430
Trout, salted	548,348	15,771
Whitefish, fresh	2,423,111	94,512
Whitefish, salted	790,065	30,475
Other fish, fresh and salted	16,473	629
Total	6,115,992	220,968

The fisheries in the Canadian waters of the lake in which Americans are pecuniarily interested are of considerable importance, as shown by the table. They are prosecuted with gill nets, pound nets, and fyke nets, and the principal fish taken are whitefish and trout. In the year covered by the investigation 1,137,387 pounds of fish, valued at $34,472, were brought into the United States from these fisheries on the northern and eastern shores of the lake.

Boats, apparatus, etc.	Number.	Value.	Species.	Pounds.	Value.
Boats	29	$2,840	Pike, fresh	8,000	$240
Pound nets	22	5,950	Sturgeon, fresh	36,170	1,085
Gill nets	322	10,108	Trout, fresh	330,000	9,900
Fyke nets	35	350	Trout, salted	20,000	700
Shore property		8,750	Whitefish, fresh	687,032	20,611
Cash capital		13,700	Whitefish, salted	56,185	1,936
Total investment		41,698	Total	1,137,387	34,472

As has been shown, the value of the fisheries of this lake in 1890 was more than in 1880, but less than in 1885. The decrease between the two later years was marked in every important fish and was especially serious in the case of whitefish and trout.

Comparison of the yield of the fisheries of Lake Superior in 1880, 1885, and 1890.

Species.	1880.	1885.	1890.
	Pounds.	*Pounds.*	*Pounds.*
Whitefish	2,257,000	4,571,947	3,213,176
Herring	34,000	324,680	199,121
Trout	1,464,750	3,488,177	2,613,378
Sturgeon	....	182,760	47,482
Other fish	60,875	258,216	42,835
Total	3,816,625	8,825,780	6,115,992

It can not be said that the decline in the fisheries of this lake has been principally due to a noteworthy or permanent diminution in the abundance of fish. While individual localities reported a scarcity of fish in 1890, the general opinion was that the catch was fully as good as it had been for a number of years. The diminished output appears to have been due almost entirely to the following circumstances:

1. A change in the methods of preparing fish for market, as a result of the growing demand for fresh fish. In 1885 3,916,250 pounds of salt fish were prepared by the fishermen of this lake. In 1890 that part of the yield sold in a salted condition amounted to only 1,378,261 pounds. As the best fish are usually salted only when they can not be disposed of in a fresh state, it follows that an increasing demand for fresh fish and a dull market for salt fish will necessarily reduce the output of localities that are remote from shipping centers.

2. As has been seen, considerable capital formerly devoted to the fisheries of the American side of the lake has been diverted to Canadian waters, under the provisions of the tariff law permitting the free entry of fish owned by citizens of the United States. Several unfavorable years and the supposed greater abundance of fish on the northern side of the lake have caused some extensive dealers to transfer their plants from American to Canadian ports, the home fishing being discontinued. The statistics show a decrease in the number of fishermen and a corresponding decrease in the amount of apparatus in localities from which wholesale purchasing houses have been removed.

Gill nets are the most important apparatus employed in this lake; they yield much larger quantities of products than all other means of capture combined. In 1890 they were employed from vessels to the number of 1,318 and from small boats to the number of 4,656. The aggregate catch was 3,778,012 pounds, valued at $133,636, of which 2,709,693 pounds, valued at $92,550, were taken in the shore fishery, and 1,068,319 pounds, worth $41,086, in the vessel fishery, the last-named figures representing only whitefish and trout.

Pound nets rank next to gill nets in the amount and value of the fish taken. Five-sixths of the quantity and value of the yield consists of whitefish. Trout and sturgeon are the only other fishes that are important items in the catch. The results of the fishery in 1890 were 1,669,017 pounds, valued at $62,911.

None of the other forms of apparatus in this lake is very important.

Fyke nets, seines, set lines, spears, and dip nets are sparingly used, but the aggregate catch is small in comparison with that in gill nets and pound nets, amounting in value to less than $25,000.

The following table shows in detail the quantity and value of each of the principal fishes taken with the various kinds of apparatus in 1890:

Table showing by apparatus and species the yield of the fisheries of Lake Superior.

Species.	Pounds.	Value.
Gill nets:		
Herring, fresh and salted	169,811	$4,021
Pike perch, fresh and salted	64	2
Trout, fresh	1,621,697	56,176
Trout, salted	441,280	12,912
Whitefish, fresh	1,258,096	49,403
Whitefish, salted	287,064	11,122
Total	3,778,012	133,636
Pound nets:		
Herring, fresh and salted	3,310	55
Pike, fresh and salted	12,628	453
Sturgeon, fresh and salted	42,982	1,266
Trout, fresh	184,188	6,796
Trout, salted	48,118	1,628
Whitefish, fresh	910,663	34,642
Whitefish, salted	466,530	18,057
Other fish, salted	598	14
Total	1,669,017	62,911

Species.	Pounds.	Value.
Fyke nets:		
Pike, fresh	13,200	$660
Trout, fresh	3,500	175
Whitefish, fresh	4,000	200
Other fish, fresh	3,875	135
Total	24,575	1,170
Seines:		
Herring, fresh	26,000	540
Trout, fresh	2,657	93
Trout, salted	1,825	64
Whitefish, fresh	28,524	1,066
Whitefish, salted	36,471	1,296
Total	95,477	3,059
Lines:		
Pike, fresh	470	19
Sturgeon, fresh	4,500	135
Trout, fresh	242,068	8,644
Trout, salted	57,125	1,167
Total	304,163	9,965
Other apparatus:		
Trout, fresh	10,920	546
Whitefish, fresh	221,828	9,201
Other fish, fresh	12,000	480
Total	244,748	10,227
Grand total	6,115,992	220,968

LAKE MICHIGAN.

In the number of persons engaged, in the amount of capital invested, and in the value of its fisheries this lake ranks second, a position which it has always held since the fishing industry of the lake region became prominent. The principal features of the fisheries of this lake are the large numbers of pound nets and gill nets employed. The extent of the gill-net vessel fishery here prosecuted surpasses that in all the other lakes combined, the great expanse of deep water being favorable for this fishery and affording the best protection against the exhaustion of the supply. Trout are the chief fish taken in the lake as regards both quantity and value; in no other lake are these fish so important. Next to trout in value are whitefish, although the lake herring, which rank third in value, are taken in larger quantities than whitefish.

The following tables show the extent and principal features of the fisheries of the lake:

Persons employed in Lake Michigan fisheries.

How engaged.	Number.
Vessel fishing	293
Shore fishing	2,215
Shore industries	369
Total	2,877

Apparatus and capital employed in Lake Michigan fisheries.

Designation.	Number.	Value.
Vessels	50	$173,350
Tonnage	793.65	....
Outfit	....	21,318
Boats	1,052	71,663
Apparatus of capture, vessel fisheries:		
Gill nets	18,810	106,854
Apparatus of capture, shore fisheries:		
Pound nets	844	244,880
Gill nets	22,086	109,060
Fyke nets	731	11,316
Seines	30	3,480
Lines and spears	....	2,144
Shore property	....	434,759
Cash capital	....	258,400
Total	....	1,437,224

Products of Lake Michigan fisheries.

Species.	Pounds.	Value.
Bass	143,139	$6,477
Herring	6,082,082	102,721
Perch	1,943,953	46,641
Pike and pike perch	566,021	21,987
Sturgeon	946,897	34,253
Suckers	1,800,783	27,106
Trout	8,364,167	349,193
Whitefish	5,455,079	219,059
Other fish	1,132,145	23,028
Total	26,434,266	830,465

The fisheries of Lake Michigan are more extensive than in 1880, but somewhat less so than in 1885, when, as shown in a preceding general table, more persons were engaged, more capital was invested, and more money accrued from the sale of fishery products. In 1880 whitefish constituted more than half the catch, in 1885 a little more than a third, in 1890 about a fifth. Sturgeon have decreased in a still more marked degree. Trout, however, have increased about 300 per cent, herring 200 per cent, and other fish between 300 and 400 per cent since 1880. The aggregate catch shows an increase of about 3,300,000 pounds over 1880, and 2,900,000 pounds over 1885, although, owing to the preponderance of the cheaper grades of fish, the value of the yield since 1885 has diminished $58,000. Following is a comparison of the production of this lake in the three years named:

Comparison of the yield of the fisheries of Lake Michigan in 1880, 1885, and 1890.

Species.	1880.	1885.	1890.
	Pounds.	*Pounds.*	*Pounds.*
Whitefish	12,030,400	8,682,986	5,455,079
Trout	2,659,450	6,431,298	8,364,167
Sturgeon	3,839,600	1,406,678	946,897
Herring	3,050,400	3,312,493	6,082,082
Other fish	1,562,025	3,684,693	5,586,041
Total	23,141,875	23,518,148	26,434,266

The gill net is the most important form of apparatus employed in the fisheries of this lake; it takes larger quantities of fish and yields more money returns than all other devices combined. Trout, whitefish, and herring constitute the bulk of the catch, trout predominating. Pound nets are the only other relatively important apparatus; they take about five-sevenths of the fish obtained in gill nets. Whitefish are the principal fish caught, although trout, herring, and sturgeon, are of considerable value; the yield of sturgeon by this means is much greater than in all other apparatus. Among minor devices are fyke nets, lines, seines, and spears. Fykes take chiefly herring, perch, pike, and suckers. Lines are employed mostly for perch; seines yield perch, pike, and suckers, and spears take small quantities of trout and pike.

The following table shows the quantity and value of each principal kind of fish taken in this lake with each form of apparatus:

Table showing by apparatus and species the yield of the fisheries of Lake Michigan.

Species.	Gill nets.		Pound nets.		Fyke nets.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	20,179	$1,006	14,800	$755	19,310	$950
Herring	3,608,968	67,434	2,103,733	30,321	332,650	4,436
Perch	427,575	12,020	453,680	10,098	419,700	8,862
Pike and pike perch	85,110	3,462	247,905	9,939	141,960	5,557
Sturgeon	16,595	636	844,887	30,224		
Suckers	673,216	10,613	620,033	10,266	335,410	3,887
Trout	6,409,190	263,322	1,513,229	63,761	11,980	470
Whitefish	2,873,784	111,435	2,560,456	106,792	5,285	235
Other fish	372,581	7,394	426,614	8,120	44,750	1,161
Total	14,487,198	477,322	8,785,337	270,276	1,311,045	25,558

Species.	Seines.		Lines and spears.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass			88,850	$3,766	143,139	$6,477
Herring	36,731	$530			6,082,082	102,721
Perch	185,117	3,086	457,881	12,575	1,943,953	46,641
Pike and pike perch	91,046	3,029			566,021	21,987
Sturgeon	6,250	220	79,165	3,173	946,897	34,253
Suckers	172,124	2,340			1,800,783	27,106
Trout			429,768	21,640	8,364,167	349,193
Whitefish	11,154	465	4,400	132	5,455,079	219,059
Other fish	35,910	988	252,290	5,365	1,132,145	23,028
Total	538,332	10,658	1,312,354	46,651	26,434,266	830,465

LAKE HURON.

The fisheries of this lake in 1890 exceeded those of Lake Superior by a few thousand dollars in the value of the catch, the number of persons employed was greater, and the invested capital was somewhat less. The principal fishing-ground is Saginaw Bay, where more than half the fishery products of the entire lake are taken. The extent of the commercial fisheries of this lake in 1890 was as follows:

Persons employed in Lake Huron fisheries.

How engaged.	Number.
Vessel fishing	26
Shore and boat fishing	590
Shore industries	110
Total	726

Apparatus and capital employed in Lake Huron fisheries.

Items.	Number.	Value.
Vessels (tonnage 79.05)	7	*$14,590
Boats	410	22,308
Gill nets	2,206	21,665
Pound nets	551	88,515
Seines	6	600
Fyke nets	221	6,385
Lines		770
Shore and accessory property		208,625
Cash capital		45,400
Total		408,858

* Includes outfit.

Products of Lake Huron fisheries.

Species.	Pounds.	Value.
Black bass, fresh	29,351	$2,167
Catfish, fresh	172,171	5,428
Herring, fresh	2,383,851	25,385
Herring, salted	130,700	2,796
Perch, fresh	1,817,628	20,792
Pike perch and pike, fresh	1,483,072	50,834
Sturgeon, fresh	365,718	8,924
Suckers, fresh	1,110,177	15,372
Trout, fresh	1,500,619	50,742
Trout, salted	5,000	300
Whitefish, fresh	1,002,694	37,135
Whitefish, salted	1,400	112
Other fish, fresh	54,000	1,080
Total	10,056,381	221,067

The changes in the fisheries of this lake since 1885 have consisted of a decrease in the number of fishermen, a corresponding diminution in the amount of apparatus used, a large decline in the yield of the more important fishes (viz, whitefish and trout), and a noticeable increase in the catch of lake herring. The fisheries of the north shore of the lake and the Saginaw Bay region show the most marked reduction since 1885. Compared with 1880 the only noteworthy improvement has been a larger catch of sturgeon, herring, and minor fishes. The following table is a comparative statement of the output of the Lake Huron fisheries in 1880, 1885, and 1890:

Comparison of the yield of the fisheries of Lake Huron in 1880, 1885, and 1890.

Species.	1880.	1885.	1890.
	Pounds.	*Pounds.*	*Pounds.*
Whitefish	2,700,778	1,425,380	1,004,094
Herring	246,800	1,265,650	2,514,551
Trout	2,084,500	2,539,780	1,505,619
Sturgeon	204,000	215,500	365,718
Other fish	1,969,195	6,010,860	4,666,399
Total	7,205,273	11,457,170	10,056,381

Pound nets are the most prominent apparatus now used in this lake. The number fished in 1890 was 551, of which 326 were operated in Saginaw Bay, the chief fishing-ground. The most important fish taken are whitefish, herring, trout, wall-eyed pike, and perch. The aggregate catch was 7,525,796 pounds, for which the fishermen received $150,825. Herring constituted about one-third of the yield, but was less valuable than whitefish.

Gauged by the value of the catch, gill nets rank next to pound nets in importance. They are used by both vessel and boat fishermen, though the vessel fishing is much less extensive than the boat fishing. In 1890 2,206 nets were operated, of which 336 were used on vessels. The gill-net catch consisted of 1,371,984 pounds, valued at $44,113, of which 407,075 pounds, worth $14,401, were taken with vessels. The principal fishing center for gill nets is Alpena. The only species that constitutes a prominent element in the yield is trout.

Fyke nets are important only in Saginaw Bay and River, where they take large quantities of the minor kinds of fish, notably perch and suckers. Of the total number of such nets used, viz, 221, 170 were employed in the region named, where they are set in conjunction with pound nets. The fyke-net catch in 1890 was 1,088,751 pounds, for which $23,156 was received.

The list of apparatus in this lake is completed by the enumeration of seines and lines, which are unimportant, the combined yield being only 69,850 pounds, having a value of $2,973.

The extent to which each prominent fish in this lake enters into the catch of each apparatus is shown in the following table:

Table showing by apparatus and species the yield of the fisheries of Lake Huron.

Apparatus and species.	Pounds.	Value.
Pound nets:		
Black bass, fresh	21,701	$1,402
Catfish and bullheads, fresh	167,071	5,275
Herring, fresh	2,358,301	25,065
Herring, salted	130,700	2,796
Perch, fresh	1,257,182	12,751
Pike and pike perch, fresh	1,363,072	44,224
Sturgeon, fresh	365,718	8,924
Suckers, fresh	742,622	8,321
Trout, fresh	329,292	12,167
Whitefish, fresh	776,937	29,636
Other fish, fresh	13,200	264
Total	7,525,796	150,825
Gill nets:		
Herring, fresh	18,550	290
Trout, fresh	1,122,477	35,972
Trout, salted	5,000	300
Whitefish, fresh	224,557	7,439
Whitefish, salted	1,400	112
Total	1,371,984	44,113
Fyke nets:		
Black bass, fresh	7,650	$765
Catfish and bullheads, fresh	5,100	153
Herring, fresh	1,000	10
Perch, fresh	558,446	8,021
Pike and pike perch, fresh	108,000	6,330
Suckers, fresh	367,555	7,051
Whitefish, fresh	200	10
Other fish, fresh	40,800	816
Total	1,088,751	23,156
Seines:		
Herring, fresh	6,000	20
Perch, fresh	2,000	20
Pike and pike perch, fresh	12,000	280
Trout, fresh	1,000	40
Whitefish, fresh	1,000	50
Total	22,000	410
Lines:		
Trout, fresh	47,850	2,563
Grand total	10,056,381	221,067

LAKE ST. CLAIR, ST. CLAIR AND DETROIT RIVERS.

This lake, with its two tributary rivers, although not one of the Great Lakes, is sufficiently distinct from Lake Huron on one side and Lake Erie on the other to warrant separate consideration of its fisheries, which, although less extensive than those of any of the Great Lakes proper, are nevertheless important, especially in view of the relatively small area of the fishing-grounds. The principal fishing is done with pound nets and seines, and the chief fish taken is the whitefish, the abundance of which, as judged by the catch, seems to have considerably increased in the past five years. The fisheries in 1890 were as a whole much more important than in 1885, which year exhibited an increase over 1880. The number of persons employed has increased, and the quantity and value of the catch have advanced, but the aggregate investment is somewhat less. A very important trade in fish is carried on in Detroit, and four steam vessels, fitted out with gill nets, are owned in the region, but prosecute fishing in Lakes Erie and Huron.

These fisheries had the following extent in 1890, the figures including the vessels fishing in the other lakes but owned in this section:

Persons employed in Lake St. Clair fisheries.

How engaged.	Number.
Vessel fishing	28
Boat and shore fishing	517
Shore industries	66
Total	611

Apparatus and capital employed in Lake St. Clair fisheries.

Items.	Number.	Value.
Vessels (tonnage, 38.56)	4	*$24,400
Boats	162	4,375
Gill nets	314	9,418
Pound nets	34	9,450
Seines	28	6,240
Fyke nets	148	4,480
Lines and spears	......	1,100
Shore and accessory property	150	106,082
Cash capital	......	44,600
Total	......	210,145

* Includes outfit.

Products of Lake St. Clair fisheries.

Species.	Pounds.	Value.
Black bass	9,086	$544
Catfish	26,275	616
Herring	490,334	5,797
Perch	763,093	10,160
Pike and pike perch	524,669	17,533
Sturgeon	309,003	7,794
Trout	244,847	12,242
Whitefish	238,764	14,753
Other fish	388,500	4,138
Total	2,994,571	73,577

A comparison of the catch of the principal fishes in 1880, 1885, and 1890 shows, as the principal features of the changes, a large increase in whitefish in 1890 over the other years, a decrease in herring in 1890 as compared with 1885, a decrease in sturgeon as compared with 1880, and an increase in minor fishes over both the earlier years. The statistics for the three years are as follows, the figures applying only to the fish taken in the lakes and rivers and not including the vessel gill-net catch in the larger lakes:

Comparison of the yield of the fisheries of Lake St. Clair and the St. Clair and Detroit rivers in 1880, 1885, and 1890.

Species.	1880.	1885.	1890.
	Pounds.	*Pounds.*	*Pounds.*
Whitefish	77,922	41,125	209,700
Herring	250,700	1,208,150	192,400
Sturgeon	998,500	227,780	309,003
Other fish	523,805	708,740	1,636,104
Total	1,850,927	2,185,795	2,347,207

The quantities and values of the fish taken, with the various kinds of apparatus employed, in this lake in 1890 are given in the table below. It is seen that the largest yield is with pound nets, after which come gill nets, seines, fyke nets, and lines and spears. The entire gill-net production was obtained in the vessel fisheries:

Table showing by apparatus and species the yield of the fisheries of Lake St. Clair and the St. Clair and Detroit rivers.

Apparatus and species.	Pounds.	Value.
Pound nets:		
Black bass	103	$6
Catfish	15,025	306
Herring	116,000	1,740
Perch	56,750	864
Pike and pike perch	177,280	5,367
Sturgeon	284,867	7,125
Whitefish	174,000	10,440
Other fish	241,500	2,710
Total	1,065,525	28,558
Seines:		
Black bass	7,400	444
Catfish	3,250	81
Herring	76,400	1,078
Perch	136,750	1,819
Pike and pike perch	171,303	5,334
Sturgeon	20,936	581
Whitefish	35,500	2,840
Other fish	59,125	850
Total	510,664	13,027

Apparatus and species.	Pounds.	Value.
Gill nets:		
Herring	297,934	$2,979
Perch	29,243	877
Pike and pike perch	46,276	1,851
Trout	244,847	12,242
Whitefish	29,064	1,453
Total	647,364	19,402
Fyke nets:		
Black bass	1,583	94
Catfish	8,000	229
Perch	263,850	3,245
Pike and pike perch	50,610	1,814
Sturgeon	3,200	88
Whitefish	200	20
Other fish	87,875	578
Total	415,348	6,068
Lines and spears:		
Perch	276,500	3,355
Pike and pike perch	79,170	3,167
Total	355,670	6,522
Grand total	2,994,571	73,577

LAKE ERIE.

Lake Erie, though one of the smallest of the chain, maintains fisheries that are much more extensive than those of any other lake. In the items of persons employed and capital invested, Lake Erie surpasses any other three lakes combined, and the value of its products is one-and-a-half times greater than the aggregate fisheries of all the other lakes, omitting Lake Michigan; the latter it exceeds by nearly $200,000. Although surpassed by Lake Michigan in the number of vessels engaged in actual fishing, it takes the lead in the quantity of netting used and in the quantity and value of the catch. The transportation of fish from the fishing-grounds to the markets, which in all the other lakes is an inconspicuous feature of the fisheries, is here prominent, 22 steam vessels being so employed in the year covered by the investigation. One-half the pound nets, nearly one-half the gill nets and fyke nets, more than one-third of the boats, and more than one-half the shore and cash property employed in the Great Lakes fisheries are found in Lake Erie. More than one-half the fishery products credited to the entire lake region is here taken, and two-fifths of the money value of the products represents the operations of Lake Erie fishermen.

Lake Erie is peculiar in having a relatively large number of fishes of great commercial importance. In the other lakes the important species are only two to four in number, while in Lake Erie there are eight fishes of which very large quantities are taken, including several that are prominent in no other lake, as, for instance, the blue pike and the sauger.

The preëminently important fish of Lake Erie is the lake herring, which constitutes much more than half the total quantity of fish taken and about two-fifths of the value of the catch. The remaining fishes, in the order of their value, are blue pike, whitefish, wall-eyed pike, sturgeon, sauger, catfish, and perch, and in order of quantity taken, blue pike, sauger, perch, whitefish, wall-eyed pike, sturgeon, and catfish.

The following tabular statements exhibit in some detail the extent of the fisheries of this lake:

Persons employed in Lake Erie fisheries.

How engaged.	No.
Vessel fishing	315
Shore fishing	3,198
Shore industries	969
Total	4,482

Apparatus and capital employed in Lake Erie fisheries.

Designation.	No.	Value.
Vessels fishing	56	$270,100
Tonnage	1,385.34	
Outfit		32,183
Boats	1,393	217,750
Apparatus of capture—vessel fisheries:		
Gill nets	19,046	67,944
Apparatus of capture—shore fisheries:		
Pound nets	1,787	542,260
Gill nets	30,274	101,569
Fyke nets	1,175	64,450
Trap nets	106	5,840
Seines	44	5,305
Lines and spears		6,151
Shore property		749,750
Cash capital		753,000
Total		2,816,302

Products of Lake Erie fisheries.

Species.	Pounds.	Value.
Black bass	248,418	$13,521
Blue pike	7,488,903	148,201
Catfish	1,926,057	45,914
Herring	38,868,283	399,452
Perch	2,870,407	30,299
Saugers	4,179,867	51,721
Sturgeon	2,078,907	73,703
Trout	121,420	5,183
Wall-eyed pike	2,105,733	90,615
Whitefish	2,341,451	115,970
Other fish	2,621,427	22,252
Turtles and frogs		4,074
Total	64,850,873	1,000,905

The condition of the fisheries of this lake as compared with 1880 and 1885 is an important consideration, which has been the subject of much solicitude on the part of those most directly interested. It has been apparent to almost everyone that the supply of whitefish, at least, has been decreasing yearly, and that the catch has only been maintained by the use of larger quantities of apparatus. The following comparison of the output of the fisheries of this lake shows that in 1885 the yield of 3,532,000 pounds of whitefish was about 200,000 pounds more than in 1880 and 1,200,000 pounds more than in 1890. The increased apparatus in 1890 should, other things being equal, have resulted in an increase in the catch over 1885, amounting to at least 3,000,000 pounds. The output of trout, an unimportant fish in this lake, has increased slightly over 1885, owing chiefly to the larger quantity of gill-netting employed. Sturgeon show a diminished abundance, although more were taken than in 1880. Herring have more than doubled in quantity since 1885. The production of other fishes, considered in the aggregate, is somewhat less than in 1885. The large increase in herring much more than overbalances the decreases noted, and results in an augmentation in the yield of 13,400,000 pounds compared with 1885, although the value of the catch has fallen from $1,109,096 to $1,000,905.

Comparative table showing the yield of the fisheries of Lake Erie in 1880, 1885, and 1890.

Species.	1880.	1885.	1890.
	Pounds.	*Pounds.*	*Pounds.*
Whitefish	3,333,800	3,531,855	2,341,451
Trout	26,200	106,900	121,420
Sturgeon	1,970,000	4,727,950	2,078,907
Herring	11,774,400	19,354,900	38,868,283
Other fish	11,982,900	23,734,912	21,440,812
Total	29,087,300	51,456,517	64,850,873

From the following table, giving the quantity and value of each of the principal fishes taken with the different appliances, the importance of gill nets and pound nets as means of capture will be clearly seen. Gill nets yield the largest money returns and take the largest quantities of whitefish, blue pike, and sturgeon, while the pound nets have the largest aggregate catch and surpass the gill nets in the output of herring, saugers, and wall-eyed pike.

Table showing by apparatus and species the yield of the fisheries of Lake Erie.

Species.	Gill nets.		Pound nets and trap nets.		Fyke nets.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	5,730	$261	112,403	$5,887	82,585	$4,534
Blue pike	5,411,863	108,759	1,952,308	32,068		
Catfish	500	10	470,832	12,132	376,250	7,670
Herring	18,642,800	203,787	20,210,983	194,775		
Perch	1,101,517	14,733	1,270,700	8,038	303,670	2,440
Saugers	237,400	7,401	3,226,562	30,425	368,855	4,056
Sturgeon	1,340,790	47,777	531,243	19,626		
Trout	120,720	5,148				
Wall-eyed pike	278,342	11,771	1,399,846	57,301	318,660	15,404
Whitefish	1,402,888	69,557	937,063	46,323		
Other fish	305,803	3,950	1,077,829	8,050	1,031,925	7,275
Total	28,848,353	473,157	31,189,769	414,625	2,481,945	41,379

Species.	Seines.		Lines, spears, grapnels, etc.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	43,000	$2,565	4,700	$271	248,418	$13,521
Blue pike	11,500	350	113,232	7,024	7,488,903	148,201
Catfish	230,375	5,275	848,100	20,827	1,926,057	45,914
Herring			14,500	890	38,868,283	399,452
Perch	77,100	937	117,420	4,151	2,870,407	30,299
Saugers	142,050	4,269	205,000	5,570	4,179,867	51,721
Sturgeon			206,874	6,300	2,078,907	73,703
Trout			700	35	121,420	5,183
Wall-eyed pike	56,925	3,004	49,960	3,135	2,105,733	90,615
Whitefish			1,500	90	2,341,451	115,970
Other fish	189,670	2,369	16,200	608	2,621,427	22,252
Turtles and frogs				4,074		4,074
Total	752,620	18,769	1,578,186	52,975	64,850,873	1,000,905

LAKE ONTARIO.

A preliminary report * on the fisheries of this lake has already been published in the Bulletin of the U. S. Fish Commission for 1890. It was issued to supply a demand for recent information during a very important discussion of the question of the condition of the industry and of the necessity for further protection to the fishes. The fisheries of this lake are less valuable than those of any other member of the system, and the threatened further reduction of their importance, due (1) to fishing abuses, or (2) inadequate fish-cultural operations, or (3) to a combination of these causes, drew an unusual amount of attention to Lake Ontario and furnished the basis for a noteworthy movement for the preservation and increase of the fish supply of the lake, for a discussion of which reference is made to the report cited.

In 1890 the fishing industry of the lake had the following extent:

Persons employed in Lake Ontario fisheries.

How engaged.	No.
Vessel fishing	11
Shore fishing	356
Shore industries	22
Total	389

Apparatus and capital employed in Lake Ontario fisheries.

Items.	No.	Value.
Vessels (tonnage 46.17)	3	*a* $9,585
Boats	373	21,577
Gill nets ... feet	1,103,945	18,110
Pound nets and trap nets	288	24,577
Fyke nets	684	9,822
Seines	27	656
Set lines ... feet	139,632	490
Miscellaneous		49
Shore and accessory property		25,777
Cash capital		12,890
Total		123,533

a Includes outfit.

Products of Lake Ontario fisheries.

Species.	Pounds.	Value.
Black bass	33,092	$2,364
Catfish	471,955	12,444
Eels	257,190	8,913
Herring	598,978	20,936
Perch	358,947	5,368
Pike	129,490	6,284
Pike perch	331,002	28,729
Sturgeon	541,752	22,291
Suckers	279,170	4,578
Trout	41,010	2,089
Whitefish	148,771	6,875
Other fish	255,091	3,915
Total	3,446,448	124,786

* The fisheries of Lake Ontario. By H. M. Smith, M. D. 39 pp., 30 plates of fishes.

In a preceding general table the statistics of the fisheries of this lake in 1880, 1885, and 1890 appear. The fisheries for the last year show a marked decline in the essential features of the industry as compared with 1880, although the capital invested and the value of the products were somewhat greater than in 1885. The aggregate decrease in the quantity of fish taken between 1880 and 1890 was only 193,522 pounds, an amount which is in itself insignificant; but an inspection of the statistics shows that a more unfavorable result was obviated only by a very large increase in the production of the cheaper grades of fish, while the catch of the two most valuable fishes in 1880, viz, whitefish and lake trout, was reduced nearly 90 per cent. A slight improvement, made up chiefly of minor species, such as might arise from seasonal variations in the abundance of fish, is seen to have occurred between 1885 and 1890. The following comparison of the production of the fishes in 1880, 1885, and 1890 exhibits the variations in the catch of all the species for which it is possible to give separate figures for 1880:

Comparison of the yield of the fisheries of Lake Ontario in 1880, 1885, and 1890.

Species.	1880.	1885.	1890.
	Pounds.	*Pounds.*	*Pounds.*
Whitefish	1,064,000	90,711	148,771
Lake trout	569,700	20,510	41,010
Sturgeon	545,283	386,974	541,752
Herring	611,217	403,585	598,978
Other fish	849,800	1,496,686	2,115,937
Total	3,640,000	2,398,466	3,446,448

In this lake larger quantities of fish are caught with gill nets than with any other kind of apparatus. The principal part of the catch consists of sturgeon and the minor species of whitefish usually designated herring. More common whitefish are also taken with these nets than in any other manner, although the actual yield is small. Trap nets and pound nets rank next to gill nets in the amount and value of the fish secured. Pike perch or wall-eyed pike represents more than half the value but less than one-third the quantity of the trap-net production, and is the most important fish now taken in the lake. Fyke-net fishing is of considerable extent, catfish, pike, and yellow perch being the chief products. All other kinds of apparatus used are unimportant.

The following table indicates the efficiency of the different means of capture employed in Lake Ontario, the quantity and value of each fish taken being shown:

Table showing by apparatus and species the yield of the fisheries of Lake Ontario.

Species.	Gill nets.		Pound nets and trap nets.		Fyke nets.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	23,284	$1,547	6,488	$623		
Catfish	8,530	330	49,010	1,222	400,273	$10,484
Eels			196,204	6,550	56,336	2,177
Herring	586,629	20,516	5,724	161		
Perch	30,210	648	150,975	1,427	170,645	3,111
Pike	41,740	2,032	520	26	73,770	3,340
Pike perch	26,970	1,330	297,132	26,967		
Sturgeon	428,919	17,607	26,075	992		
Suckers	13,580	351	93,800	938	76,320	1,056
Trout	10,637	566	30,181	1,513		
Whitefish	78,249	3,717	68,392	3,007		
Other fish	8,968	177	120,350	1,278	122,183	2,393
Total	1,257,716	48,821	1,044,851	44,704	899,527	22,561

Species.	Seines.		Lines.		Minor apparatus.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	1,967	$118	1,353	$76			33,092	$2,364
Catfish	6,735	240	2,847	77	4,560	$91	471,955	12,444
Eels			4,650	186			257,190	8,913
Herring	6,625	259					598,978	20,936
Perch	6,117	162	1,000	20			358,947	5,368
Pike	1,685	81	9,275	730	2,500	75	129,490	6,284
Pike perch	4,718	312	2,182	120			331,002	28,729
Sturgeon	2,480	78	84,068	3,608	210	6	541,752	22,291
Suckers	44,580	1,290	1,250	25	49,640	918	279,170	4,578
Trout			192	10			41,010	2,089
Whitefish	2,130	151					148,771	6,875
Other fish	3,590	67					255,091	3,915
Total	80,627	2,758	106,817	4,852	56,910	1,090	3,446,448	124,786

CHESAPEAKE BASIN.*

The investigations in the Middle Atlantic States were, during the fiscal year 1891–92, confined to the Chesapeake Basin and the adjoining ocean shores of Maryland and Virginia. The canvass of this important fishing region was extended to the limits of economic fishing in all the rivers tributary to the bay. The very careful and comprehensive inquiries here made were fully warranted by the vast extent and importance of the fisheries. The Chesapeake, with its tributaries, constitutes the most productive inland fishing-ground in the United States, and probably the most important in the world. The value of the fishery objects here taken is over $10,000,000 annually, a sum equal to nearly one-fourth the value of the fisheries of the entire country.

The investigation of the fisheries of this section was begun in the first part of November, 1891, and occupied the attention of the field force for about three months. The canvass in Maryland was conducted by Messrs. Ansley Hall, E. E. Race, and Charles H. Stevenson, and in Virginia by Messrs. T. M. Cogswell, Charles H. Stevenson, and W. A. Wilcox. That part of the Chesapeake Basin extending into Delaware and Pennsylvania was visited by Mr. Race.

The canvass of the fisheries of this region disclosed the extent of the various branches of the industry in the four States supplied by the

* Including adjoining ocean shores of Maryland and Virginia.

Chesapeake and its tributaries to be as follows: The number of persons finding employment in 1891 was 64,654; the amount of capital invested was $10,474,334; the value of the products taken was $10,126,748. The extent to which the different States were represented is shown in the following tables, which give details of the industry:

THE FISHERIES OF THE CHESAPEAKE BASIN IN 1891.

Persons employed.

States.	Fishermen.	Shoresmen.	Total.
Pennsylvania	637	....	637
Delaware	129	353	482
Maryland	28, 209	11, 735	39, 944
Virginia	20, 316	3, 275	23, 591
Total	49, 291	15, 363	64, 654

Vessels, boats, apparatus, and capital employed.

Designation.	Pennsylvania.		Delaware.		Maryland.		Virginia.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels *	....	......	15	$14, 650	1, 627	$1, 838, 249	944	$939, 136	2, 586	$2, 792, 035
Boats	383	$5, 967	48	660	9, 825	579, 488	9, 247	463, 722	19, 503	1, 049, 837
Seines	58	3, 325	6	450	536	76, 780	220	58, 320	820	138, 875
Gill nets	....	......	132	695	11, 976	97, 289	6, 979	46, 030	19, 087	144, 014
Pound nets	....	......	17	155	1, 005	71, 778	916	162, 690	1, 938	234, 623
Fyke nets and pots	58	350	45	172	14, 002	41, 937	449	5, 865	14, 554	48, 324
Dredges	....	......	....	......	4, 487	121, 883	658	22, 850	5, 145	144, 733
Tongs	....	......	....	......	13, 415	77, 039	12, 105	56, 675	25, 520	133, 714
Other apparatus	....	676	....	......	......	7, 493	......	3, 914	......	12, 083
Shore property	....	1, 957	....	16, 500	......	2, 446, 327	......	717, 857	......	3, 182, 641
Cash capital	....	......	....	18, 500	......	2, 107, 455	......	467, 500	......	2, 593, 455
Total	....	12, 275	....	51, 782	......	7, 465, 718	......	2, 944, 559	......	10, 474, 334

* Value includes outfit.

Products.

Species.	Pennsylvania.		Delaware.		Maryland.		Virginia.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives	......	......	87, 100	$495	17, 418, 850	$131, 245	11, 004, 085	$93, 819
Bluefish	......	......	......	......	516, 364	22, 761	1, 802, 674	66. 004
Bonito	......	......	......	......	......	......	195, 250	4, 948
Catfish	4, 500	$224	6, 540	296	1, 296, 752	45, 502	952, 769	28, 538
Eels	13, 725	758	......	......	792, 044	32, 919	7, 500	500
Menhaden	......	......	......	......	30, 952, 120	65, 307	105, 980, 334	197, 523
Mullet	......	......	......	......	101, 540	2, 974	101, 700	2, 196
Perch	7, 800	390	20, 785	928	2, 494, 625	105, 078	415, 378	16, 335
Pike	4, 000	600	1, 550	93	563, 264	35, 261	9, 450	615
Sea bass	......	......	......	......	113, 370	4, 544	9, 440	475
Shad	201, 089	13, 420	57, 533	3, 186	6, 224, 873	211, 575	6, 498, 242	207, 394
Sheepshead	......	......	......	......	3, 185	396	20, 625	1, 101
Spanish mackerel	......	......	......	......	44, 837	5, 369	739, 910	50, 756
Spots and croakers	......	......	......	......	273, 283	12, 119	1, 683, 457	60, 863
Squeteague	......	......	......	......	750, 465	25, 902	3, 938, 019	124, 891
Striped bass	14, 200	1, 278	150	15	1, 264, 693	97, 770	467, 861	40, 953
Sturgeon	......	......	......	......	72, 445	2, 343	720, 451	21, 267
Other fish	46, 500	2, 904	2, 300	120	816, 947	24, 667	2, 654, 419	82, 569
Clams (meats)	......	......	......	......	[1] 147, 760	8, 226	[2] 559, 278	36, 030
Crabs	......	......	......	......	[3] 7, 605, 770	303, 716	[4] 2, 890, 427	62, 039
Crayfish and shrimp	......	......	......	......	15, 394	4, 655	......	......
Oysters (meats)	......	......	......	......	[5] 69, 615, 406	5, 295, 866	[6] 43, 061, 452	2, 520, 068
Terrapins	......	......	......	......	89, 780	22, 333	52, 215	18, 494
Turtles	......	......	......	......	4, 060	231	187, 621	3, 904
Total	291, 814	19, 574	175, 958	5, 133	141, 177, 827	6, 460, 759	183, 952, 557	3, 641, 282

[1] 18,470 bushels.
[2] 69,910 bushels.
[3] 22,817,310 in number.
[4] 8,671,281 in number.
[5] 9,945,058 bushels.
[6] 6,151,636 bushels.

Products—Continued.

Species.	Total. Pounds.	Total. Value.	Species.	Total. Pounds.	Total. Value.
Alewives	28,510,035	$225,559	Spots and croakers	1,956,740	$72,982
Bluefish	2,319,038	88,765	Squeteague	4,638,484	150,793
Bonito	195,250	4,948	Striped bass	1,746,904	140,016
Catfish	2,260,561	74,560	Sturgeon	792,896	23,610
Eels	813,269	34,177	Other fish	3,520,166	110,260
Menhaden	136,932,454	262,830	Clams (meats)	[1] 707,038	44,256
Mullet	203,240	5,170	Crabs	[2] 10,496,197	365,755
Perch	2,938,588	122,731	Crayfish and shrimp	15,394	4,655
Pike	578,264	36,569	Oysters (meats)	[3] 112,676,858	7,815,934
Sea bass	122,810	5,019	Terrapins	141,995	40,827
Shad	12,981,737	435,575	Turtles	191,681	4,135
Sheepshead	23,810	1,497			
Spanish mackerel	784,747	56,125	Total	325,598,156	10,126,748

[1] 88,380 bushels. [2] 31,488,591 in number. [3] 16,096,694 bushels.

Not the least important point involved in the investigation of the fisheries of this section is the question of their condition and maintenance in view of the enormous annual drain on the supply of fishes and other aquatic animals required to yield to the fishermen a yearly income of over $10,000,000.

Comparing the extent of the industry in 1891 with its extent in 1880, it appears that a large increase has occurred in the number of persons employed in fishing and in the dependent shore branches. The number of fishermen increased 12,336 in Maryland, 4,265 in Virginia; the number of shore employés increased 1,600 in Maryland and 462 in Virginia, giving a combined increase in fishing population of 18,663 in these two States.

The aggregate number of vessels now employed is apparently somewhat less than in 1880; there has been an increase of 177 in Maryland and a decrease of 502 in Virginia, giving a net decrease of 325. It may be said, however, that only approximate figures for the oyster vessels were obtained in 1880, and, in view of the increased number of oyster vessel fishermen, it is probable that the vessel estimates were too large. A large advance has occurred in the item of boats; 9,629 more of these were used in 1891 than in 1880, both States exhibiting a marked increase; the value of the boats increased $564,042. Every important form of fishing apparatus is now employed in larger quantities than in 1880; seines have increased from 293 to 756, gill nets from about 7,720 to 18,955, fyke nets and pots from 4,150 to 14,450, and pound nets and weirs from 268 to 1,921. One of the most prominent features of the fisheries is the enormous augmentation in the number of pound nets employed and the tendency in certain localities to supplant the earlier and less effective means of capture with this apparatus. The aggregate investment in fishing property has increased in both States, amounting to $1,123,285 in Maryland and $1,030,440 in Virginia.

The foregoing increase in fishing population and fishing property prepares us for a substantial advance in the results of the fisheries, provided there has been no serious impairment of the supply. The figures at hand indicate a general maintenance of the abundance of most of the important products and show a marked advance in the case of some special objects. The value of the industry in Maryland has increased $2,819,900, that in Virginia $516,838, the aggregate increase being $3,273,640, or nearly 50 per cent. Figures for the fisheries of Pennsylvania and Delaware tributary to the Chesapeake are not available for 1880; their importance, however, is relatively so little that they may be discarded from the comparisons. The comparatively unimportant fishery interests of the ocean shores of Maryland and Virginia are included in order to make the statistics for those States complete.

Among the fishery products whose importance entitles them to special mention and concerning which some notes on the fisheries may be given are alewives, bluefish, menhaden, Spanish mackerel, squeteague, striped bass, shad, crabs, and oysters.

Alewives or herrings.—Next to shad these are the most valuable food-fishes taken in this region; the quantity annually consumed is much greater than that of any other food-fishes. They are secured principally with seines and pound nets. In 1891, 17,418,850 pounds, for which the fishermen received $131,245, were caught in Maryland, and 11,004,085 pounds, worth $93,819, were obtained in Virginia, the total yield in the two States being 28,422,935 pounds, with a value of $225,064. This is a very large increase over 1880, although it is not anomalous in view of the augmented quantities of apparatus used. In 1880 the output of alewives was 16,129,372 pounds, valued at $217,092, the proportion of the catch in each State being about the same as in 1891.

Bluefish.—This erratic species is, with one exception, the most important typically salt-water fish taken in Maryland and Virginia. The largest part of the catch is obtained with pound nets. The aggregate yield in 1891 was 2,319,038 pounds, having a value of $88,765; of this quantity, 516,364 pounds were taken in Maryland and 1,802,674 pounds in Virginia. The increase over 1880 was 762,621 pounds, worth $52,442. The increase was most noticeable in Maryland, where only 10,000 pounds were reported in 1880, while 516,364 pounds were caught in 1891.

Menhaden.—The presence of a large number of oil and fertilizer factories on the Chesapeake occasions an extensive fishery for menhaden carried on with steamers and sailing vessels. The fish are liable to seasonal fluctuations, like the bluefish, but the catch in recent years has been fairly constant. The quantity of fish taken in 1891 was 136,932,454 pounds, equivalent to about 228,220,755 fish, nearly all of which were utilized at the oil and guano works; the cost of the fish to the factory operators was $262,830, or at the rate of about $1.15 per thousand fish. In 1880 the quantity of menhaden taken was 92,116,800 pounds, valued at $246,760, or at $1.60 per thousand fish. A conspicuous feature of the fishery is the increased catch of menhaden in Maryland, owing chiefly to the establishment of factories at several places in the State and the consequent employment of fishing vessels belonging in Maryland. In Virginia the output is approximately the same as in 1880.

Spanish mackerel.—The abundance of this species in recent years presents a marked decrease as compared with 1880. In the latter year 1,627,663 pounds, worth $100,104, were taken, the fish ranking third in importance among the food-fishes of the region, while in 1891 less than half the quantity was caught and the fish declined to the ninth place. The catch in Maryland was very small in both 1880 and 1891, but was larger in the latter year than in the former. The decrease may evidently be traced to the capture, chiefly in pound nets, of large quantities of the fish early in the season in the lower part of the Chesapeake, before the fish have spawned.

Squeteague.—Two species of squeteague, locally known as weakfish and trout, rank third in importance among the food-fishes of this section. As compared with 1880, they were taken in much larger quantities in 1891, and the increase was marked in both Maryland and Virginia. The aggregate yield reported in 1880 was 1,541,000 pounds, valued at $31,140; in 1891 the catch amounted to 4,688,484 pounds, worth $150,793. Pound nets and seines are the apparatus chiefly employed in taking these fish.

Striped bass.—The supply of this fish seems to be holding out remarkably well in view of the large annual catch in fresh and salt water with seines, gill nets, and pound nets. The output in 1891 was about 410,000 pounds more than in 1880, although there was a decline of nearly 30 per cent in Virginia. The total yield in 1891 was 1,732,554 pounds, for which the fishermen received $138,723.

Shad.—Next to the oyster, the shad is the most valuable fishery product of this region; in 1880 it occupied the same rank. The maintenance of the supply may be clearly traced to large plants of fry in the waters of the region, and the increase in the output has been due to the employment of larger quantities of apparatus, especially pound nets. Following is a comparative statement of the catch of shad in Maryland and Virginia in 1880 and 1891:

Year.	Maryland.		Virginia.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1880	3,774,426	$140,926	3,171,953	$134,496	6,946,379	$275,422
1891	6,224,873	211,575	6,498,242	207,394	12,723,115	418,969
Increase	2,450,447	70,649	3,326,289	72,898	5,776,736	143,547

These figures show an increase of nearly 100 per cent between the years named, the advance being shared about equally by the two States.

Crabs.—The prominence which crabs have attained in the fisheries of this region is one of the most noteworthy features of the industry. In 1880 only 3,305,867 pounds of crabs, equivalent to about 9,917,600 individuals, were marketed; these brought the fishermen $78,938. In 1891, when the fishery was more extensive than ever before, 10,496,197 pounds, or about 31,488,590 crabs, valued at $365,755, were sold. In

1880 the fishery was more extensive in Virginia, but at the present time nearly four-fifths of the business is carried on in Maryland. Much the larger part of the catch is sold as soft-shell crabs.

Oyster.—This important resource now represents nearly eight-tenths of the value of the fisheries of this region. During the season covered by the inquiry the industry was in a prosperous condition. The foregoing table of products shows that 9,945,058 bushels, valued at $5,295,866, were taken in Maryland, and 6,151,636 bushels, valued at $2,520,068, in Virginia, the total yield being 16,096,694 bushels, for which the fishermen received $7,815,934. Compared with 1880, these figures show a decreased production, amounting to 654,942 bushels in Maryland and 685,684 bushels in Virginia, while the value of the output has increased $565,380 and $301,692, respectively. A large increase has also taken place in the number of persons engaging in the oyster industry. In 1880 Maryland had 13,748 fishermen and 9,654 shore hands, while in 1891 it had 21,280 fishermen and 12,108 shoresmen. In 1880 Virginia was credited with 14,236 fishermen and 2,079 shoresmen, and in 1891 16,352 fishermen and 2,250 shoresmen. The total increase was thus 12,273. The capital invested in the oyster industry in 1880 was $6,034,350 in Maryland and $1,351,000 in Virginia; in 1891 it was $7,269,245 and $1,927,792, respectively.

ALBEMARLE REGION, NORTH CAROLINA.

In April, 1892, the writer visited Albemarle Sound and some of the rivers debouching into it in the interests of the Division of Scientific Inquiry. The primary object of the visit was the collection of the fresh-water fishes of the region. At the same time an opportunity was afforded to inspect the commercial fisheries.

Forty-five species of fishes were ascertained to inhabit this region at the time of the inquiry; of these about thirty may be regarded as food-fishes, two or three others are sometimes eaten but have no recognized economic value, and the remainder are small fishes whose principal importance arises from the fact that they constitute a prominent part of the food supply of other fish.

This is one of the most important fishing sections on the Atlantic coast. Albemarle Sound is the largest coastal body of fresh water in the United States, and more extensive fresh-water fisheries are maintained in it and its tributaries than are prosecuted elsewhere on our coast. The most prominent fish occurring are shad, alewives, striped bass, black bass, and white perch, but many other fishes common to the section are taken in greater or less numbers and materially contribute to the income of the fisherman, among which sturgeon, catfish, eels, suckers, pike, mud shad, hickory shad, several kinds of sunfishes, yellow perch, and flounders may be mentioned.

The annual fish production of this region is about 9,000,000 pounds, of which nearly two-thirds represents alewives. The value of the catch is about $465,000, nearly half of which sum represents shad.

The changes which have taken place in the forms of apparatus used in this region are interesting. In early times the favorite means of capture, especially for shad and alewives, was the seine. This is still an important device, taking more fish than any other single form, and the most extensive seine fisheries in the country for the fish named are here carried on. After a time the gill net was brought into more general use and began to increase in importance until finally it took precedence over the seine in taking shad and one or two less valuable fish. In the past decade the introduction of the pound net in great numbers has been a very marked feature of the fisheries, and because of its efficiency it has supplanted to a considerable extent both the seine and the gill net, and will probably, within a short period, attain even greater prominence.

BOSTON AND GLOUCESTER, MASS.

The studies of the fisheries tributary to these places, as mentioned in the previous report of the division, have continued along the same general lines already referred to. The importance of the fishing industry of these cities warrants the small sums expended in keeping well informed regarding the condition of the business and in maintaining close relations with the fishermen and dealers. The inquiries here made cover the operations of about seven-eighths of the offshore fishing vessels of New England, are valuable adjuncts to the general investigation of the fisheries, and afford an excellent basis for determining the condition and resources of the great ocean fishing-grounds off the New England coast.

In Boston Mr. F. F. Dimick has continued his efficient services as local agent. He has obtained a record of each vessel arriving from the fishing-grounds, noting the kind, quantity, and value of the fish landed, the particular grounds on which caught, and other useful and interesting data concerning the fisheries.

The fish trade of Boston is of greater magnitude than that of any other city of the United States. The investigations have shown that in the calendar year 1891 the quantity of fishery products there landed by American fishing vessels was 69,945,088 pounds, mostly fresh, having an approximate value to the fishermen of $1,840,336. This quantity is in addition to very large receipts, chiefly from the provinces, over regular rail and steamer lines. The most important single product brought into Boston by our fishing vessels is the haddock, of which 33,860,197 pounds, valued at $824,132, were landed. Of the cod, the next prominent fish, 16,655,200 pounds were landed, having a value of $547,851. Hake ranks next, the receipts being 12,347,730 pounds, worth $168,817. Other fish deserving mention are halibut, cusk, pollock, and mackerel.

An analysis of the following table, giving the receipts classified by fishing-grounds, shows the great predominance of Georges Bank and South Channel as sources of supply, these two grounds furnishing nearly one-half the fish landed in Boston. The next important grounds, in their order, are the general shore grounds, La Have Bank, off Highland Light, Jeffreys Ledge, Browns Bank, Middle Bank, Cashes Bank, and the Cape Shore.

Of the 4,119 trips of fish landed in Boston in 1891 209 were from grounds off the shores of the British provinces east of the 66th meridian of west longitude, the largest number being from La Have Bank. The total catch in this region was 7,027,985 pounds, including several fares of salt mackerel from the Cape Shore; of this quantity 2,964,000 pounds were haddock and 2,155,500 pounds were cod. The average fare from the eastern grounds was 33,627 pounds. From the grounds off the New England coast 3,910 trips of fish were landed, of which 1,549 were from the general shore grounds, 738 from South Channel, 395 from Georges, 387 from Jeffreys Ledge, 281 from the grounds off Highland Light, and 258 from Middle Bank. The quantity of fish here taken was 62,917,103 pounds, including small quantities of mackerel, swordfish, eels, bluefish, herring, menhaden, and lobsters. The average fare from these grounds was 16,091 pounds.

Summary by fishing-grounds of the fishery products landed at Boston, Mass., in 1891 by American fishing vessels.

Fishing-grounds.	No. of fares of fish.	Cod.	Cusk.	Haddock.	Halibut.	Hake.
East of 66° W. longitude:		*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Quereau Bank	1	30,000			3,000	
Western Bank	8	39,000	4,700	41,500	25,000	39,000
La Have Bank	146	1,456,500	301,000	2,171,500	183,225	787,000
Cape Shore	54	630,000	102,500	751,000	10,960	226,500
Total	209	2,155,500	408,200	2,964,000	222,185	1,052,500
West of 66° W. longitude:						
Browns Bank	96	1,212,700	248,100	1,095,700	284,100	99,790
German Bank	1	45,000	15,000	20,000		
Georges Bank	395	3,066,900	209,800	8,451,400	272,805	809,000
Cashes Bank	63	340,500	365,900	499,600	12,960	743,900
Fippenies Bank	6	20,500	10,000	14,000	1,600	25,500
Tillies Bank	1	7,000		2,500		2,000
Clark Bank	4	23,000	8,500	57,000	850	63,000
Ipswich Bay	54	164,400	5,000	266,500		36,500
Jeffreys Ledge	387	658,300	82,500	2,273,750	27,130	653,600
Middle Bank	258	497,500	140,700	1,332,900	10,440	619,350
Off Highland Light	281	1,430,100	206,350	1,644,300	17,735	820,990
Off Chatham	37	114,700	5,600	348,500	2,450	31,200
South Channel	738	4,913,700	920,900	9,766,500	253,920	4,847,200
Nantucket Shoals	40	175,700	1,500	649,800	5,950	114,800
Shore, general	1,549	1,836,000	186,120	4,473,747	10,590	2,423,400
Total	3,910	14,499,700	2,405,970	30,896,197	900,530	11,295,230
Grand total	4,119	16,655,200	2,814,170	33,860,197	1,122,715	12,347,730

Summary by fishing-grounds of the fishery products landed at Boston, Mass., in 1891 by American fishing vessels—Continued.

Fishing-grounds.	Mackerel, fresh.	Mackerel, salted.	Pollock.	Swordfish.	Other fish.	Lobsters.	Total.	Average fare per trip.
East of 66° W. longitude:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Quereau Bank							33,000	33,000
Western Bank			9,700				158,900	19,862
La Have Bank			89,400				4,988,625	34,169
Cape Shore		106,000	20,500				1,847,460	34,212
Total		106,000	119,600				7,027,985	33,627
West of 66° W. longitude:								
Browns Bank			63,800				3,004,190	31,293
German Bank			5,000				85,000	85,000
Georges Bank			66,900				12,876,805	32,599
Cashes Bank			23,900				1,986,760	31,536
Fippenies Bank			1,000				72,600	12,100
Tillies Bank							5,200	5,200
Clark Bank			3,000				152,350	38,087
Ipswich Bay							475,400	8,803
Jeffreys Ledge			354,900				4,050,180	10,465
Middle Bank			57,500				2,658,390	10,304
Off Highand Light			47,900		2,000		4,169,375	14,837
Off Chatham			1,500		58,100		562,050	15,190
South Channel			245,590		17,060		20,964,870	28,407
Nantucket Shoals			24,975				972,725	24,318
Shore, general	479,325	429,850	210,940	186,146	393,730	246,360	10,881,208	7,024
Total	479,325	429,850	1,106,905	186,146	470,890	246,360	62,917,103	16,091
Grand total	479,325	535,850	1,226,505	186,146	470,890	246,360	69,945,088	16,981

The inquiries at Gloucester have had a similar scope to those at Boston. Capt. S. J. Martin, the local agent, has brought the practical experience of a long fishing career to bear on the work, and has been extremely diligent, faithful, and energetic in the discharge of his duties.

While Gloucester receives less fish than Boston, it ranks first in the extent of its salt-fish trade in home-caught fish and in the aggregate amount of fish receipts from American fishing vessels. The inquiries conducted by the division show that in 1891 the quantity of fish there landed by fishing vessels was 76,949,347 pounds, of which 49,721,248 pounds were salt, and a large part of the remainder was salted after being discharged at the wharves. The value of the receipts was $2,784,996.

The most important single kind of fish landed at Gloucester is the cod, of which 44,249,970 pounds of fresh and salted fish were received; these had a value at first hands of $1,563,452. Next to cod in quantity is hake, of which 9,726,360 pounds, valued at $103,960, were landed. Halibut, while taken in smaller quantities than hake, is much more valuable; of this species 7,414,501 pounds of fresh and salted fish, with a market value of $690,302, reached Gloucester directly from the fishing-grounds. The receipts of the remaining fish of importance were haddock, 4,294,775 pounds, worth $54,305; cusk, 3,897,420 pounds, valued at $82,245; pollock, 2,729,421 pounds, worth $27,188; mackerel, 4,366,000 pounds, with a value of $258,955; and other products, 270,900 pounds, worth $4,589.

The following table shows the fish receipts at Gloucester classified by fishing-grounds. From this it appears that 3,420 fares of fish were brought into Gloucester during the year; of these, 644 were from grounds east of the sixty-sixth meridian of west longitude and 2,776 from grounds west of that line. The largest number of trips from the more eastern grounds were from La Have, Western, and Grand banks, and from the Cape Shore, and the catch consisted chiefly of fresh halibut, salt cod, and salt mackerel. The aggregate receipts from this region were 36,373,016 pounds, of which 19,259,165 pounds were from the Grand Banks. The grounds off the coast of the United States yielded 40,576,331 pounds of fish which went to Gloucester. More fares came from the shore grounds adjacent to the New England coast than from any of the offshore banks; 1,590 arrivals from these grounds brought in 12,098,638 pounds, mostly cod, hake, pollock, and mackerel. The most important of the offshore grounds was Georges Bank; 674 fares of fish were received from there, aggregating 12,690,158 pounds, chiefly cod. Cashes Bank, South Channel, Browns Bank, and Nantucket Shoals are other important grounds in this section.

Summary by fishing-grounds of the fishery products landed at Gloucester, Mass., in 1891, by American fishing vessels.

Fishing-grounds.	No. of trips from each ground.	Halibut.				Cod.		
		Fresh.	Salted.	Fins.	Sour.	Fresh.	Salted.	
							Large.	Small.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
East of 66° W. longitude:								
La Have Bank and ridges	104	920,876	13,600		4,000	56,500	705,700	371,980
Western Bank	129	1,879,520	16,880		29,300	20,000	1,514,510	960,830
Quereau Bank	55	1,013,910	2,600		10,650		304,680	112,320
Misaine Bank	5	156,450					40,000	160,000
St. Peters Bank	18	424,675					46,000	9,500
Greens Bank	3	82,110						
Grand Bank	161	680,640	175,650		10,200		9,839,892	8,498,503
Canso Bank	6		9,280				316,800	162,020
Cape Shore	138	52,900	4,800			173,500	1,483,570	696,210
Iceland	11		1,542,900	108,200				
Cape North	3	15,500	3,000				137,000	84,500
Gulf of St. Lawrence	10							
Off Newfoundland	1	31,020						
Total	644	5,257,601	1,768,710	108,200	54,150	250,000	14,388,152	11,055,863
West of 66° W. longitude:								
Nantucket Shoals	91	18,200				6,500	336,130	1,890,660
South Channel	130					176,360		
Georges Bank	674	80,620	3,300			715,430	8,685,565	1,878,543
Browns Bank	43	61,060				118,000	472,410	215,980
Cashes Bank	241	59,330	700			1,417,650	224,280	80,715
German Bank	7						102,500	26,000
Shore, general	1,590	2,630				1,725,412	369,400	114,420
Total	2,776	221,840	4,000			4,159,352	10,190,285	4,206,318
Grand total	3,420	5,479,441	1,772,710	108,200	54,150	4,409,352	24,578,437	15,262,181

Summary by fishing-grounds of the fishery products landed at Gloucester, Mass., in 1891, by American fishing vessels—Continued.

Fishing-grounds.	Haddock.		Hake.		Pollock.	
	Salted.	Fresh.	Salted.	Fresh.	Salted.	Fresh.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
East of 66° W. longitude:						
La Have Bank and ridges		216,000	9,300	323,400		
Western Bank		85,000	48,000	10,000		
Quereau Bank	3,000		20,500			
Grand Bank			50,280			
Canso Bank	5,000		46,000			
Cape Shore	107,060	176,000	614,000	166,000	18,000	
Total	115,060	477,000	788,080	499,400	18,000	
West of 66° W. longitude:						
Nantucket Shoals	7,200	10,000	4,000		7,000	
South Channel		1,158,500		1,581,100		
Georges Bank	10,500	854,100	120,500	187,400	11,500	
Browns Bank		261,890	22,000	12,000		
Cashes Bank	19,000	579,820	285,000	3,752,800		
German Bank	14,580		59,000		4,500	
Shore, general	71,550	715,575	802,000	1,613,080	533,000	2,155,421
Total	122,830	3,579,885	1,292,500	7,146,380	556,000	2,155,421
Grand total	237,890	4,056,885	2,080,580	7,645,780	574,000	2,155,421

Fishing-grounds.	Cusk.		Mackerel.		Other species.		Total.
	Salted.	Fresh.	Salted.	Fresh.	Salted.	Fresh.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
East of 66° W. longitude:							
La Have Bank and ridges	34,000	95,500					2,750,856
Western Bank	7,000	2,000					4,573,040
Quereau Bank	7,000						1,474,660
Misaine Bank							356,450
St. Peters Bank							480,175
Greens Bank							82,110
Grand Bank	4,000						19,259,165
Canso Bank	4,000						543,100
Cape Shore	57,200	19,700	1,108,000		12,000		4,688,940
Iceland							1,651,100
Cape North							240,000
Gulf of St. Lawrence			242,400				242,400
Off Newfoundland							31,020
Total	113,200	117,200	1,350,400		12,000		36,373,016
West of 66° W. longitude:							
Nantucket Shoals							2,279,690
South Channel		317,950					3,233,910
Georges Bank	57,400	83,300				2,000	12,690,158
Browns Bank	10,000	26,000					1,199,340
Cashes Bank	134,500	2,249,220			55,000		8,858,015
German Bank	10,000						216,580
Shore, general	283,550	495,100	3,008,000	7,600	181,400	20,500	12,098,638
Total	495,450	3,171,570	3,008,000	7,600	236,400	22,500	40,576,331
Grand total	608,650	3,288,770	4,358,400	7,600	248,400	22,500	76,949,347

Attention may very properly be called to the practical value of these inquiries as represented in the information shown in the preceding tables. The preservation of the fishing-grounds resorted to by the New England fleet is the most vital question connected with the fisheries of that region, and it becomes a matter of great consequence to know their condition from time to time, and if depletion is taking place to have definite and accurate statistical data to serve as a basis for the determination of the extent of the deterioration, the special grounds and fish which it affects, and the steps that may be necessary to prevent it. The absence of such information as is here shown for an earlier year than 1889 makes all the more desirable the careful, continuous study now going on.

REMARKS ON REPORTS.

Following is a résumé of the reports and papers emanating from this division during the fiscal year 1892. These covered a variety of subjects, some general and others special in their scope. Considerable work was also done on a number of other papers dealing with our fishery interests, which will be issued during the next fiscal year.

In addition to the information which is utilized in the preparation of reports, the office is accumulating a vast amount of descriptive and illustrative matter on apparatus, boats, vessels, fish and other products, etc., which will be available when the occasion or opportunity for its utilization arises. While the elaborate studies in the Fisheries and Fishery Industries of the United States make the necessity for similar descriptive reports a remote contingency, the important subject of fishing apparatus was not treated of in that series, and constitutes, among other topics, an inviting field for a report, the material for which is now being gathered.

Notes on the King-Crab Fishery of Delaware Bay. (Bulletin, 1889, pp. 363–370, 3 plates.)

Although the king crab (*Limulus polyphemus*) occurs in greater or less abundance along the entire Atlantic coast from Massachusetts to Florida, and in many places is taken in small quantities for fertilizer, etc., it is only in Delaware Bay that the capture of the animal is accomplished by means of specially devised apparatus and becomes a matter of commercial importance. This paper shows that in 1888 the combined catch in New Jersey and Delaware was 1,822,000 crabs, valued at $8,150, of which 1,502,000 crabs, worth $7,510, were taken in New Jersey. Compared with 1880, these figures disclose a very marked decline in the abundance of the crabs, and it seems only a question of a few years, under existing conditions and methods, before the supply will become exhausted. Of late the yearly output has been maintained only by employing larger quantities of apparatus.

The Giant Scallop Fishery of Maine. (Bulletin, 1889, pp. 313–335, 5 plates, including map of scallop beds operated in 1889.)

The coast of Maine is the only region in which fishing for the giant scallop (*Pecten magellanicus*) is carried on. So far as known, this scallop has only a limited distribution in the available waters adjacent to the coast of Maine, and it is only in the section between Mount Desert Island and the Penobscot River and in the Sheepscot River that it has been found by the fishermen. The history of the fishery given in this report shows that it has been of very recent development, no record of its existence more than ten years ago being ascertained. The industry is prosecuted from Mount Desert, Tremont, Little Deer Isle, Sedgwick, Cape Rosier, Castine, and various towns on the Sheepscot River, and in 1889 the fishery was followed by 197 persons, who had $11,055 invested in boats, apparatus, and accessories, and took 45,368 bushels of scallops, for which $18,647 was received. While the fishery has certain natural limitations, it is no doubt capable of increasing considerably if proper measures are adopted to develop by more improved methods the beds of the scallop which exist in deeper water, where they are now almost undisturbed, owing to imperfections in apparatus.

Notes on the Oyster Fishery of Connecticut. (Bulletin, 1890, pp. 461–497, 8 plates.

There is perhaps no State in the country in which the artificial rearing of oysters has commanded more attention and been carried to a more successful result than in Connecticut. The very full account of the history, methods, conditions, and statistics of the oyster industry in this State which is given in this paper was therefore timely, and will, it is thought, do much toward promoting the oyster fishery in several other States where the necessity for a change in present methods seems to be clearly indicated if the perpetuation of the industry is to be secured. The report has attracted much attention and received favorable criticism in the oyster districts of the Atlantic coast, and there has been an exceptionally large demand for it. The subject is discussed in detail under the heads of personnel, wages, etc.; vessels and boats; historical notes; the oyster-grounds; methods of cultivation, trade, fishing, etc.; unfavorable conditions, enemies, etc.; and financial results, in addition to which very complete tabular information is given for each town for the years 1887, 1888, and 1889.

It is seen that in the last year the industry gave employment to 593 fishermen and 651 shoresmen. The capital devoted to the industry amounted to $3,675,964, of which $1,237,695 represented the value of oyster-grounds and $1,424,855 the value of the oysters thereon. The aggregate expense of cultivating the beds and preparing the oysters for market was $436,451. An interesting table is presented showing the estimated value of the oysters on artificial beds destroyed by starfish, drills, and other agencies; in 1889 the loss by these means was considerably less than during the two preceding years, but it nevertheless amounted to $464,700. From the cultivated oyster-grounds 1,412,011 bushels of oysters, having a value of $1,024,502, were taken in 1889, while the natural beds yielded only 73,850 bushels, worth $31,305. The report concludes with a digest of the oyster legislation of Connecticut, which has had more influence than all other factors in promoting the industry.

Statistical Review of the Coast Fisheries of the United States. (Report, 1888, pp. 271–378.)

As the title implies, this report is a statistical summary of the entire commercial fisheries of the coastal waters of the United States, the 154 tables presented being supplemented with only enough descriptive matter to properly elucidate them. The fisheries are considered by geographical divisions and by States. In the introductory pages certain comparisons, averages, percentages, etc., are given, having application to the entire industry. The review shows that in the year specified 137,446 persons were engaged in the fisheries of the coast States, of whom 37,811 were vessel fishermen, 70,768 were shore or boat fishermen, and 28,867 were shore employés. The aggregate capital invested in the industry was $45,619,546, of which $13,575,249 represented 6,099 vessels and their outfits; $3,082,395 was the value of 47,195 boats; $4,557,815 was devoted to apparatus of capture, and $24,404,083 to shore property and working capital. The products had a value at first hands of $34,234,045, of which $15,323,447 was the result of the general food-fish fisheries, $12,860,671 of the oyster, clam, and scallop fisheries; $1,843,752 of the seal, walrus, and sea-otter fisheries; $1,591,796 of the lobster, crab, shrimp, and prawn fisheries; $1,393,854 of the whale and porpoise fisheries; $798,604 of the menhaden fishery; $254,515 of the sponge fishery, and $167,406 of the alligator, turtle, terrapin, and frog fisheries. The tables making comparisons with 1880 show a generally satisfactory condition of the industry. There was an increase in the number of fishery employés of 18 per cent, an advance in the amount of investment of 27 per cent, and a decrease in the value of products of 1 per cent. The decline in the value of the catch was principally due to a diminished yield of whales and mackerel in the New England States and of oysters in the Middle Atlantic region. A very interesting and instructive comparison is made by States and sections of the catch of shad and alewives. The maintenance of the supply of shad is so important that the report may be appropriately quoted on this subject. It says:

This comparison has a special interest, since it may fairly be taken as a basis for estimating the effect of artificial propagation of certain species of food-fish which, under natural conditions, have become noticeably depleted. It is proper to state that the supply of shad had been so much reduced by overfishing that in the years immediately succeeding 1880 there was reason to fear that the species would soon become so scarce that it would no longer be available as a reasonably cheap article of food or the object of a profitable fishery.

In order to comprehend the full significance of this comparison it is well to remember that the artificial propagation of shad on a large scale by the U. S. Fish Commission was not undertaken until 1881; therefore the effect of it upon the abundance of the species could not be felt or observed until 1885, when the artificially hatched fish attained maturity and returned to the rivers for reproductive purposes. It will thus be seen that the excess of the catch of 1888 over that of 1880 practically shows the result attained by artificial propagation of shad in the third season after its effects could, by natural limitations, be observed; and the very important facts are shown that the yield of the fishery was almost double, and that its value, based on prices obtained in 1880, was increased nearly $700,000.

It may be admitted that the increased catch has to some degree been due to the use of larger quantities of apparatus, but it is evident that without a marked increase in the abundance of shad, as a result of artificial hatching, the profitable employment of additional fishing gear would not be possible. But the fact should not be lost sight of that each year a larger proportion of shad is caught in the bays, estuaries, and lower reaches of the rivers, where pound nets and other gear have been multiplied to such an extent in recent years as to largely prevent anadromous species from ascending to their natural spawning-grounds in the headwaters of the streams. For this reason the maintenance of the abundance of shad is more dependent now than ever before upon artificial propagation.

A comparison of the catch of the shad with that of the alewife for the years named will prove instructive, inasmuch as the latter is not hatched artificially, and these species are practically taken in the same waters on the Atlantic coast and to a large extent at the same season and in the same forms of apparatus. It is only just to say, however, that it is claimed by good authority that the alewife has an advantage over the shad. When it is caught it is commonly in a ripe condition; the adhesive eggs are pressed out in great quantities when the fish are taken in pound nets, and masses of them can generally be seen attached to the apparatus. Nevertheless, the comparative figures in the tables show the alewife catch to have increased only about 23 per cent, while the value of the fish to the fishermen has declined about 5 per cent. This relatively slight augmentation of the catch in 1888 as compared with 1880 indicates actual diminution in the supply, when the increased quantities of apparatus used for the capture of this species are taken into consideration.

The most important single fishery product of the United States is the oyster, the quantity and value of the catch of which in 1880 and 1888 are shown by States and sections. The aggregate yield in 1880 was 22,195,915 bushels, valued at $12,029,502; in 1888 it was 21,765,640 bushels, worth $11,329,918. The decrease in output was relatively small, but the tables show that a much more unfavorable presentation was prevented only by an almost phenomenal increase in certain States having only minor oyster interests in 1880, while the most important oyster region in the country, viz, Chesapeake Bay and its tributaries, underwent a very significant decline.

Report on the Fisheries of the Pacific Coast of the United States. (Report, 1888, pp. 3–269, 49 plates, including maps of fishing-grounds.)

This is thought to be the most complete and comprehensive report ever issued on the fisheries of the Pacific States. The fisheries and the various shore branches dependent thereon are discussed by civil or natural divisions, and the history, methods, and statistics of the industry are given in great detail. The number of persons employed in the fisheries of this region is shown to be 13,850. The capital invested was $6,498,239, and the value of the products was $6,387,803. The most important objects of capture were salmon, worth $2,082,809; sea otters, fur-seals, and other pinnipeds, worth $1,832,552; whalebone, oil, and ivory, worth $690,729; and oysters, worth $601,999. The salmon-canning industry utilized 41,632,223 pounds of salmon, for which $1,783,227 was paid, and prepared 622,037 cases of canned fish, for which $3,703,838 was received. Compared with 1880, a gratifying increase in the fisheries of the region has occurred, amounting to 3,177 in persons engaged, $4,196,856 in investment, and $2,111,300 in value of catch. The usefulness of the report to the fishing interests is considerably enhanced by the incorporation of 32 plates of the principal commercial fishes and cetaceans of the region, and 15 folding charts showing the littoral and fluvial fishing-grounds. Census Bulletin 167, on the Fisheries of the Pacific States, is based entirely on this report.

The Fishing Vessels and Boats of the Pacific Coast. (Bulletin, 1890, pp. 13–48, 13 plates and 4 text figures.)

This paper is supplemental to the article on the fisheries of the Pacific coast, and was originally prepared for incorporation in that report. The vessels and boats employed in each of the more important commercial fisheries are described and figured, and their adaptation to the special branches is discussed. Special chapters treat of the whale fleet, the fur-seal and sea-otter vessels and boats, the skin boats of the aborigines (kaiaks, bidarkas, oomiaks, etc.), the cod and halibut fleets, salmon vessels and boats, the market fleet, oyster vessels and boats, dories and sharpies, and Chinese fishing craft.

Report upon the Participation of the U. S. Fish Commission in the Centennial Exposition, held at Cincinnati, Ohio, in 1888. (Report, 1888, pp. 869–885.)

In company with the other Government departments and bureaus, the U. S. Fish Commission took part in the commemoration of the one-hundredth anniversary of the settlement of Cincinnati. The exhibit was prepared, installed, and conducted under the direction of the assistant in charge of the Division of Fisheries, and may therefore be appropriately referred to as a part of the work of this office. The report reviews the origin and objects of the Exposition, cites the legislation in pursuance of which the Federal Government participated, and gives a detailed account of the scope, preparation, management, and results of the Fish Commission exhibit. The work of the principal branches of the Fish Commission, viz, the Division of Scientific Inquiry, the Division of Fish-culture, and the Division of Fisheries, was appropriately illustrated by models, photographs, sketches, charts, specimens, apparatus, publications, statistics, etc. One of the most entertaining features of the exhibit was the aquarial display of live fish and other animals, and the hatching of 45,000 eggs of the California salmon (*Oncorhynchus chouicha*).

NOTES ON THE COMMERCIAL FISHERIES.

During the year many matters of interest and importance have arisen in connection with the economic fisheries. Some of these will be dealt with in the regular reports of the division and need not here be referred to; others, however, of special interest, may be briefly noticed in this place. While no complete investigation of the fisheries of the entire country has been made for the past year, the office has kept well informed on the most prominent features of the industry through its agents and correspondents. Owing to the methods and the season of their prosecution, it will be necessary to regard the fisheries with reference to the calendar year 1891, instead of strictly observing the period covered by this report of the division.

THE FISHERIES FOR GROUND FISH.

The great bank and ocean fisheries for cod, haddock, halibut, etc., prosecuted from New England ports did not present any specially striking features which would distinguish the past season from the conditions in recent years.

For the market fishery, which is centered at Boston, the year 1891 was a very favorable one. The ground fish for which the fishery is prosecuted were very abundant in the South Channel; and on the "Golding Ground," situated 10 miles off Swampscott, haddock were found in greater numbers than for many years. The largest single fare of fresh fish ever taken in the market fishery was landed February 18, 1891, when the schooner *Sea Fox*, of Gloucester, as a result of a trip lasting one week, brought in 132,500 pounds of fresh cod, haddock, hake, cusk, and halibut taken on the Cape Shore. The total quantity of fish landed at Boston by the market fleet was 68,026,517 pounds, with a value to the fishermen of not less than $1,738,440. Of the foregoing catch, 20,964,870 pounds were taken in the South Channel and 12,876,805 pounds on Georges Bank. Haddock constituted 33,860,197 pounds, cod 16,655,200 pounds, hake 12,347,730 pounds, cusk 2,814,170 pounds, pollock 1,226,505 pounds, and halibut 1,122,715 pounds. The schooner *Sea Fox* was the "high liner" of the fleet, stocking $26,669, the value of 1,288,350 pounds of fresh fish.

The salt-cod fishery was somewhat less successful than in 1890. Most of the vessels that went to the Grand Banks secured only partial fares, although the prices received for the fish were usually high, being at the close of the season $4.75 per cwt. for large cod and $3.75 per cwt. for small cod, sold from the vessel. Cod were also scarce on Georges Bank and the salt fish brought the fishermen as much as $5 per cwt. for large and $3.75 per cwt. for small cod. The vessel in the bank cod fishery that had the largest stock was the schooner *William E. Morrisey*, of Gloucester, which landed 482,275 pounds, which sold for $18,277.

The salt-cod fishery carried on at the Shumagin Islands and in Okhotsk Sea by San Francisco vessels, which is one of the principal offshore fisheries of the Pacific coast, was quite successful in 1891. More fish were landed than during any year since 1885. The aggregate catch was 3,870,000 pounds of dried fish, equivalent to about 1,290,900 individual cod.

Vessels which went to Iceland for fares of fletched halibut did well, although no very large fares were landed. The aggregate yield was 1,542,900 pounds of salt fish and 541 barrels of fins. The largest catch, 214,000 pounds, was taken by the schooner *Senator Saulsbury*, of Gloucester, and sold for $13,694. The bank fresh-halibut fishery was not generally successful. On the eastern grounds the fish were scarce and were found in deeper water than usual. The best fishing was on Georges Bank, where a few good fares were taken. The product of the fresh-halibut fishery was about 7,460,000 pounds, of which about 2,060,000 pounds came from Georges Bank.

THE MACKEREL FISHERY.

Mackerel, which since 1885 have not been abundant, continued to be scarce, but the catch was about three times as large as in 1890, aggregating about 48,000 barrels of salt fish, worth $544,000, and about 4,375,000 pounds of fresh fish, valued at $491,000. The season opened auspiciously, and the prospects for a large catch were considered good, but the mackerel did not appear in the anticipated numbers. As the season advanced, the fish were found to be most abundant in the Gulf of Maine, and it was here that the principal catch was made. The fleet in the Gulf of St. Lawrence was the smallest in many years, numbering only 13 sail, and the average yield per vessel was only 110 barrels, while on the New England and Nova Scotia shores the average catch was 270 barrels. An unusually large catch was made by the boat fishermen on the coast of Maine.

The fish were mostly of the size and quality which in salted fish represent No. 3's. The average wholesale prices per barrel of salt fish were $18 for No. 1's, $13 for No. 2's, and $8 for No. 3's. The schooner *Lizzie M. Center*, of Gloucester, made the largest stock, landing 909 barrels of salt mackerel, which sold for $13,820.

THE PACIFIC SALMON FISHERY.

The condition of this important industry received much attention from the fishing interests of the west coast and was also the subject of a Congressional inquiry addressed to the U. S. Commissioner of Fish and Fisheries, whose report,* treating especially of the salmon industry of Alaska, contains an account of the business for the year covered by this review and obviates the necessity for giving an extended notice of the subject in this place.

The salmon pack in the United States and Alaska in 1891 amounted to about 1,300,000 cases, of which 800,000 cases were prepared in Alaska and 390,000 in the Columbia River. The pack in Alaska was the largest ever made, and resulted in a flooded market, the outcome of which was an agreement among the owners of the canneries to reduce the output in 1892 to 400,000 cases and to close all but nine canneries.

It is gratifying to be able to record a tendency to a change of sentiment among the well-informed fishermen as to the possibility of greatly reducing the supply of salmon by indiscriminate methods and the necessity for permitting a fair proportion of the fish to reach their spawning-grounds unmolested. Within ten years it has been asserted by canners and fishermen on the Columbia River that the supply of salmon in that stream is inexhaustible, but the fishing in recent years has been disappointing, and the testimony of many prominent persons might be cited in support of the statistics which show a gradually diminishing output.

It is worthy of notice that at a cannery on the Karluk River, Alaska, a private hatchery was maintained and 5,000,000 fry of the red salmon (*Oncorhynchus nerka*) were liberated. This practice can not be too highly commended and should be generally carried out, on account of the cheapness and facility with which the hatching can be done and the important results which may be expected. In order to provide for the protection and maintenance of the salmon in Alaska, the U. S. Commissioner of Fish and Fisheries recommended to Congress the following measure, which became a law in March, 1892:

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* Report of the Commissioner of Fish and Fisheries relative to the Salmon Fisheries of Alaska. Senate Mis. Doc. No. 192, Fifty-second Congress, first session. Washington, 1892.

AN ACT TO PROVIDE FOR THE PROTECTION OF THE SALMON FISHERIES OF ALASKA.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the erection of dams, barricades, or other obstructions in any of the rivers of Alaska, with the purpose or result of preventing or impeding the ascent of salmon or other anadromous species to their spawning-grounds, is hereby declared to be unlawful, and the Secretary of the Treasury is hereby authorized and directed to establish such regulations and surveillance as may be necessary to insure that this prohibition is strictly enforced and to otherwise protect the salmon fisheries of Alaska; and every person who shall be found guilty of a violation of the provisions of this section shall be fined not less than $250 for each day of the continuance of such obstruction.

SEC. 2. That the Commissioner of Fish and Fisheries is hereby empowered and directed to institute an investigation into the habits, abundance, and distribution of the salmon of Alaska, as well as the present conditions and methods of the fisheries, with a view of recommending to Congress such additional legislation as may be necessary to prevent the impairment or exhaustion of these valuable fisheries, and placing them under regular and permanent conditions of production.

SEC. 3. That section 1956 of the Revised Statutes of the United States is hereby declared to include and apply to all the dominion of the United States in the waters of Bering Sea; and it shall be the duty of the President, at a timely season in each year, to issue his proclamation and cause the same to be published for one month in at least one newspaper, if any such there be, published at each United States port of entry on the Pacific coast, warning all persons against entering said waters for the purpose of violating the provisions of said section; and he shall also cause one or more vessels of the United States to diligently cruise said waters and arrest all persons, and seize all vessels found to be, or to have been, engaged in any violation of the laws of the United States therein.

THE WHALE FISHERY.

Considered with reference to the number of vessels employed, this important fishery continues the decline which began many years ago, although the high price of whalebone has tended to keep up the value of the fishery. During the past thirty years, at the beginning of each decade corresponding with the year 1891, the whaling fleet was made up as follows: 1861, 423 vessels; 1871, 218 vessels; 1881, 161 vessels; 1891, 92 vessels. The average price of bone per pound during each of these years was as follows: 1861, $0.66; 1871, $0.70; 1881, $1.63; 1891, $5.38. The value of the bone may therefore be regarded as a fair criterion of the status of the fishery, the highest average price ever attained being coincident with the smallest fleet. The fishery continues to have its principal headquarters at San Francisco, which, in addition to maintaining a large local fleet, is also the rendezvous of about a third of the vessels hailing from New Bedford.

The receipts of whale products at United States ports in 1891 consisted of 13,015 barrels of oil from sperm whales, 14,837 barrels of oil from other species of whales, and 297,768 pounds of bone, the whole having a value at the wholesale market price of about $2,160,935.

The sperm oil was practically all taken in the Atlantic Ocean. It is reported that at the end of the year the pursuit of sperm whales had been entirely abandoned by American vessels on the famous old grounds in the Pacific and Indian oceans. The great bulk of the other whale oil and of the bone was landed at San Francisco, although the high price of bone was an incentive to vessels on the east coast to seek right whales, and a fair stock of bone was taken. The smaller vessels of the Atlantic coast that engage in shore whaling off the South Atlantic States and elsewhere had a satisfactory season. This branch of the fishery has, during the past two or three years, seemed to show evidences of growth. The principal whaling grounds now frequented by American vessels are the North Pacific and Arctic oceans, although a small fleet from New Bedford and other New England ports still resort to the old grounds in the Atlantic. The pursuit of whales in the Arctic Ocean is attended with more than ordinary risk, but this is more than offset by the relative abundance of whales. A number of vessels, in order to be early on the grounds, have braved the dangers of an arctic winter by remaining within the arctic circle, and this practice is apparently becoming more common. Two steam whaling vessels that wintered at Herschel Island in 1891 had a very successful season, taking 31 whales; and it was reported that 5 steamers intended to pass the following winter there. The 2 vessels mentioned went farther west than any other whaler had ever gone, reaching Cape Bathurst and Liverpool Bay, in longitude 128° west.

THE FUR-SEAL FISHERY.

The Bering Sea dispute has continued to be one of the leading fishery topics of the west coast, and the pelagic hunting of seals by American and Canadian vessels has received more than usual attention. In June, 1891, a temporary agreement was reached with Great Britain for the protection of seals pending the settlement of the question by arbitration; by the terms of the agreement the killing of seals in Bering Sea was prohibited, and the company having the lease of the sealing privileges on the Pribilof Islands was permitted to take only 7,500 skins. On June 15, 1891, the President issued a proclamation setting forth the terms of the agreement, the text of which was as follows:

1. Her Majesty's Government will prohibit, until May next, seal killing in that part of Bering Sea lying eastward of the line of demarcation described in article No. 1 of the treaty of 1867 between the United States and Russia, and will promptly use its best efforts to insure the observance of this prohibition by British subjects and vessels.

2. The United States Government will prohibit seal killing for the same period in the same part of Bering Sea and on the shores and islands thereof the property of the United States (in excess of 7,500 to be taken on the islands for the subsistence and care of the natives), and will promptly use its best efforts to insure the observance of this prohibition by United States citizens and vessels.

3. Every vessel or person offending against this prohibition in the said waters of Bering Sea outside of the ordinary territorial limits of the United States may be seized and detained by the naval or other duly commissioned officers of either of the high contracting parties, but they shall be handed over as soon as practicable to the authorities of the nation to which they respectively belong, who shall alone have

jurisdiction to try the offense and impose the penalties for the same. The witnesses and proofs necessary to establish the offense shall also be sent with them.

4. In order to facilitate such proper inquiries as Her Majesty's Government may desire to make, with a view to the presentation of the case of that Government before arbitrators, and in expectation that an agreement for arbitration may be arrived at, it is agreed that suitable persons designated by Great Britain will be permitted at any time, upon application, to visit or to remain upon the seal islands during the present sealing season for that purpose.

Bering Sea was patrolled by a fleet of naval and revenue vessels. The high price of seal skins was a great incentive to engage in pelagic sealing, and some American and Canadian vessels followed the migrating herds into the forbidden waters and ran the risk of seizure and confiscation. A number of vessels were seized.

The submission of the Bering Sea question to arbitration, as suggested in the fourth article of the agreement, was secured by the ratification by the U. S. Senate on March 29, 1892, of a treaty formulated for that purpose. This long-standing diplomatic question has thus reached a stage where its early settlement seems probable.

The following detailed presentation of the extent and results of this fishery is based on statements furnished to the office by Mr. Henry W. Elliott, who obtained the data from Mr. Albert Fraser, of New York City, the American agent of Messrs. Lampson and the Hudson Bay Company, the English firms which handle nearly all the skins shown. The reports of the department of marine and fisheries of Canada and special inquiries conducted by this division have also supplied additional information. The tables show the operations of the American and Canadian vessels during the years 1890 and 1891, the figures for the former year being given for purposes of comparison. In 1890 the 15 vessels sailing from United States ports are reported to have taken 14,956 seals, the value of whose skins was $190,689, the average price being $12.75; by far the larger part of the catch was obtained in Bering Sea. Twenty-nine vessels belonging in Canada secured 39,547 seals, the value of which, as ascertained from the official Canadian report, was $435,017, an average of $11 per skin; somewhat less than half the catch was obtained in Bering Sea, the remainder coming from the coast in the spring and the passes through which the seals migrate into Bering Sea, the seals killed on these grounds being designated as "spring catch" and "Sand Point catch," respectively. The aggregate production was 54,503 seals, with a first value of $625,706. The yield by American vessels in 1891 is designated as "spring catch" and "fall catch." The 30 vessels shown in the table took 14,808 seals, valued at $236,928, an average of $16 per skin. The seals taken by the Canadian vessels in 1891 are separated by fishing-grounds, as in 1890. Fifty vessels were engaged and 49,863 skins were procured, of which 29,100 came from Bering Sea. The official report of the Canadian fisheries department places the value of the catch at $15 a skin, or $747,945 in the aggregate. The combined operations of the vessels of both countries yielded 64,671 skins, worth $984,873.

Pelagic fur-sealing fleet in 1890.

Names of vessels.	Ports.	Number of seals taken.			
		Spring catch.	Sand Point catch.	Bering Sea catch.	Total.
American vessels:					
Allie I. Algar	Port Townsend, Wash	185		2,459	2,644
Annie	do			400	400
Bessie Rutter	Astoria, Oreg			707	707
City of San Diego	San Francisco, Cal			579	579
Edward E. Webster	do			*500	500
George R. White	La Conner, Wash			400	400
Henry Dennis	Seattle, Wash			1,500	1,500
James Hamilton Lewis	San Francisco, Cal			*2,600	2,600
Kate and Anna	Astoria, Oreg			362	362
Lily L	San Francisco, Cal	800		1,088	1,888
Mattie T. Dyer	do		74		74
San Diego	do			*1,000	1,000
Sophia Sutherland	do			1,138	1,138
Teazer	Seattle, Wash			600	600
Venture	Port Townsend, Wash			564	564
Total		985	74	13,897	14,956
Value					$190,689
Canadian vessels:					
Annie C. Moore	Victoria, B. C	90	703	630	1,423
Ariel	do	220	349	1,137	1,706
Aurora	do	165	797		962
Beatrice	do	220	710	854	1,784
C. H. Tupper	do		571	796	1,367
E. B. Marvin	do	368	878	918	2,164
Favorite	do	356	981	1,116	2,453
Juanita	do	97	311	770	1,178
Kate	do	156	511	230	897
Katherine	do	380	345	945	1,670
Letitia	do	70			70
Lily	do	122		500	622
Maggie Mac	do		1,200	752	1,952
Mary Ellen	do	115	951		1,066
Mary Taylor	do	104	302	592	998
Minnie	do	300	764	1,467	2,531
Mountain Chief	do	60			60
Ocean Belle	do		946	480	1,426
Pioneer	do	235	716	984	1,935
Penelope	do	148	578	445	1,171
Sapphire	do	119	1,378	745	2,242
Sea Lion	do	254	817	774	1,845
Theresa	do	175	569	450	1,194
Triumph	do	182	1,018	473	1,673
Venture	do	94			94
Viva	do	262	436	2,015	2,713
W. P. Sayward	do	154	339	459	952
Walter L. Rich	do	122	562	633	1,317
Wanderer	do	82			82
Total		4,650	16,732	18,165	39,547
Value					$435,017
Grand total		5,635	16,806	32,062	54,503
Total value					$625,706

*It is not known with certainty whether all of these seals were taken in Bering Sea.

Pelagic fur-sealing fleet of the United States in 1891.

Names of vessels.	Ports.	Number of seals taken.		
		Spring catch.	Fall catch.	Total.
Allie I. Algar	Seattle, Wash	450		450
Beaver	Port Townsend, Wash	126		126
Bessie Rutter	Astoria, Oreg		206	206
C. C. Perkins	Neah Bay, Wash		200	200
C. G. White	San Francisco, Cal		1,668	1,668
C. H. White	do		438	438
Challenge	do		172	172
City of San Diego	do	514	641	1,155
Edward E. Webster	do	600	1,400	2,000
Emma and Louisa	do		1,100	1,100
Emmett Felitz	Port Townsend, Wash	279		279
Ethel	San Diego, Cal	350		350
George R. White	Port Townsend, Wash		210	210
Helen Blum	San Francisco, Cal		46	46
Henry Dennis	Seattle, Wash	750	428	1,178
James G. Swan	Neah Bay, Wash	54		54
James Hamilton Lewis	San Francisco, Cal	470		470

Pelagic fur-sealing fleet of the United States in 1891—Continued.

Names of vessels.	Ports.	Number of seals taken.		
		Spring catch.	Fall catch.	Total.
Kate and Anna	Astoria, Oreg	180	450	630
La Ninfa	San Francisco, Cal	260		260
Leo	Port Townsend, Wash	180		180
Lily L	San Francisco, Cal		540	540
Lottie	Port Townsend, Wash		460	460
Louis Olsen (steamer)	Astoria, Oreg	301	169	470
Mattie T. Dyer	San Francisco, Cal		380	380
Nellie Martin	Port Townsend, Wash	200		200
Rose Sparks	San Francisco, Cal	148		148
San Diego	do		465	465
Serena Thayer	Wilmington, Cal		158	158
Sophia Sutherland	San Francisco, Cal	363	57	420
Undaunted	Kadiak, Alaska	395		395
Total		5,620	9,188	14,808
Value				$236,928

Pelagic fur-sealing fleet of Canada in 1891.

Names of vessels.	Ports.	Number of seals taken.			
		Spring catch.	Sand Point catch.	Bering Sea catch.	Total.
Ainoko	Victoria, B. C		406	25	431
Annie C. Moore	do	46	442	1,588	2,076
Annie E. Paint	do			154	154
Ariel	do			1,082	1,082
Aurora	do	53	340	47	440
Beatrice	do		300	600	900
Beatrice	Vancouver, B. C	59	136	876	1,071
Borealis	Victoria, B. C		473	1,547	2,020
C. D. Rand	do			20	20
C. H. Tupper	do		235	374	609
Carmelite	do		751	1,639	2,390
Charlotte G. Cox	do		517	1,519	2,036
E. B. Marvin	do	216	462		678
Eliza Edwards (steamer)	do	1		49	50
Favorite	do	35	337	2,581	2,953
Geneva	do	3	224	267	494
Hesperus	do	2			2
Kate	do	32		1,100	1,132
Katherine	do		191	1,224	1,415
Labrador	do		374	216	590
Laura	do			61	61
Letitia	do	4			4
Maggie Mac	do	137	548	3	688
Mary Ellen	do	21	609	65	695
Mary Taylor	do	54	445	264	763
Mascot	do	7		79	86
Maud S	do		394	1,030	1,424
Minnie	do	308	373	22	703
May Belle	do		701	241	942
Mountain Chief	do	21			21
Ocean Belle	do	170	568	1,170	1,908
Oscar and Hattie	do	54	409	1,062	1,525
Otto	do			48	48
Penelope	do	229	410	691	1,330
Pioneer	do	162	712	1,484	2,358
Rosie Olsen (steamer)	do	40	176	52	268
Sapphire	do	50	974	2,435	3,459
Sea Lion	do	354	584	82	1,020
Sierra	do	886			886
Theresa	do		307	985	1,292
Thistle (steamer)	do	9	294	82	385
Triumph	do	176	666	171	1,013
Umbria	do		405	504	909
Venture	do		90	659	749
Viva	do		1,261	731	1,992
W. P. Sayward	do	187	734	801	1,722
Walter A. Earle	do	198	848	1,021	2,067
Walter L. Rich	do		519	21	540
Wanderer	do	7	20	330	357
Winnefred	do	7		98	105
Total		3,528	17,235	29,100	49,863
Value					$747,945

THE LOBSTER FISHERY.

Among the shore fisheries of Maine and Massachusetts few have received more attention from the State authorities than the lobster fishery. Considering the importance of this branch, which ranks third in value among the fisheries of New England and holds the first position among the fisheries of Maine and the sixth in Massachusetts, it is not strange that its maintenance should be the subject for solicitude among those intrusted with the supervision of the fisheries or otherwise interested in the industry. The more or less local habitat of the lobster is the principal reason for believing that its abundance in a given coast area may be seriously affected by indiscriminate methods. The migration of lobsters is essentially a bathic one, the coastwise movements being limited, even if worthy of note. It is this fact which affords the strongest ground for reliance on rational regulation and artificial propagation for the maintenance or increase of the supply.

The protection accorded the lobster in the New England States has consisted in a limitation of the size of lobsters marketed and canned, the establishment of a close season for canning, and the prohibition of the sale of egg-bearing lobsters.

In the investigation of the fisheries carried on by this office, the lobster fishery has always received careful attention. By the personal inquiries of its agents, the Commission has obtained accurate statistics and has kept well informed regarding the methods employed, the status of the fishery, and the nature and the degree of enforcement of the State regulations. The office inquiries show that the output of the lobster fishery in this country in 1892 was 23,301,149 pounds, valued at $1,050,677. The catch was apportioned as follows among the different States:

States.	Pounds.	Value.
Maine	17,193,002	$649,891
New Hampshire	220,024	13,142
Massachusetts	3,177,295	205,638
Rhode Island	774,100	53,762
Connecticut	1,614,530	101,318
New York	165,093	15,655
New Jersey	143,905	10,861
Delaware	8,200	410
Total	23,301,149	1,050,677

The great interests of the New England States in the perpetuation of this fishery are evidenced by this table.

Since 1889, when this division made a complete canvass of this fishery, there has been a very important decrease in the catch of lobsters in New England, especially in Maine. In 1889 the Maine fishermen took 25,001,351 pounds of lobsters, for which they received $574,165. This was probably the highest point ever attained by the fishery. The decline of over 7,000,000 pounds in the production in three years indicates a catch in previous years far beyond the natural resources and shows that the fears entertained for the preservation of this fishery are well grounded. Notwithstanding the largely diminished output, the value of the catch has not only not decreased, but has increased about $75,000.

According to the reports of the Maine fish commissioners, lobsters in that State are being rapidly caught up, the reasons assigned being an increased demand and evasions of the law consisting of the sale, canning, and pickling of short lobsters and the sale of egg-bearing lobsters. The report of the commissioner of sea and shore fisheries for 1891–92 says:

> The conclusion [of fishermen, dealers, and smack men] is unanimous that the lobster is being rapidly exterminated along the coast of Maine. Many fishermen go so far as to assert that unless measures are at once taken to prevent such wanton waste, it will speedily happen that none of these delicious crustaceans will remain to be taken by anyone.

The decrease in the lobster catch in Massachusetts between 1889 and 1892 was 176,492 pounds, while the value of the yield increased $57,146. The conditions in this State appear to be more favorable than in Maine. Although the year 1891 showed a decreased catch of 319,338 lobsters as compared with 1890, it was coincident with the withdrawal of 52 fishermen and 4,106 traps from the fishery, according to the returns made to the State authorities; and the average catch per trap in 1891 was a little over 1 per cent greater than in 1890.

In New Hampshire, Rhode Island, and Connecticut there has been an increase in the lobster catch, largely owing to increased attention to the fishery because of the higher prices commanded. The returns for the three Middle Atlantic States having a lobster fishery indicate a decrease in the abundance of the lobsters; the diminution in the catch, while actually slight, is important in view of the relatively small output in these States.

THE OYSTER FISHERY.

The oyster is the most valuable fishery product of the United States. The gross value of the fishery in 1891 was about $15,000,000. It is five times as valuable as the next important product, the salmon, and equals the combined value of the catch of cod, haddock, halibut, mackerel, menhaden, shad, alewives, herring, salmon, whales, lobsters, shrimps, and clams. It is additionally important in that it is the most generally distributed of our fishery objects, occurring in commercial abundance in every State (except Maine and New Hampshire), having a frontage on salt water. It is not especially remarkable, therefore, that the oyster should receive great attention, and that, with the large increase of population in the coast States and the improved facilities for shipping it into the interior in recent years, the question of the maintenance and increase of the supply should be kept prominent. At a comparatively early date some of the principal oyster-producing States began to appreciate the importance of preventing the depletion of the natural grounds by unrestricted methods, and took steps to preserve this valuable resource, but in some of the States largely interested the possibility of a reduction of the supply was lost sight of and inadequate steps were taken to check a gradually diminishing output. The States taking the most advanced stand recognized the value and necessity of artificial methods in the oyster fishery; they provided for the lease or sale of the barren grounds to individuals, who were given proprietary rights in the oyster beds, and inaugurated a system of revenue from the sales, licenses, and taxes that was a material addition to the States' income.

During the year the oyster question was an important topic in most of the States having oyster interests, and the subject affected more or less directly nearly every State and Territory. The agitation of the condition and needs of this valuable industry constituted one of the most prominent features of the fisheries of the country during this period. Especially worthy of mention was the attention given to the subject in Maryland, Virginia, and the Southern States generally. The output in Maryland was over 1,000,000 bushels more than in the previous year, a result generally attributed to the law requiring the return to the water of oysters under $2\frac{1}{2}$ inches in length, and to the recovery of the oyster beds from the deleterious effect of freshets in the spring of 1889. In Virginia an impetus was given to oyster-culture by the act, approved February 25, 1892, requiring the survey and mapping of the oyster reefs, and extending the provisions for obtaining private areas for planting purposes. The tendency of recent legislation has been to promote oyster-culture by selling, leasing, or granting lands for oyster planting for long periods or in perpetuity, and by securing protection to the planters in their operations. The success of the oyster farmers in Connecticut, New York, and New Jersey, as the result of the encouragement and assistance of modern laws, is well known, and the development of the extensive oyster resources of the Southern States has begun under auspicious legislation, but in the most important oyster region in the country, viz, the Chesapeake Bay and its tributaries, the suggestion of general private ownership of the oyster-grounds has not up to this time met with the favorable consideration which all experience teaches should be accorded, and it may be a number of years before the radical sentiment and local prejudices there prevalent will permit the formulation of a practical plan for the maintenance of the oyster industry.

The importance of the oyster industry and the attention it is receiving can be well gauged by the large number of inquiries regarding it addressed to this Commission and the very general demand for oyster literature, especially from the Southern States. Considerable correspondence, often requiring careful research, has been had with persons desiring information on the present condition of the oyster industry in the country at large and in special States, on the methods of culture and on the benefits of artificial means in increasing the supply and in stopping the depletion of natural beds.

IMPROVEMENTS IN FISHING VESSELS.

The tendency on the part of New England vessel-owners to adopt only modern types in adding to their fleets has steadily increased, until at the present time very few vessels intended for the offshore fisheries are constructed on the old lines. In the last report of the division attention was drawn to the advantages which have accrued to the fisheries through the introduction of the new forms of vessels. Personal inquiries recently addressed to fishermen in the principal ports confirm all the claims that have been made and show that the new vessels are yearly coming more into use and favor. From numerous available records of the practical value of the improvements, the following example, quoted from the Gloucester Daily Times of April 4, 1892, may be given:

Schooner *Nannie C. Bohlin*, from the banks, Sunday, reports a most thrilling experience. On the morning of March 12, at about daylight, while bowling along by the wind, under full sail, with the usual watch on deck, a sudden squall arose. Capt. Bohlin was just coming on deck, and was standing in the companion-way, when a fierce gust from the northwest threw the vessel down. The captain managed to reach the deck. The man at the wheel, with great presence of mind, threw the wheel down, although both he and the wheel were submerged. He then rushed for the starboard side of the vessel and hung out over the stern, which was almost under water. One other of the crew also hung over the side and escaped being washed overboard. The crew in the forecastle were soon on deck (those in the cabin were unable to get out), and one of them rushed forward and let go the head sails. The vessel soon came up. It was a narrow escape, and had the *Bohlin* not been an extra good craft and the squall abated somewhat, she might have filled and sunk. The vessel had lain flat in the water, her sails half under. One of her crew walked along her side from the wheel box to the fore rigging, so flat did she lie. The bait boards were torn off the house and two of the dories floated off by the water.

Commenting on this incident, Forest and Stream of the same date makes the following statement:

The importance of the recent improvements in the fishing vessels of New England, due to the precept and example of the U. S. Fish Commission, though generally acknowledged, has never been more strongly exemplified than in the recent occurrence, the particulars of which are stated in the Gloucester Times of April 4. The *Nannie C. Bohlin* is one of the deep schooners and something like the *Fredonia* designed by the late Mr. Burgess, and has before this occasion demonstrated in the highest degree her special fitness for the business in which she engaged, so far as both seaworthiness and speed are concerned. It is evident to anyone at all familiar with naval architecture and the peculiar peril in which she was placed that had she been as shallow as the vessels in common use in the New England fisheries a few years ago none of her crew would ever have returned to tell of their experience.

ATTEMPT TO ESTABLISH A BEAM-TRAWL FISHERY.

Experiments conducted with a view to introduce new methods into our commercial fisheries, to develop new fishing-grounds, and to place new fish in the markets of the country must always be among the most important current matters connected with the fishing industry. Such was the attempt to use the beam trawl on the New England coast during the winter of 1891–92, and although the experiment was not on the whole successful and was eventually abandoned it was not without its practical results and will no doubt lead to other trials in the near future. While a few other attempts have been made to establish the beam trawl in the vessel fisheries of New England, the one in question was much more extensive and important than any other of which there is record, and it seems proper to chronicle its history.

In the spring of 1891 Capt. A. Bradford, commanding the schooner *Mary F. Chisholm*, of Boston, Mass., conducted some preliminary experiments with the beam trawl, the success of which led to the construction of the trawler *Resolute*, of 95 tons, of a type similar to the vessels employed in the fisheries of the North Sea. Capt. Bradford has furnished this office with a detailed account of his trips.

The first voyage of the *Resolute* was made in November, 1891. The first set was on Middle Bank, where fish were found to be scarce. In Ipswich Bay, where the next set was made, there was also a scarcity of fish. Some witch soles were taken on muddy bottom, but the supply of cod and haddock was very limited. The vessel then proceeded to the southern part of Georges Bank, where, in the first haul, occupying three hours, 10,000 pounds of haddock were secured, together with dogfish in troublesome numbers; a second set yielded 5,000 pounds of haddock and some soles. The next haul in the same locality was in 25 fathoms of water. The net came up full, but in being lifted the trawl was torn, owing to darkness, and every fish was lost in the same way. A final successful set was made, and the vessel proceeded to market with about 28,000 pounds, representing 20 species of fish, the largest quantities being haddock, plaice, witch soles, lemon soles, turbot, butter-fish, cod, hake, and sturgeon.

The second trip was to the same grounds. During the first night 12,000 pounds of fish were secured. Subsequent sets were unsuccessful, owing to the weakness of the nets, which would burst with a weight of only 15,000 pounds, whereas they should have held at least 25,000 pounds. The vessel made port with only 18,000 pounds.

On the third voyage the same ground was first visited, but the fish had moved, and the vessel went to the South Channel, where, in 90 fathoms of water, fish were found to be abundant, but the nets invariably tore when being lifted. Capt. Bradford states that there was one bag of fish that he was exceedingly sorry to lose, as it contained some kinds which he had never seen before and of which he intended to send specimens to the Fish Commission if he had saved them. The large net, which had been in the water only three hours, came up full to the mouth, but when the tackles were put on the net broke, as in previous trials, and the fish were lost. The vessel made port with 15,000 pounds of fish, and the crew set to work to construct a net of superior twine.

The details of the fourth and final voyage are as follows: The first night on the bank 12,000 pounds of haddock and soles were taken at first haul; at second haul there was a calm, and only 3,000 pounds were secured. Then for nine successive nights the weather was so calm that it was useless to lower the trawl. On the tenth night a light breeze sprang up, and at 4 o'clock the net was shot in 29 fathoms of water; at 5 o'clock the trawl was so full of fish that "the vessel was almost stopped in her drift," to quote Capt. Bradford; at 7 o'clock, when the net was being hoisted, a northeast wind and a heavy sea tore the net from the beam. The vessel lay to for forty-eight hours and then proceeded to market. The parties interested with Capt. Bradford thought he had experimented enough, and declined to prolong the attempt, much to the regret of Capt. Bradford, who had faith in the ultimate success of the venture and thought that the worst had happened that could happen. The captain writes:

> We had tried only one little area of water on the coast and met with success, as the crew shared $7 to $14 per trip. I can name many vessels which had 16 men which came home in debt, while we had only 7 men. We used less than a ton of coal per trip, and 900 gallons of water.

THE NEWFOUNDLAND BAIT QUESTION.

One of the most important factors in the fisheries carried on by New England vessels on the more eastern banks is the supply of fresh bait, which has been drawn to a considerable extent from Newfoundland ports. Canadian and French bank fishing vessels have also found it convenient to resort to the Newfoundland coast for bait. The regulation by the Newfoundland government of this privilege of obtaining bait from the local fishermen has long been an important question and has attained considerable prominence on account of its international bearing. The original bait laws of the province were formulated for the purpose of discriminating against the French fishermen at Miquelon and St. Pierre, who, on account of the large bounties paid by the French Government, were able to undersell the Newfoundland fishermen, and so control the trade in the common markets, especially those of southern Europe. In 1890 the local regulations permitted the purchase of bait by American and Canadian vessels on the payment of a license fee. This at first consisted of a tonnage tax, which had to be repaid on the occasion of each entry into Newfoundland ports, but later was modified to a tax of $1 per barrel on all bait secured, the licenses issued by the Canadian Government under the *modus vivendi* not being recognized by the provincial authorities. In 1891, in a spirit of retaliation against the British Government, the Newfoundland authorities granted no privileges to the Canadian fishermen, but gave to American vessels the right to purchase bait without the payment of any fee, the only restrictions being the limitation of the amount of bait taken and of the frequency of the visits to Newfoundland ports.

SNAPPER FISHING ON CAMPECHE BANK, GULF OF MEXICO.

In the latter part of the fiscal year 1891 the Red Snapper Fishing Company, of Galveston, Tex., entered into communication with this office, with a view to have the Fish Commission secure from the Mexican Government, through the Department of State, the privilege of using as a fishing rendezvous a portion of one of the sandy islands on Campeche Bank, lying off the coast of Yucatan, in the Gulf of Mexico, about 600 miles from Galveston. The office brought the matter to the attention of the Department of State, and in August, 1891, the request was granted subject to certain simple conditions. This initial step to develop the more remote offshore fishing-grounds in the Gulf of Mexico seems worthy of more than passing notice, although it is too soon to predict what the results of the venture will be.

The abundance of snappers and other desirable food-fish in the more distant waters of the Gulf of Mexico has often been attested, but the distance of the grounds from United States ports, the impracticability of employing sailing vessels in the business, and the comparatively limited demand for fish in the local markets of the Gulf coast have up to this time deterred fishermen and capitalists from engaging in a business with so many elements of risk. The company in question, however, proposes to keep welled fishing smacks continually on the grounds and to have the fish landed in a fresh condition by one or more steamers, which will make frequent trips with the fish to Galveston or other shipping-points, whence the catch will be distributed to Northern and Northwestern States. As a matter of general interest and for the special information of those who may hereafter be disposed to take advantage of the liberal policy of the Mexican Government, the conditions imposed on the fishing company in question may be quoted. They are given in a letter which the subsecretary of the department of public works of Mexico transmitted through the American minister to the manager of the said company on August 7, 1891:

> The President of the Republic has taken note of your communication, dated the 13th of May last, transmitted to this department by the department of public works, wherein, as manager of the Red Snapper Fishing Company, of Galveston, you pray for permission to occupy, during the fishing season, the arenas or Alacran inlets, for the sole purpose of meeting there to fish or to take refuge in case of bad weather, and to transfer fish from fishing vessels to steamers to be carried thereby to the port of Galveston; and in virtue thereof the said chief magistrate has decided, pending the issue of the general fishing ordinance, that the permission you seek in the name of the company may be granted under the following conditions:
>
> 1. The companies may select, in the arenas or Alacran inlets, whatever places it may consider most expedient, for the sole and exclusive purpose of anchoring there their fishing vessels, taking refuge there in case of bad weather, and transferring therefrom fish from the fishing vessels to steamers, to be carried thereby to Galveston.

2. The company shall engage to advise this department of the number and the class of the vessels which it proposes to send to the arenas or Alacran grounds for fishing purposes, also the names thereof, in order to give due advice to the departments of the treasury and of war and marine.

3. The company shall likewise engage to comply with the regulations given in the premises by the aforesaid departments of the treasury and of war and marine; furthermore, the company shall engage to comply with the instructions established under the regulations on marine fishing which may hereafter be issued, pledging not to resort to any measure not accepted among civilized nations.

4. This permit will take effect from and after the 1st of next September, and be good till April 30 of next year (1892), the company having the option to renew the same.

I advise you of the foregoing for the information of yourself and of the company you represent; praying acknowledgment of receipt of this permit, to the effect that the said company agrees to the conditions established thereunder.

MISCELLANEOUS MATTERS.

INTERNATIONAL FISHERY CONFERENCES.

The agitation of the condition of the fisheries of the international lakes, especially Lake Ontario, to which reference is elsewhere made, resulted in the call of a meeting in New York City for the purpose of discussing the question of fish protection and fish propagation in Lake Ontario. The meeting was held October 22, 1891, and was attended by special commissioners appointed by the provinces of Ontario and Quebec and by the State of New York, together with others interested in the fisheries of the Great Lakes. The attendance of the U. S. Commissioner of Fish and Fisheries was urged, but, owing to his inability to participate in the meeting, the writer was delegated for that purpose. The meeting, which was informal and simply preliminary, was called to order at the Fifth Avenue Hotel, and Hon. Robert B. Roosevelt, of New York City, was made chairman and Mr. A. D. Stewart, of Hamilton, Ontario, was designated as secretary.

On motion of Gen. Richard U. Sherman, of New Hartford, N. Y., the question of the consideration of the object of the meeting, viz, the protection, preservation, and propagation of food-fish in the Great Lakes, was referred to a committee which was to meet at Rochester, N. Y., November 10, 1891, and formulate a report to be presented to a full conference of Canadian and State representatives, to be called by the chairman. The committee, as announced, consisted of Dr. G. A. MacCallum, chairman of the Ontario Fish and Game Commission; Hon. J. W. Gregory, member of the Quebec Fish Commission; Hon. H. C. Ford, president of the Pennsylvania Fish Commission; Hon. Henry Burden, member of the New York Fish Commission; Hon. R. U. Sherman, member of the special commission to revise and codify the fish and game laws of New York; Mr. Frank J. Amsden, secretary of the Cheaper Food-Fish Association of New York; Dr. J. A. Henshall, president of the Ohio Fish Commission; Dr. J. C. Parker, president of the Michigan Fish Commission; and the writer, representing the U. S.

Commission of Fish and Fisheries. The committee was later enlarged by the selection of representatives of the fish commissions of Wisconsin, Illinois, and Minnesota.

The conference held at Rochester occupied two days and was well attended, not only by members of the committee, but by numerous public and private individuals interested in the lake fisheries. Gen. Sherman acted as chairman of the meeting. This Commission was represented as on the previous occasion, but, owing to the evident impropriety of the General Government taking part in discussions and recommendations regarding contemplated legislation on the part of Canada and the lake States, the writer, under instructions from Washington, asked to be relieved from active service on the committee. The members of the conference seemed to be satisfied with the results accomplished in the way of formulating the laws to protect the food-fish and in securing an harmonious agreement between the representatives of New York, Pennsylvania, and Michigan on the one hand and Ontario and Quebec on the other. The question of Government control of the lake fisheries was informally discussed; the sentiment of the meeting was generally inimical to the relinquishment by the States of jurisdiction over the waters. It was given out that the hope was entertained that the Canadian provinces would be allowed by the Imperial Government to assume authority over the fisheries of their side of the lakes, in order that they might be in position to reach some mutual agreement with the States. The more important recommendations which it was decided to present to the conference were as follows:

1. A resolution urging all States interested in the lake fisheries to secure the passage of laws forbidding the taking or marketing of salmon trout or lake trout weighing less than 2 pounds, of black bass weighing less than 1 pound, of pike perch weighing less than three-fourths of a pound, and of whitefish weighing less than 2 pounds.

2. A resolution providing for the prohibition of all kinds of commercial fishing in the St. Lawrence River.

3. A resolution asking Congress to authorize the United States Commission of Fish and Fisheries to make a biological survey of the great lake fisheries, including the determination of the food, habits, and migrations of the commercial fishes.

The meeting adjourned to convene on December 8, 1891, at Hamilton, Ontario, where the conference was presided over by Hon. Donald McNaughton, of Rochester. The action and recommendations of the Rochester meeting were approved, and the conference adjourned without day, with the understanding that similiar conferences were to be held each year as long as the condition of the fisheries warranted solicitude and mutual legislative action on the part of the States and provinces most interested.

PHOTOGRAPHIC WORK.

In the Great Lakes and Chesapeake Bay a large number of photographs were taken by field agents using hand cameras in conjunction with the regular fishery investigations. A very valuable series of views, representing fishing towns, vessels, apparatus, methods of catching and curing fish, etc., was obtained, which is available for illustration of reports. Several hundred of these views, with others secured during previous inquiries in the South Atlantic and Gulf States, were enlarged for use in the Fish Commission exhibit at the World's Columbian Exposition.

FISHERY MATTERS BEFORE CONGRESS.

On January 30, 1892, a bill was introduced in the House of Representatives by Mr. Lapham, of Rhode Island, entitled "A bill to regulate the fisheries, and for other purposes" (H. R. 5030). On January 26 Mr. Aldrich, of the same State, presented a similar bill in the Senate (S. 1899). The measure was intended to grant full authority to menhaden and mackerel fishermen using purse seines to fish unrestrictedly in all the coast waters of the States bordering on the Atlantic Ocean. The text of the bill was as follows:

That any citizen of the United States may at all times take menhaden and mackerel with purse seines along the seacoasts and shores of the United States, and along the shores of the several islands thereunto adjacent, and in the bays, harbors, and estuaries of the said seacoasts and shores of the United States and of the said islands, in all waters under the maritime jurisdiction of the United States where the tide ebbs and flows, subject only to such control and restriction as Congress may prescribe from time to time, any law, custom, or usage of any State to the contrary notwithstanding.

The Commissioner of Fish and Fisheries is hereby directed to make such inquiries and investigations as may be necessary for ascertaining to what extent, if any, there has been diminution in the abundance of fishes of commercial importance along the coasts of the United States and in the Great Lakes, and to report to Congress the result of these investigations, together with recommendations, if in his opinion any are necessary, as to the proper measures to be adopted for the preservation of the fisheries and the continuance of an ample supply of fish.

Section 4321 of the Revised Statutes of the United States is hereby amended by inserting immediately after the word "fisheries," whenever it occurs in said section 4321, the words "on the open ocean or along the seacoasts and shores of the United States, and along the shores of the several islands thereunto adjacent, and in the bays, harbors, and estuaries of the said seacoasts and shores of the United States and of the said islands, and in all waters under the maritime jurisdiction of the United States where the tide ebbs and flows," so that it shall read in the title of a fishing license, "License for carrying on the fisheries for menhaden and mackerel with purse seines on the open ocean or along the seacoasts and shores of the United States, and along the shores of the several islands thereunto adjacent, and in the bays, harbors, and estuaries of the said seacoasts and shores of the United States and of the said islands, and in all waters under the maritime jurisdiction of the United States where the tide ebbs and flows."

And also in the body of said section, after the description of the vessel, to read: "License is hereby granted for the said vessel to be employed in carrying on the fisheries for menhaden and mackerel with purse seines on the open ocean or along the seacoasts and shores of the United States, and along the shores of the several islands thereunto adjacent, and in the bays, harbors, and estuaries of the said seacoasts and shores of the United States and of the said islands, and in all waters under the maritime jurisdiction of the United States where the tide ebbs and flows, subject only to such control or restriction as Congress may prescribe from time to time, any law, custom, or usage of any State to the contrary notwithstanding, for one year from the date hereof, and no longer."

Numerous committee hearings were accorded those who favored and opposed the contemplated legislation, and in the House the matter was finally reported on adversely. A substitute bill introduced later was also unfavorably acted on, on the ground of unconstitutionality.

RELATIONS WITH THE ELEVENTH CENSUS.

On September 9, 1891, the writer was appointed special agent of the Census Office in charge of fish and fisheries, without compensation, and at once entered upon the duties connected with that position. Active connection with the Census Office was maintained until January 5, 1892, when, owing to the fact that the work was requiring much more time and attention than was anticipated, and that satisfactory work in one department was only accomplished at the expense of the other, it was decided to discontinue the writer's services, although his commission as special agent was temporarily retained at the request of the Superintendent of the Census.

Upon assuming charge of the work it was learned that Mr. Charles F. Pidgin, of Boston, Mass., was also a special agent in charge of the fisheries division, with headquarters in Boston. Under the arrangement then in force the work of compiling the statistics from the field agents' returns devolved upon the Washington office, and tabulations were prepared for publication at the branch office in Boston.

In making reference in this report to the connection established between the Census Office and the Fish Commission it will probably not be necessary to do more than briefly mention some of the more important matters that arose during the continuance of that relation.

The clerical force available for work in the fisheries division was very small and entirely inadequate to properly deal with the extensive subject. It was therefore necessary to restrict the work to a consideration of certain special branches pending an increase in the force. The principal subject to which attention was given was the compilation of statistics showing the extent of the carp industry of the United States from 1880 to 1889. The Census Office had very complete returns covering more than 60,000 carp ponds, lakes, etc., and the results of one of the most interesting and important experiments in fish-culture were exhibited. The compilation of figures for the States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Pennsylvania was completed, and work on numerous other States was well advanced, but it was evident that many more employés would be needed in order to finish this branch of the work in a reasonable time. Another special line of work undertaken by the office force was the preparation for publication of the material illustrative of the alligator industry of Florida, for which the Census Office had approximately complete returns.

The personal services of the special agent in charge, aside from general supervision of the office affairs, chiefly consisted of work on the bulletins elsewhere mentioned. The proof of the first of these was revised, the manuscript of the second was in part prepared, and the introduction of the third was written and the tables in the same revised. Two visits to Boston, occupying seventeen days, were made in connection with this work.

On November 30, 1891, the force in the fisheries division was practically disbanded, owing to financial considerations. It was anticipated, however, that work would be resumed with an adequate force about the 1st of March.

In a report on the census work which the writer made to his superior officer in the Fish Commission on December 19, 1891, the following statement occurs, which discloses the principal consideration which necessitated the severance of active relations between the two bureaus which took place in the next month:

> From the experience I have already had with the fishery census, I am led to believe that, should the work resume with the necessary force, nearly if not quite all my time will be required to properly direct and carry on the business of the office. I feel that if the responsibility of making a creditable statistical and descriptive presentation of the fisheries of the United States is to fall on me, I should have unlimited time at my disposal, and should not be handicapped by having to divide my time and energy between two different departments. There is a great amount of work remaining to be done, and, however much of this I may be able to detail to subordinates, personal attention will have to be given to the important subjects of preparing the descriptive and tabular matter for the bulletins and the final volume, and to correspondence. I make this statement so that the conditions under which the work will be resumed may be clearly understood by you at the outset.

The following bulletins of the Census Office relating to fish and fisheries were issued during the connection of the writer with that bureau in the capacity of special agent in charge. One of these was based wholly on Fish Commission material, and in the preparation of the others recourse was had to Fish Commission records for the verification and emendation of the census returns.

Bulletin No. 123. Marine Mammalia: In the introduction to this bulletin, the Superintendent of the Census refers to this office in the following words:

> It is with pleasure that the assistance rendered by the U. S. Commission of Fish and Fisheries is gratefully acknowledged. The statistical resources of that department have been placed freely at the disposal of the Census Office for the purposes of comparison and verification, and the accuracy and completeness of this bulletin are largely due to the opportunities thus afforded.

The authors also make this reference to the Fish Commission:

> The most complete and reliable comparative statistics are naturally furnished by the U. S. Commission of Fish and Fisheries, which has a permanent body of experienced agents engaged in the work, and whose cordial coöperation with the Census Office work has been acknowledged.

Bulletin No. 167. Fisheries of the Pacific States: The figures in this bulletin were obtained from the proof sheets of the Fish Commission report, then going through the press, on the fisheries of the Pacific States. Concerning the utilization of this material the Superintendent of the Census says:

In 1889 the U. S. Commission of Fish and Fisheries conducted an exhaustive inquiry into the fisheries of this region, the results of which have been embodied in a report not yet published, the proofs of which have been consulted in the tabulation of this bulletin. Although the data thus made available mostly pertain to the year 1888, it is known that changes which occurred in the fisheries of this region between that time and the census year were not marked, and will not invalidate the presentation of the following figures as the census of 1889.

Bulletin No. 173. Fisheries of the Great Lakes: The authors, after referring to the field work of the census agents in the Great Lakes, say:

A similar work was done by the agents of the U. S. Fish Commission in the year 1885, and the very comprehensive report issued by that department, entitled Review of the Fisheries of the Great Lakes in 1885, furnished a most valuable basis of comparison between the returns made by the field agents of the Census Office and those made by the Fish Commission. A mass of unpublished statistical data in the possession of the Fish Commission has been placed at the disposal of this office by Hon. Marshall McDonald, Commissioner of Fish and Fisheries, and the best service of both departments has been freely used to contribute to the completeness and accuracy of this bulletin.

RECOMMENDATIONS.

In concluding this report, some suggestions will be made for the future field work of the division. The canvass of the coastal regions of the country and the Great Lakes has been so recently made, and the extent and condition of the fishing industry of those sections have been so often presented, that it is thought that the services of the regular field force may be advantageously and properly withdrawn temporarily from the consideration of this work and directed for a season toward other important branches or phases of the fisheries that have received little or no attention from this office.

One of the most inviting and important inquiries that properly fall to the attention of the Division of Fisheries is the investigation of the fisheries and fishery resources of the minor lakes and inland streams of the United States. An effort was made during the prosecution of the fishery census of 1880 to secure statistics of the inland fisheries, but the time, force, and means available were so limited that the results achieved were not satisfactory, and no figures were published except a general statement that the minor fisheries of the smaller lakes and interior rivers had an estimated annual value of about $1,500,000.

The meager information at hand goes to show that this estimate is probably very much below the actual figures, and it can be confidently asserted that an investigation of these so-called minor fisheries will demonstrate the existence of a much more extensive and important industry in interior waters than is generally supposed.

The value of the small lakes and inland water-courses as sources of food supply is already great and is increasing yearly with the increase in population; and the necessity for determining their fishery resources is thought to need no demonstration. It seems only a question of time, when, with the rapid settlement of certain inland States, the natural fishery advantages will demand and receive as much attention as is now bestowed on similar water areas on the continent of Europe. In some of the States of the Great Lake region it is probable that the present extent of the fisheries of the small lakes will compare very favorably with that in the Great Lakes, while the possibilities of the interior waters for fish production and fish-culture are no doubt much greater from many points of view. It will probably be impossible for the small available force of field agents to make a complete investigation of the inland fisheries in a single year, but the territory could be so divided into States or river basins that definite regions could be canvassed and reports issued from time to time, as has been found necessary to do in the case of the coastal States.

The following statement of the Wisconsin fish commissioners regarding the resources of the inland lakes in that State is no doubt typical of conditions in a number of other States in that region:

We have not even the pretense of official statistics of the value of fish catches from the inland waters, but from various private sources—principally railway and express companies—we are able to present a few suggestive figures. It is reported to us from the Lake Winnebago district, comprising the waters of Lakes Winnebago and Poygan, and Wolf and Fox rivers, there was shipped to outside markets, during the season of 1889, a total of 675,224 pounds. At the low estimate of 4 cents per pound, this export must have netted the fishermen $27,012.96, nearly one-tenth of the value of Wisconsin's fishing industry on the Great Lakes. It is probable that an equal amount was either sent to the home markets or consumed by the fishermen and their families.

Upon the Four Lakes at Madison, there are, from April to November, an average of 25 fishermen in daily employment, taking out $4,000 or $5,000 worth of fish in the season for the home market and for export. Throughout the winter a large number of men are engaged in fishing through the ice and earn fair wages.

It is reported that during 1888 there was shipped from Lake Koshkonong some 200,000 pounds of fish, valued at $8,000; and it is fair to say that from scores of inland lakes like Koshkonong—for instance, in Waukesha, Walworth, Racine, Kenosha and Green Lake counties—equally large shipments are annually made. It is unfortunate that we find it impossible, in the lack of proper reporting agencies, to present the statistics of this trade; were we able to do so, it would doubtless be found that the value of the inland fisheries was at least equal to that of the Great Lakes, and quite as deserving of legislative attention.—(Report of the Commissioners of Fisheries of the State of Wisconsin, 1889–90.)

There are few fisheries of the Atlantic coast that have attracted more attention and occasioned more discussion and comment in recent years than the menhaden fishery. The phases of the controversy between the advocates and opponents of the fishery need not here be referred to, but it seems proper that one of these, viz, the extent to which other fish besides menhaden enter into the catch of the vessels, should receive attention from this office, because it is one of the most important questions connected with the subject and is better adapted to consideration by this division than some of the more scientific problems which have arisen. During all the discussion which in past years has taken place regarding the effects of this fishery on the abundance of other fish, there has been an entire absence of authentic data on the quantities of food-fish captured with menhaden. This lack of information has, no doubt, often led to a misconception of the effects of the fishery and caused unjust criticism on the part of well-meaning persons. Since it appears probable that the menhaden fishery will, for some years at least, be the subject of legislative consideration and personal controversy, it seems important to secure and have available for use all information that can possibly be obtained that is calculated to aid in the solution of the very difficult problems involved.

It is therefore conceived that valuable material relating to the special point under discussion may be obtained by placing the field force of the division on vessels fishing off various parts of the coast and having the agents make actual records of the results of every seine-haul during a period of two or three months. While this plan would involve a study of a small part of the menhaden fleet, it would nevertheless afford a valuable basis for generalization.

The plan has not yet been fully elaborated, but includes the use by each agent and on each vessel of a special blank on which the following information is to be recorded for each haul of the seine during the year: Date; hour; fishing-ground; quantity of menhaden caught; number of bluefish, mackerel, Spanish mackerel, squeteague, sea bass, sheepshead, drum, cero, albicore, scup, striped bass, sharks, skates, rays, and other fish taken with menhaden; disposition made of fish, and value, if sold. There may be added to this inquiry a consideration of the dependence of the line fisheries for bluefish, sea bass, etc., on the menhaden fishery as a source of bait supply—another important question involved in the menhaden controversy.

INDEX TO REPORT OF COMMISSIONER.

1.—REPORT UPON THE INVESTIGATIONS OF THE U. S. FISH COMMISSION STEAMER ALBATROSS FOR THE YEAR ENDING JUNE 30, 1892.

By Lieut. Commander Z. L. TANNER, U. S. N., commanding.

CRUISE TO BERING SEA WITH THE U. S. BERING SEA COMMISSIONERS.

San Francisco to Bering Sea.—The *Albatross* was in dry dock at the Union Iron Works, San Francisco, Cal., at the close of the fiscal year ending June 30, 1891, for the purpose of cleaning and painting her bottom. The vessel had been in the water but five months, yet her service in the tropical waters of the Gulf of Panama and the region of the Galapagos resulted in a luxuriant growth of barnacles and grass, to which was added a coating of slime, bryozoa, and mussels accumulated while lying at Mare Island. The estimated weight of the accumulation was 17 tons, and the reduction of speed caused by it, about 1½ knots an hour. The bottom was painted with a coat of red lead, followed by one of white zinc, at her previous docking, a preparation which gave satisfaction in the cold waters of Bering Sea, but proved ineffective in the tropics. Inferior zinc may have contributed largely to this result.

A communication was received from the U. S. Commissioner of Fish and Fisheries, inclosing an order from the Navy Department, reducing the crew from 67 to 53 men on July 1, and taking from us some of our most important ratings. This reduction was ordered on account of the lack of men for manning the new ships of the Navy recently completed. After leaving the dry dock the bunkers were filled with coal, and, with the exception of an incomplete list of officers, the vessel was ready for her usual Bering Sea cruise on July 7. We proceeded to the navy-yard at Mare Island on the afternoon of the same day.

Assistant Paymaster C. S. Williams was relieved on the 2d of July by Assistant Paymaster John S. Carpenter. Paymaster Williams was attached to the *Albatross* nearly four years, performing the duties of disbursing agent for the Fish Commission in addition to those regularly devolving upon him as paymaster; and I avail myself of this opportunity of saying that the Fish Commission is under many obligations to him for the prompt and efficient manner in which he performed this duty. Personally I am greatly indebted to him for the cheerful alacrity with which he responded to every call without reference to the character of service required. He received his detachment on July 9.

The following telegram was received from the Commissioner on July 9:

President directs *Albatross* to carry agents of the Government to Seal Islands, Bering Sea, and remain with them during their investigation to continue all summer. You will arrange to carry out President's instructions. Fish Commission work will be given up unless you find opportunity to do something. Agents will meet you in San Francisco. Full details later.

Ensign H. B. Wilson, U. S. Navy, reported for duty on the 10th.

Learning from the public press that Prof. T. C. Mendenhall, superintendent of the U. S. Coast and Geodetic Survey, had been appointed commissioner, I met him by arrangement on his arrival in San Francisco and made all necessary preparations for the voyage. His colleague, Dr. C. Hart Merriam, had not arrived, but was expected at any time, and then they would be ready to sail.

Little remained to be done except to take on a further supply of fuel, mess stores, etc., and, returning to San Francisco on the 14th, final preparations were completed the next day, when the following telegram was received from the Commissioner:

T. C. Mendenhall and C. Hart Merriam have been designated as agents to visit Bering Sea. In accordance with President's directions you will receive them on board and carry out the instructions they may give you. All possible facilities for the conduct of their inquiries will be furnished by you.

The commissioners came on board at 5 p. m., July 16, when we immediately got under way and proceeded to sea en route to the Seal Islands, via Unalaska. It was desirable to reach our destination as soon as practicable, yet I deemed it advisable to start at moderate speed, with fires under one boiler only, as nearly all of the engineer's force were new to the ship, and strangers to each other. A heavy head sea was encountered during the first night and next day, but on the 18th the weather moderated, and everything was working so smoothly that fires were started under the second boiler, and the speed increased to 10½ and 11 knots per hour.

The weather was generally cloudy, with frequent mists and showers of rain, and light to moderate winds from northwest to southwest. Few birds were seen during the trip, mostly petrels and the brown albatross. A question arose as to whether the same birds followed the vessel day after day, and, to decide the point, one of the latter was taken and labeled; when released he deviated neither to the right nor left, but disappeared as quickly as his rapid flight would allow, and was never seen again. Whales were of almost daily occurrence, and porpoises were seen occasionally. No seals were observed, however, outside of Bering Sea.

The water was literally covered for hours at a time during the trip with velellas, medusæ, and floating barnacles, the latter in clusters from 1 to 6 inches in diameter, each individual being joined by its stem to a fleshy mass common to the colony. Many of these masses were opened and found to contain the skeleton of a velella. A piece of kelp was seen on the 23d, 500 miles from the nearest of the Aleutian Islands, and the next day puffins, gulls, etc., began to appear. Occasional vessels were seen as we approached the land.

The volcano of Akutan was sighted early on the morning of the 25th, and at 3:45 p. m. the same day we dropped anchor in Iliuliuk, Unalaska, having made the trip from San Francisco in a little less than nine days. The steamer *Danube* having on board Sir George Baden-Powell and Dr. George M. Dawson, the British commissioners to Bering Sea, was found in port; she had arrived the same day.

The harbor presented a most animated appearance for a place so remote from the ordinary routes of commerce and travel. In addition to the vessel mentioned there were lying in the harbor H. B. M. S. *Nymphe*, *Pheasant*, and transport *Costa Rica;* the U. S. S. *Alert*, *Thetis*, revenue steamer *Rush*, and transport *Al Ki*. There were also the barks *Carrolton* and *Ferris S. Thompson* with coal; the Alaska Commercial Company's steamer *Dora* and schooner *Matthew Turner;* and the prize *La Nimfa*. The steamers *Lakme* and *Farallon* were lying in Dutch Harbor, about a mile distant.

Pribilof Islands.—The *Danube*, with the British commissioners on board, left for the Seal Islands at 10 a. m. on the 26th, and, after coaling, the *Albatross* followed at 6 a. m. on the 27th. We exchanged signals with the U. S. S. *Mohican* about noon, and heard a steamer's fog whistle about midnight, but did not see her. Seals were frequently encountered after crossing the 100-fathom line into shoaler water. They were seen singly as a rule, and there were seldom more than two or three in sight at a time.

Steaming through the night at low speed, in a thick fog, we made St. George Island at 8 a. m. the following morning, and anchored off the village two hours later.

The commissioners landed at 10 a. m. and returned at meridian, bringing with them Mr. J. Stanley-Brown, special Treasury agent, and Capt. A. W. Lavender, Treasury agent for St. George Island, for passage to St. Paul. Getting under way as soon as they arrived, we ran over to the latter island, and reached Village Cove at 5:45 p. m. during a dense fog. The *Danube*, with the British commissioner on board, was lying at anchor in the bay, having arrived about noon.

Mr. Tingle, agent of the North American Commercial Company, and Mr. Murray, U. S. Treasury agent, came on board and called on the U. S. commissioners. The time required in going to and from the ship, even under favorable conditions, and the uncertainty of communication at all times, induced the commissioners to take up their quarters ashore during their stay at the island, and they were landed the following day, July 29. There is no protected harbor on either island and anchorages are sought to leeward of projecting points, or under the lee of the island itself, to be changed with the shifting winds of that ever-varying climate. A well-found steamer may remain safely at anchor long after communication with the shore has become impracticable; in fact, she might lay out many of the short summer gales, even with the wind blowing on-shore.

We were greatly entertained during the first night of our visit at St. Paul by the graceful antics of the seals which were constantly playing about the ship. They were greatly interested in the electric lights, and their efforts to obtain a nearer view of them through the side ports were persistent and very amusing. Numbers of them remained about the ship day and night watching every movement on deck or aloft, their particular delight, however, being the ship's boats, which they would escort to and from the vessel, playing about in the most graceful manner just clear of the oars.

I visited Lukannon rookery on the afternoon of the 29th in company with J. Stanley-Brown and the U. S. commissioners, and had an excellent opportunity of observing it carefully. The first impression of the novice is unbounded amazement at the seemingly endless numbers of seals (*Callorhinus ursinus*) covering the ground adjacent to the beach, yet further observation revealed the fact that only a small proportion of the original rookery was occupied. The grassy margins define unmistakably the extent of the rookery at successive periods.

I made no survey of the rookery, made no measurements whatever; yet, standing on Lukannon Hill, overlooking nearly every foot of its adjacent breeding and hauling grounds, a fairly good estimate could be made of the comparative area of the original rookery and the space occupied at present. The family relations were beginning to break up, the pups being several weeks old and many of the cows absent from the rookery seeking food; but the old bulls still occupied their harems with such of their females and young as they could keep about them.

The interval of time which has elapsed since the first indicated contraction of area was estimated at from seven to ten years; my own opinion, based upon the appearance of the grass which covered the surface, inclines to the shorter period.

The Treasury agent informed me on the evening of the 29th that a sealer had been at work off Northeast Point rookery for three days, his rifles being distinctly heard in the fog, and, in the absence of naval vessels or revenue cutters, he appealed to the *Albatross* to assist him to capture or warn the poacher off. We offered all practicable aid, as a matter of course, and, with the agent and a boat's crew from the village on board, we examined the region north and east of the island next day, but saw nothing of the vessel. We learned subsequently, however, that she was captured by the revenue cutter *Corwin* on the 28th of July and taken to Unalaska. Early in the morning of August 3 the United States and British commissioners, officers of the *Danube* and *Albatross*, and others, met on the village killing-ground to witness the killing of 120 young male seals, a part of the quota of 7,500 allowed for the subsistence of the natives.

The seal-killing over, we returned on board and got under way immediately for a dredging trip. Five hauls of the beam trawl were made off the south and west sides of the island, in depths ranging from 20 to 51 fathoms, bottom of fine gray or black sand and shells; a few pebbles were found at some stations, and a trace of black mud at others.

The general character of life was much the same in all of the hauls, and while but few individuals of each kind were taken, the variety of species was comparatively large. An exception should be made, however, in the case of starfishes and ophiurans, the former being quite plentiful, and the latter coming up by the bushel in most of the hauls.

The catch for the day may be summarized as follows: Small pollock (one specimen); young cod, tomcod, young sculpins, eels, *Lycodes* and *Agonidæ* (a few specimens each); flounders (*Limanda aspera*, few, and *Lepidopsetta bilineata*, one); crabs, hermit crabs, shrimps, prawns, and pycnogonids; annelids; mollusks of several species, including naked mollusks and a large *Trophon*; ascidians and bryozoans; holothurians, sea-urchins, starfishes, and ophiurans; medusæ, hydroids, and sponges.

Nothing was taken with the hand lines, though they were tried at several stations. The natives report that cod and halibut frequent the waters about the island during the winter and early spring, but the former become scarce soon after the seals arrive and only a few of the latter remain during the summer. Neither of these species is ever taken in large numbers. It is a well-known fact that feeding seals go farther and farther from the islands in search of food as the season advances, until in the latter part of July they reach the vicinity of the 100-fathom line south and west of the Pribilofs, from 50 to 100 miles and more from their rookeries.

After finishing the biological explorations for the day, several hydrographic soundings were made off the western extremity of the island, and an excellent anchorage for the night was found in 8 fathoms to the westward of Cross Hill, near Northeast Point. The revenue cutter *Rush* passed the night there also. A number of sea-lion skins were procured the next day for specimens, and in the afternoon we returned to our former anchorage at Village Cove.

On the morning of August 5 the U. S. commissioners, Prof. T. C. Mendenhall and Dr. C. Hart Merriam, came on board, accompanied by the British commissioners, Sir George Baden-Powell and Dr. George M. Dawson, with a stenographer and interpreter, to visit the Northeast Point rookery. They were landed on the east side of the point near Cross Hill, where they were joined by Mr. G. R. Tingle, general agent for the North American Commercial Company, Mr. J. C. Redpath, and Mr. Fowler, employés of the company, who acted as guides. Mr. Fowler was in charge of the rookery.

This rookery is the largest in the world, and the view from the summit of Hutchinson's Hill is simply astounding. Yet the evidences of diminution in numbers are unmistakable.

Returning to Village Cove, the *Albatross* remained at anchor until our final departure from the islands.

A hunting and fishing party was sent out on the 6th and returned with 3 halibut and 5 small codfish, the results of a hard day's work. One of the best native fishermen was employed as pilot, and having the steam cutter at their disposal they were able to change their ground as often as desirable; hence all conditions were favorable, and the catch was considered satisfactory for the time of year. The hunters secured a variety of birds from Otter Island, from which excellent specimens were prepared. They were all well-known species, however.

The *Danube*, with the British commissioners on board, left for Nunivak, St. Matthews Island, etc., during the morning.

British and United States men-of-war and revenue cutters were constantly coming and going, and there was seldom a day that one or more failed either to call or pass within signal distance.

At 9:45 a. m. August 9 the *Albatross* got under way, and with the U. S. commissioners and Mr. J. Stanley-Brown on board, steamed to St. George Island, arriving at 2:30 p. m. The gentlemen above mentioned and a number of officers landed and made a cursory examination of the rookery near the village, returning at 5:20 p. m. Mr. Stanley-Brown remained on the island. I had a casual glance only at one rookery at St. George, but here, as on St. Paul, there were unmistakable evidences of great reduction in numbers, a large portion of the original hauling-grounds being overgrown with grass.

The commissioners landed again at 8:30 the following morning, and returned at 10 a. m., when we took our final departure from the seal islands.

It was foggy during the day, with short intervals of clear weather. An occasional seal was seen until we reached the vicinity of the 100-fathom line, but none beyond that point.

Bogoslof Island.—We were under low speed during the night, and at 7 o'clock next morning hove-to off the volcano of Bogoslof and landed the commissioners. A party of officers and men visited the island also. We noted many changes since our visit the previous year. New Bogoslof was still active, smoke and steam escaping through numberless crevices throughout the whole mass from the water's edge to the summit. It was at least 100 feet lower and was otherwise changed in outline. What had been the rocky pinnacle was now lying in huge masses strewn down the steep incline, even to the surface of the sea, silent witnesses of great convulsions that had occurred during the previous winter.

The old and new volcanoes are about a mile apart, and were a year ago connected by a narrow isthmus but little above the level of the sea, composed of fine volcanic cinders. Now, however, there is an open passage through it several hundred feet in width near the new cone, the remainder of the spit extending from old Bogoslof having been moved bodily to the westward with a broad sweep. A bar or middle ground was found a few hundred yards to the eastward of a line drawn between the cones. Wishing to anchor while the party was on shore, a boat was sent ahead sounding into the bight midway between the old and new peaks. Good anchorage being reported, with nothing less than 20 fathoms until near the spit, we started ahead slowly, the first sounding 20 fathoms and the next 9 feet, the vessel having moved less than twice her length. Of course the bow was aground, but we backed off without damage or delay. The boat had crossed the bank before commencing to sound. The beaches, the bank above mentioned, and the isthmus formerly connecting the two cones are composed of fine cinders, ashes, etc., lighter than sand or gravel, and are in consequence washed back and forth with every heavy gale.

Myriads of guillemots covered the rugged cliffs of the active volcano, as well as the extinct cone, and huge flocks were constantly coming and going in their usual active, bustling manner, their curiosity being evinced frequently by hundreds or thousands deviating from their course and circling around the vessel several times as closely as they considered prudent, observing us with apparent interest.

A sea-lion rookery referred to in former reports, near the base of old Bogoslof, was occupied as usual. This colony is notable for the unusual size of some of the old bulls. They seemed quite tame, permitting several of the shore party to approach close to them before showing signs of fear. Their location being remote from the usual routes in Bering Sea, they are seldom disturbed, and the few that have been killed were taken by officers of the Alaska Commercial Company, who never wantonly destroy or disturb these, to them, useful animals.

Bogoslof Island to Puget Sound.—The party returned from shore a few minutes after noon, when we started for Unalaska. The afternoon was clear, and the snow-capped peak of Makushin volcano was visible even from Bogoslof, and as we approached the rugged shores of Unalaska the peak of Akutan became visible while Bogoslof was still in sight, thus affording the unusual view of three active volcanoes at the same time.

We hove-to off Cape Cheerful and put the cod lines over, but the trial was unsuccessful. Probably it was too late. Our experience in Bering Sea has been that codfish usually cease to bite about sunset. A few scattering specimens were taken at all hours of the night when the vessel was at anchor on fishing-grounds, but never in paying numbers. After a delay of 10 minutes we steamed ahead and arrived at Iliuliuk at 8:10 p. m.

The revenue-cutters *Rush* and *Corwin* came in and anchored a few minutes later.

We went to the coal wharf the following morning, and at 12:05 p. m. August 13 finished coaling. The U. S. S. *Alert* arrived during the morning. Mail was received from the vessels in the harbor as well as from shore, and at 12:25 p. m. the lines were cast off from the wharf and we proceeded to sea. Fires were lighted under one boiler only, which gave the vessel a speed of 9 knots per hour. Entering the Pacific through Unalga Pass, a course was laid for the north end of Vancouver Island. The sea being smooth and the weather unusually clear, our last view of the Aleutian Chain had little in it to remind us of our high latitude except the snow-capped peaks of Akutan and Shishaldin.

Fires were started in the second boiler on the 14th, and the revolutions gradually increased until at noon of the 16th we were making ordinary full speed. Cape St. James was sighted at 11:55 a. m. on the 19th; passed the Triangles the same evening and entered Goletas Channel at 2:50 a. m. on the 20th. We experienced light to moderate winds from NE. to NW., with pleasant weather as a rule, although it was occasionally overcast and squally. Whales were seen nearly every day, and the usual birds of those latitudes accompanied the ship from land to land.

Steaming through Goletas Channel, we soon entered the broad estuary of Queen Charlotte Sound, passed through Broughton Straits, and at 8:20 a. m. came to in Alert Bay, British Columbia. The commissioners visited the cannery and Indian village, and the naturalists busied themselves making collections of native hunting and fishing implements for the Columbian Exhibition.

Continuing our course after a delay of an hour and a half, we threaded the narrow channels of Johnstone Straits and Seymour Narrows to the Gulf of Georgia, finally anchoring in Departure Bay at 1:22 a. m., August 21. Going to the wharf at 9 a. m., 91 tons of coal were taken on board, and at 5:15 p. m. we steamed away again to the southward. Entering Active Pass at 9:12, its narrow sinuous channel was followed without difficulty or delay, notwithstanding the night was dark and the atmosphere thick with smoke. Our course led us through Swanson Channel, the Straits of Haro, and across the Straits of Fuca to Port Townsend, where we arrived at 2:40 a. m. the following morning.

We carry no pilot, and in navigating the tortuous inland passages of this region it is our usual practice to run during daylight only. The departure from this custom during the trip was occasioned by the anxiety of the commissioners to reach their destination as soon as practicable. The detention at Port Townsend was for the purpose of procuring mail which had accumulated during the trip; having received it, we left at 10:35 a. m. for Tacoma, arriving at 4:40 p. m., when the commissioners, Prof. Mendenhall and Dr. Merriam, took their final departure.

Mr. Ivan Petroff, special census agent for Alaska, was found in Iliuliuk on our return from the Seal Islands, August 11, anxiously awaiting transportation to the southward, his work in northern regions having been completed. As the *Albatross* was the first departure, he requested passage, which was of course granted, and he immediately took up his quarters on board. He brought with him a one-man kayak made by the natives of Nunivak, which he donated to the Fish Commission exhibit at the World's Columbian Exposition.

The following is a brief summary of the movements of the *Albatross* while employed in transporting the United States commissioners to the Seal Islands, Bering Sea, and return:

July 16. Left San Francisco for Unalaska.
July 25. Arrive at Unalaska.
July 27. Left Unalaska for Seal Islands.
July 28. Arrived at St. Paul Island via St. George.
Aug. 9. Left St. Paul and arrived at St. George Island.
Aug. 10. Left St. George Island,
Aug. 11. Arrived at Unalaska via Bogoslof Volcano.
Aug. 13. Left Unalaska.
Aug. 20. Arrived at Alert Bay, British Columbia.
Aug. 21. Arrived at Departure Bay, British Columbia; took coal.
Aug. 22. Arrived at Tacoma, Wash., via Port Townsend.

No. of days on the voyage, 37; total distance made under steam (in knots), 4,686.

The cruise was made without accident resulting in delay, damage or loss of any kind.

INVESTIGATIONS ON THE COAST OF WASHINGTON.

Orders were received at Port Townsend on August 25 to explore the waters of the Straits of Fuca, and later to extend the work to Hood Canal.

A number of articles collected in Bering Sea for the Columbian Exposition were shipped to Washington on the morning of the 27th, and at 11:40 a. m. we got under way and steamed into the straits.

Commencing off New Dungeness, the beam-trawl was cast at 97 fathoms, and a line consisting of 4 stations occupied from that point to the vicinity of Race Rocks, the depths ranging from 80 to 100 fathoms. The bottom was mostly muddy, with a few pebbles; rocky bottom was found at one station in 100 fathoms. The results of the hauls may be stated in a general way as follows: Among the fishes were a few flounders (*Microstomus pacificus*), 4 species of small fishes, ratfish (*Chimæra colliei*), alligator-fish, *Liparis*, etc. The list of invertebrates included 6 species of prawns, shrimps, crabs, sea-urchins, naked mollusks, worms and tubes, pectens, and several species of small shells. Two species of brachiopods were found in great numbers, and were a marked feature of the hauls. Hydroids, cup corals, pycnogonids, starfishes, ascidians, and sponges were found in each haul.

The surface net found the waters almost barren of life, a few small crustaceans being all that were found during daylight. After dark medusæ came to the surface, and a half bushel or more were taken at each haul.

Anchorage for the night was found at 11:50 p. m. in Neah Bay. Work was resumed on the morning of the 28th, by setting two cod and two halibut trawl lines in from 80 to 100 fathoms, off Neah Bay. Hand lines were put over, but the current was too strong to admit of their being used successfully. The trawls was out but a few minutes when the buoys disappeared, one by one, beneath the surface, and we never saw them again.

Our investigations for the remainder of the day were confined to the beam trawl, while a new set of lines was being prepared. Six stations were occupied in from 98 to 151 fathoms, between Neah Bay and Cape Flattery, on rocky bottom. The results were satisfactory, but the wear and tear on trawl nets was unprecedented. The weather was excellent for that stormy region and the sea unusually smooth, yet strong and erratic currents swept the ship about in the most extraordinary manner, largely increasing the losses incident to rocky bottoms. A marked change in the character of the fauna was observed, deep-sea types occupying a more prominent position. The following forms were noted among the fishes: A single specimen of the true cod (*Gadus morrhua*) was found in one of the hauls, the first taken by the *Albatross* south of Alaska. The flounders were represented by *Microstomus pacificus*, *Glyptocephalus zachirus*, and *Atheresthes stomias*. The former were abundant and averaged 3 pounds in weight. It is an excellent fish, and is sometimes called the deep-sea sole, as is also the *Glyptocephalus*. A few of the following were scattered through the hauls: ratfish (*Chimæra*), dogfish, skate, *Sebastodes*, *Sebastolobus*, *Myctophum*, and *Liparis*.

The invertebrates were represented by prawns, shrimps, crabs, hermit-crabs, pycnogonids, brachiopods, and other shells, sea-urchins, starfishes, sponges, worms, and a single small squid.

Anchorage for the night was found in Neah Bay.

We were under way again at daylight on the 29th (August), and, steaming to a promising locality in the straits, one cod and one halibut trawl line were set in 140 fathoms, gravel bottom. Heavy grapnels were used for mooring each end of the lines, and double buoys were attached to the buoy ropes. Mr. A. B. Alexander, fishery expert, was so confident that his gear was sufficiently strong for the purpose, that the ship took up other work pending the hauling of the trawls; but it was not long before one of the buoys disappeared. The other end was secured by a boat and 100 hooks recovered, from which were taken 3 black-cod. The largest weighed 28 pounds and was 51 inches long.

Another trawl line was set at 12:30 p. m. in 125 fathoms, rocky bottom, boats being used as buoys, and we succeeded in recovering the gear, taking 14 black-cod averaging 12½ pounds in weight, sufficient evidence, our expert thought, of the presence of this excellent fish in the waters of the straits.

Two hauls of the trawl were made during the day, adding a few antedons and astrophytons to our list of specimens. It was foggy most of the day, sometimes very thick, otherwise the weather was favorable. At 10:45 p. m. we came to for the night in Royal Roads, off Esquimalt, B. C.

Our supply of trawl anchors, buoys, etc., having been expended, a sufficient number were procured in Victoria and we returned to Neah Bay on the morning of the 31st, prepared to make another attempt at trawl-line fishing in the Straits of Fuca.

Work was resumed at daylight September 1, and four sets of the trawl line were made between Neah Bay and the Vancouver shore. A few black-cod, red rockfish, and dogfish were taken. In one set the currents were so strong that nearly all the hooks were stripped of bait.

Four hauls of the beam trawl were made and the list of specimens enlarged by a fine cultus-cod weighing 29 pounds, several crinoids, isopods, and ophiurans.

We passed the night in Neah Bay, commencing work again at daylight on the 2d. Four sets of the trawl line and four hauls of the beam trawl were made between Neah Bay and Pillar Point, where we anchored for the night. The depths ranged from 53 to 123 fathoms, with sandy bottom at three stations, and rocky at the fourth, yet there was nothing taken on the trawl lines except a few dogfish. We did better with the beam trawl, however, and added to our list a young halibut (*Hippoglossoides*), several specimens of *Parophrys vetulus* and *Citharichthys sordidus*, a dozen young cod, and many crinoids.

Three sets of the trawl line and one haul of the beam trawl were made on September 3 in from 64 to 95 fathoms, sand or rocky bottom, between Pillar Point and Port Angeles. A few dogfish were the only results from the trawl lines, and there was nothing new among the specimens taken with the beam trawl.

Anchoring in Port Angeles at 4:20 p. m., a haul of the seine was made in which were taken flounders, perch, butter-fish, rock-crabs, sculpins, etc. Another haul of the seine was made early next morning, in which were taken flounders, herring, butter-fish, sculpins, and a single salmon trout.

Getting under way at 9:20 a. m., a series of hand-line stations were occupied running diagonally across the straits to the vicinity of Victoria, in which nothing at all was taken. These trials were made to demonstrate the practicability of that method of fishing in the upper part of the straits, but the currents were so strong that it was quite impossible to keep the lines on or near the bottom except close to land. Four hauls were made with the beam trawl, three of them quite successful, although nothing new was found.

We have demonstrated the existence of several species of sea fishes in the open waters of the Straits of Fuca, and have also shown the impracticability of taking them in paying quantities by the usual methods. Should the black-cod ever take the place it deserves in the market, means will doubtless be devised for its capture, even in the straits. In the vicinity of Cape Flattery the currents reach the bottom with strong scouring effect, and the state of tides on the surface is no indication of their condition at the bottom. A heavy confused swell will also be encountered, even in the calmest weather. Of course, this soon becomes modified after passing up the straits.

After finishing work for the day we steamed into Esquimalt, anchoring at 5:10 p. m. Official visits were exchanged with Admiral Hotham, R. N., the captain of H. B. M. flagship *Warspite*, and the dock-yard officials. The U. S. Coast Survey steamer *McArthur* was at anchor in the harbor, and H. B. M. S. *Garnet* arrived on the 6th; official visits were exchanged.

SURVEY FOR A CABLE ROUTE BETWEEN CALIFORNIA AND THE HAWAIIAN ISLANDS.

Preparations for the survey.—On the evening of September 5, I was informed by telegraph that the Navy Department desired to have the *Albatross* make the survey for a cable route between San Francisco and Honolulu, for which a special provision had been made by Congress, and that it was important to begin the same as soon as possible. Reply was made that the ship was in condition to make the survey and could commence the work two weeks after arriving at San Francisco. On September 9 we went to Departure Bay for the purpose of coaling, where, the following day, we received orders to proceed at once to San Francisco.

Having finished coaling at 3 p. m., we left immediately for Port Townsend, and thence to San Francisco, arriving at the navy-yard, Mare Island, on the morning of the 15th, and reporting by telegraph. There were no instructions waiting us, and nothing further was heard concerning the survey until the 19th, when the following letter was received from Commodore F. M. Ramsay, Chief of the Bureau of Navigation, Navy Department, dated Washington, D. C., September 12, 1891:

> The Department has been informed that the *Albatross* will be placed under its orders for the purpose of sounding out a route for the proposed telegraph cable between San Francisco and Honolulu. The Bureau desires to know what you will need for the work and about what time the vessel will be ready. Arrangements have been already made to supply you with wire, but there may be some delay in its being delivered.

The following reply was made by telegraph on September 19:

> Letter of 12th received; will need wire, sinkers, cylinders, spare reel, additional coal-bunker, docking and painting bottom. Time, 15 working days, following our usual methods. Letter by mail.

The following telegram from the Acting Commissioner of Fisheries, dated September 18, was received on the 19th:

> In compliance with request of Secretary of Navy the *Albatross* is hereby placed under his directions for making an ocean survey for telegraphic cable between San Francisco and Honolulu. You will report to the Navy Department the receipt of these instructions.

The following message was accordingly sent to the Secretary of the Navy on the same day:

> Have received telegram from United States Commissioner of Fish and Fisheries placing *Albatross* under your directions for surveying telegraphic route from San Francisco to Honolulu. Will wait your orders. Letter by mail.

Letters were written the same day to the Secretary of the Navy, Commissioner of Fish and Fisheries, and the Chief of the Bureau of Navigation, the latter as follows:

Your communication of September 12, with reference to the *Albatross* having been placed under the Department's orders for the purpose of sounding out a route for the proposed telegraphic cable between San Francisco and Honolulu, is received. I wired you this morning in relation to the matter as follows:

"Letter of 12th received. Will need wire, sinkers, cylinders, spare-reel, additional coal-bunker, docking, and painting bottom. Time, 15 working days, following our usual methods. Letter by mail."

The sinkers, sounding-cylinders, spare reel, etc., can be procured from the yard. The additional bunker will increase our coal capacity about 40 tons. The docking and painting can probably be done at the yard; if not, I can do it at San Francisco without delay, although the expense will be greater. Our sounding-machine is now placed forward, and the wire is held vertically after sounding, until it is all reeled up, as in our work other operations prevent steaming ahead while the wire is coming in. We purpose to put the machine on the stern in such a position that we can start ahead as soon as the sinker reaches the bottom, thus gaining a mile or more on every sounding.

The estimate of 15 days to prepare the ship for the work is, as stated in the message, on the supposition that we will follow our usual methods, which enable us to procure everything required promptly without the routine of requisitions. I can give no estimate of the time which would be required to do the work under the ordinary navy-yard methods.

It would facilitate preparations very much if I had a general idea of the proposed scheme of the work.

A word of explanation may not be out of place regarding the references in the foregoing letter to "our usual methods" and "the ordinary navy-yard methods." In refitting, small articles will be required from time to time as the work progresses, and it has been our custom to procure them at once by open purchase without the delay incident to the making of requisitions, sending out proposals, and getting competitive bids. On the other hand, the navy-yard methods are controlled by the necessity of following the indicated routine, with the frequent and uncertain delays attending it; hence the difficulty of estimating the time required to complete a job with any degree of accuracy.

On September 21, Rear-Admiral John Irwin, commandant of the navy-yard, received the following telegram, a copy of which he forwarded to me.

Fit out *Albatross* for sounding between San Francisco and Honolulu.

F. M. Ramsay,
Acting Secretary Navy.

I received instructions at the same time to make requisitions on the navy-yard for everything needed for the survey. The work of preparation was pushed forward as fast as possible. The vessel was docked the following day, September 22, and her bottom cleaned and painted, work on needed changes and repairs proceeding at the same time. Everything required for the survey, except wire, was furnished from the navy-yard or purchased at San Francisco.

On September 24 I wired the hydrographer asking the scheme of survey, intervals, and route, and the same day received the following reply:

Shortest practicable route probably just north of *Tuscarora's* route. Intervals of 10 and 2 miles; temperatures to be taken; letter explanations has been written.

Having received no definite instructions regarding the survey, the following letter was written to the chief of the Bureau of Navigation for the double purpose of giving the Department the benefit of such local knowledge as I had on the subject, and to avoid delay.

I have the honor to inform you that the *Albatross* will be ready to commence work on the cable survey in a few days. It may perhaps be advisable for me to acquaint you of the knowledge I already possess in this line. With reference to a practicable landing for the cable on the coast of California: A glance at Coast Survey chart 675 will show 100 fathoms within $1\frac{1}{2}$ miles of Salinas Landing, Monterey Bay, and over 50 fathoms half a mile from land. From this point seaward extends a constantly widening gully in a southwesterly direction, in which the depths increase rapidly with a bottom of soft mud. I have, in connection with our regular work, run a line of soundings from the shore to 900 fathoms without change in the character of the bottom. There is no other place on this coast in the vicinity of San Francisco that a cable could be landed without passing over a greater or less extent of ground where vessels may anchor; neither is there any other place where so soft a bottom can be found. If the slope from the 900 to the 2,000 fathom curve proves as free from obstructions as I have reason to expect, Monterey Bay will be the best possible place to land the cable, as there would be less than a mile of the shore-end liable to damage from vessels' anchors, and thence to deep water it would rest securely in a soft bed of mud. In our operations along the California coast, we have frequently found the slope from the shore platform to the ocean-bed dotted with outcroppings of rock sharp enough to endanger the safety of any submarine cable. This was noticeably so to the southward of the Farallones, where the lead usually indicated sand bottom; but in hauling the trawl, the net often came in contact with these sharp projections.

In commencing the survey on the California coast we will be liable to meet with delay from coast fogs, boisterous weather, etc.; therefore, I think it will be advisable to complete that portion of the line, watching for a favorable opportunity if necessary, carrying it as far offshore as convenient, then return to San Francisco and fill up with coal. We can then take up the line and carry it to the islands if we meet with no expected delays; I count on the usual gales incident to the season.

The route I recommend, providing it starts from Monterey Bay, is practically a great circle to the east end of Oahu, passing about 40 miles to the northward of the *Tuscarora's* submarine mountain, and between the soundings of 2792 and 2711 shown on H. O. chart 527.

I suppose you will send us large scale projections on which to plot our soundings. It will be a great convenience, particularly if we find it necessary to run traverses in searching for a practicable route. We have received no instructions yet, but suppose they are en route. A telegram from the acting hydrographer gave us some information as to intervals of soundings. We have everything necessary for the commencement of the work within reach and expect to leave San Francisco to locate the shore-end on the 5th or 6th of October. If anything is lacking at that time we can pick it up on our return for coal.

The following instructions for the cable survey were received October 1, 1891:

BUREAU OF NAVIGATION, NAVY DEPARTMENT,
Washington, September 22, 1891.

SIR: When fully prepared for work, you will proceed with the vessel under your command to take deep-sea soundings between San Francisco, Cal., and Honolulu, Hawaiian Islands, with a view to determining a suitable route for a submarine cable between these ports. Soundings taken at alternate intervals of 10 and 2 miles will be sufficient to demonstrate any irregularity of bottom. It may not be necessary, however, to confine yourself to these distances; I merely give them as being such as will insure with certainty the proper development. Should any unusual rise in the bottom occur, it will, of course, need close examination to determine a feasible route.

You will please keep a complete record of all resulting data for transmission to the Department at the completion of the work, and will record upon appropriate forms the latitude, longitude, depth, nature of bottom, with frequent surface and bottom temperatures, and occasional serial temperatures.

The books and papers for the records will be furnished you from the Hydrographic Office, with a sheet showing the soundings taken by the *Tuscarora* in 1875, from which it appears that the desirable route is likely to be just to the northward of this line.

By direction of the Secretary of the Navy.

Very respectfully,

F. M. RAMSAY,
Chief of Bureau.

Lieut. Commander Z. L. TANNER, U. S. N.,
Commanding U. S. F. C. S. Albatross.

The vessel was ready October 3, with the exception of a supply of wire, books, etc., which were to be furnished by the Hydrographic Office. We waited for them until the 5th, then went to San Francisco and coaled. The following telegram was received on the 6th from the Chief of the Bureau of Navigation:

Method of survey proposed letter September 27 approved.

Monterey Bay to the Hawaiian Islands.—Messrs. C. H. Townsend, naturalist, and A. B. Alexander, fishery expert, were assigned to temporary duty on shore. We finished coaling on the 8th, having taken on board 171$\frac{3}{4}$ tons. Proceeding to sea at daylight the following morning, we arrived off Santa Cruz at 2:50 p. m., and swung ship under steam, observing azimuths on every point to determine the errors of compass, finally anchoring off the town for the night. A dense fog obscured the sun during the forenoon of the 10th, but passed off at 2 p. m., when we swung ship for heeling error, first with a starboard list of 6° to 7$\frac{1}{2}$°, then with a like inclination to port, bearings being taken on the cardinal points. The results were widely different from previous observations, but they seemed reliable. The maximum heeling error did not exceed one-quarter of a point.

The first sounding of the survey was made at 9:45 a. m. on the 11th of October in 52 fathoms, 2$\frac{1}{2}$ cables W. $\frac{1}{2}$ N. (mag.) from the head of Salinas Pier, a wooden pile structure about 150 yards in length; thence to the beach a line of soundings was run by boat. Taking a southwesterly course, following the submarine gully before mentioned, the depth increased to 165 fathoms at 3 miles, and 618 fathoms at 11 miles. soundings having been taken at 1 mile intervals. Extending the line 17 miles with increasing intervals of 2, 3, and 4 miles, the depths increased to 868 fathoms, the character of bottom remaining the same, thus insuring a secure bed of soft mud in which a cable would soon sink beyond all its enemies.

From the above position, 28 miles from the initial station, an approximate great-circle course was taken, depths increasing uniformly to the normal ocean bed in 2,500 fathoms, and reaching a depth of 2,895 fathoms in latitude 33° 12′ north, bottom of brown ooze. Mud took the place of ooze at the last station, and an interval of 8 miles showed 225 fathoms less water. with small fragments of lava intermixed with the mud. The bottom soils from every station were submitted to microscopic examination, and the first warning of marked elevations of the ocean bed were almost invariably discovered by this means.

Uniform or slightly increasing depths continued for 50 miles followed by a gradual ascent, until in latitude 32° 44′ north we found ourselves on the summit of an elevation having 2,014 fathoms of water. The angles were so small and regular that the shoaling could not be considered as an obstruction, but an abrupt descent of 392 fathoms in the next 2 miles might be considered in that light. Traces of lava soon disappeared, but mud extended 12 miles from the summit, and was then replaced by brown ooze, which, with normal depths, extended to latitude 31° 43′ north. Here the line was dropped and we returned to Monterey Bay for the purpose of further developing the submarine canyon extending seaward from Salinas Landing, which, for convenience, will hereafter be referred to as the "cable trough." It was thought that more uniform depths might possibly be found by bearing slightly to the westward of the first line, but there was little choice between them. Having completed the examination, we returned to San Francisco, reaching port October 24.

The meteorological conditions, while unfavorable for the prosecution of the survey, were not unusual for the season of the year. Fogs prevailed some portion of each day in the vicinity of the land; strong coast winds with hazy, cloudy weather, extended 100 miles or more offshore; cloudy weather was the rule, and a southeast gale with heavy seas and drenching rain was encountered during the last two days the vessel was engaged on the line.

The preliminary trip developed a few weak points which were remedied in a couple of days, and the remainder of the outfit, completed during our absence, was taken on board. The 2,000 pounds of sounding wire contracted for by the Navy Department for the survey had not arrived. We waited for it until October 31; then with 160 pounds procured from the storehouse, 100 pounds from the *Thetis*, and a similar amount belonging to this vessel we left the navy-yard, took on board 190 tons of coal at San Francisco, and sailed November 4, for the further prosecution of the survey. Arrangements were made with the commandant of the navy-yard, Mare Island, to forward 400 pounds of wire to Honolulu as soon as practicable. Mr. C. H. Townsend, resident naturalist, returned on board, from special duty ashore.

The preliminary line passed about 40 miles north of the Belknap Rise, a huge submarine mountain, 14,000 feet above the ocean bed, yet no sign of it appeared either in depth, contour, or character of bottom.

The experience of the *Albatross*, following that of the *Tuscarora*, warned us of our approach to a region abounding in elevations and depressions of frequent occurrence, making it advisable to examine a wider area. With this object in view, and to avoid the elevation encountered on the preliminary trip, a parallel line was run from latitude 33° 7′ north, from 6 to 8 miles to the southward of it for about 200 miles. The elevation was avoided, and normal conditions continued to 31° 54′ north, where a depression was encountered having a maximum depth of 3,186 fathoms, and extending about 70 miles in a southwesterly direction. From 2,500 to 2,700 fathoms continued thence to 29° 11′ north, where another elevation occurred having a depth of 2,085 fathoms. The bottom specimen at this station contained a few grains of sand, minute quartz crystals, which were apparent only under the microscope. The normal depth was soon reached, and for 700 miles the average was about 2,900 fathoms, the maximum exceeding 3,000 fathoms. The bottom was, with few exceptions, composed of brown ooze, but traces of lava were found at three stations and sand at two.

In latitude 23° 14′ 30″ north, 200 miles from the east end of Oahu Island, was found the most important elevation in the line; from a base of 300 miles in diameter the depths gradually decreased from 2,839 to 1,256 fathoms. Approaching the island, a depression was crossed 60 miles from land, having a depth of 2,878 fathoms, mud bottom, all traces of foraminiferous ooze having disappeared at a distance of 100 miles from the nearest point of Oahu.

The shore platform was reached in 570 fathoms 20 miles from land, after a steep ascent from the normal ocean bed. From 300 to 400 fathoms, with smooth sand bottom, was carried through the Kaiwi Channel between Molokai and Oahu, but from the shore line to about 200 fathoms frequent coral lumps were found scattered over the sandy bottom.

Survey about the Hawaiian Islands.—We reached Honolulu at 12:30 p. m. November 21, and moored head and stern in the usual manner. The U. S. S. *Pensacola* was lying in port on our arrival. Slight repairs to machinery and sounding apparatus were made and reports of progress prepared. On December 1 a package of wire, 253 pounds gross weight, was received by steamer from San Francisco. It was the first of the new wire to reach us, and was received with no little pleasure, as it insured us an ample supply for the completion of the work. The hydrographic office blanks, before referred to, for plotting the data of the survey, were also received by the same steamer.

The order for a cable survey contemplated a single line, but our experience convinced me of the advisability of further development of the route, and on November 24 I wrote the hydrographer as follows:

> Have finished the great-circle route, with the exception of the shore landing on Oahu. While it may be considered practicable, I do not feel that any single line will be wholly satisfactory, and will, therefore, as soon as possible, extend the second route on a rhumb line, which will be about as far to the southward of the *Tuscarora's* line as the great circle is to the northward of it. I don't know that it will be any better than the one we have already examined, but it will give us two surveys and a reconnoissance on practically parallel lines.

At 10:50 a. m., December 2, we left port to locate a cable landing on the east or south side of Oahu. Four of the most promising points were examined, as follows: Hanauma Bay, Mauna Loa Bay, Kapua Entrance, and Waikiki Bay. The latter lies about 3 miles from Honolulu, and all things considered seems the best, though Kapua Entrance or Mauna Loa Bay affords practicable landings.

A second line was run from Kaiwi Channel to an intersection with the great circle in latitude 21° 47′ north, practically completing that line, and defining another contour line from the shore platform to the ocean bed, about 10 miles south and west of the first one.

The currents in the vicinity of the islands are strong and erratic, frequently attaining a velocity of 4 to 6 miles per hour on the eastern shores of Oahu, and often reaching the bottom with scouring effect. In Kaiwi Channel there is sufficient drift to prevent the deposit of mud, yet not enough to hinder the growth of various delicate forms, which we found in large numbers.

A critical examination of the bottom was made in Kaiwi Channel and near the points selected for cable landings with beam trawl and tangles, to determine more definitely the character of bottom and its fauna, having special reference to the existence of coral lumps and such forms as might be destructive to a submarine cable. The general results of these few hauls may be briefly stated as follows:

Dredging station 3467: 6 specimens of *Macruri*, 2 chimæras, 2 starfishes, 3 shells, 1 sea-urchin, 1 brisinga, 2 ascidians, 1 *Pentacheles*, 2 alcyonarians, 1 gorgonian.

Dredging station 3468: 2 small fishes, 5 sea-urchins, a few crabs, little coral, 3 ophiurans, much bryozoa.

Dredging station 3469: 1 starfish, 2 shells, much coral, little bryozoa, little algæ.

Dredging station 3470: many small fishes, 1 large fish, few starfish, 1 octopus, many prawns, 1 squid.

Dredging station 3471: many small fishes, 12 prawns, 1 holothurian, 1 pennatula.

Dredging station 3472: 6 *Macruri*, many specimens of *Myctophum*, 2 flounders, 6 eels, 12 starfish, few shells, few crabs, 6 prawns, 1 holothurian, few sponges.

Dredging station 3473: 4 *Macruri*, 2 *Sternoptyx*, 1 starfish, 3 shells, 1 crab, 4 prawns 1 naked mollusk, 1 pennatula.

Dredging station 3474: 35 *Macruri*, 2 specimens of *Myctophum*, 2 of *Sternoptyx*, 2 eels, many starfish, few shells, 5 sea-urchins, 4 crabs, few ophiurans, few prawns, few sponges, few naked mollusks, 1 pennatula.

Dredging station 3475: 24 *Macruri*, many starfish, few shells, 3 sea-urchins, few prawns, few sponges, few naked mollusks, few pennatulas, 1 squid, 3 crinoids, few sea-anemones.

Dredging station 3476: many *Macruri*, many specimens of *Sebastes*, 1 *Monocanthus*, few starfish, few crabs, few *Pentacheles*, 1 octopus, few prawns, 1 holothurian, few sponges, 1 pennatula, few squid, 1 crinoid.

We were strongly tempted to extend our biological work to the almost unknown waters of Hawaii, where every haul brought many interesting forms entirely unknown to our naturalists, but the element of time was of such importance in the cable survey that we did not feel justified in doing anything that would interfere in the slightest degree with its progress. Enough was learned, however, to show us that the prolific waters of the Hawaiian Archipelago present an exceedingly interesting and almost virgin field for the scientific explorer.

The investigations above detailed occupied us until December 6, when we returned to Honolulu, took on board 172¾ tons of coal, and made final preparations for running a second line of soundings to the California coast.

We received many courtesies as well as material aid from the officers of the Hawaiian Coast Survey and others, which greatly facilitated our work.

Hawaiian Islands to Monterey Bay.—We took our final departure from the beautiful harbor and hospitable people of Honolulu at 4:50 p. m., December 11, and steaming around Diamond Head anchored for the night in Mauna Loa Bay. Getting under way early the following morning, the rhumb line was commenced in latitude 21° 18′ north, longitude 157° 33′ west, and extended N. 63° E. true for the California coast.

The outer verge of the shore platform was found in 603 fathoms, 20 miles from land, and a sharp descent of 29 per cent from this point developed the same bold contour that was found on previous lines. The bottom retained its character of mud and sand also, without the least indication of the rocky projections so apt to occur under like conditions. Increasing depths were revealed with each succeeding cast, and 75 miles from Oahu we entered a depression 30 miles in extent, having a maximum depth of 3,027 fathoms. Thence for 160 miles the mean was not far from 2,600 fathoms, increasing to a maximum of 3,038 fathoms in 135 miles, which proved to be the deepest cast on the rhumb line. A mean of 2,900 fathoms was then carried for 345 miles to an elevation having 2,346 fathoms, and 2,700 fathoms for 120 miles to a rise over which were 2,375 fathoms.

The great central plateau averaged about 2,600 fathoms, with elevations having 1,924, 1,858, and 2,175 fathoms, the latter lying S. 46° E. true, 28 miles from the crest of the great Belknap Rise, a remarkable submarine mountain, which has an elevation of about 14,000 feet above the ocean bed, and reaches within 388 fathoms of the surface. There is a strong probability that the last-mentioned sounding was on a remote spur of this elevation, although the soundings do not positively indicate it.

The northern limit of the central plateau, following the rhumb line, lies about 450 miles from the California coast, and is succeeded by a depression 24 miles in width, having a maximum depth of 2,773 fathoms. Normal depths were soon reached again, and continued with remarkable uniformity for about 260 miles, when the water gradually shoaled toward the coast, 170 miles distant. The two lines intersected 35 miles from Salinas Landing; then followed the same route through the cable trough.

Head winds and continuous bad weather exhausted our coal, and made it necessary to drop the line in 31° 45′ north, on December 27, and go to San Francisco for a supply. We arrived on the 31st, but the next day being a holiday, and Sunday following, we were unable to commence coaling until January 3, 1892. The bunkers were full on the evening of the 6th, however, when we left the coal wharf, proceeded directly to sea, and, steaming to the spot where the line was dropped, took it up on the 10th and carried it to its intersection with the great circle in latitude 36° 40′ north. The last sounding was made in 1,053 fathoms at 8 p. m., January 15, 1892, and, the line being completed, we started for port, reaching Mare Island at 10:15 a. m., January 16.

Winds and weather.—During the preliminary trip, and while engaged upon the great-circle line, the meteorological conditions were about normal for the season of the year. Fogs and boisterous winds were experienced near the land, and after leaving the coast cloudy weather prevailed. A southeast gale was encountered between parallels 32° and 30° north, and thence to the vicinity of the islands we carried moderate to brisk trades. Heavy westerly swells were encountered at times, resulting from remote winds which did not reach us.

Good weather was the rule while we were employed in the examination of the shores of Oahu for a cable landing, although fresh winds and heavy ground swells were encountered in Kaiwi channel.

On the homeward trip bad weather was encountered from the start; a heavy norther with furious squalls and high-breaking seas struck us as soon as we left the protection of the land, but this we took philosophically, as it insured fairly clear weather, enabling us to locate the line at the slope from the shore platform to the ocean bed by cross bearings and astronomical observations. The storm continued from the 12th to the 14th, the trades springing up from ENE. on the 15th, light at first, but increasing rapidly to a strong wind with heavy squalls, rain and rising swell until, on the 20th, they attained the force of a moderate gale with heavy head sea. It began to subside on the 23d, and on the 25th we had light northeast trades, clear weather, and smooth sea, the first really pleasant day since our departure from the islands.

Wind and sea were nearly ahead for ten days, making it necessary to turn the vessel stern to it at every station, holding her in position from an hour to an hour and a half while taking the sounding, then repeating the critical operation of turning her again to her course. The work was successfully prosecuted at no small risk to life and limb, and at the expense of great and unusual strain and wear and tear on hull and machinery.

We were obliged to drop the line at noon of the 27th and go to San Francisco for coal, encountering a heavy southwest gale en route. The following extract from a San Francisco paper, describing the trip of the U. S. S. *Charleston* from Honolulu to San Diego during the last half of December, shows the weather experienced by that vessel:

San Diego, *January* 1.—At 9 o'clock this morning the cruiser *Charleston* rounded Point Loma and steamed into the bay. * * * Her sides were rusty and dirt-begrimed, and she looks as if she had experienced a hard trip and rough usage. * * * During the past week the vessel passed through one of the most terrific storms ever experienced by anybody on board, it being so bad for the 24 hours ending Thursday morning, that everything had to be strapped down, and it was impossible for a person to maintain footing anywhere on the decks.

Returning to complete the line we found light winds, pleasant weather, and smooth seas, except a few hours of boisterous coast wind on the 15th of January.

Wear and tear.—Deep-sea sounding and dredging are much more destructive to machinery, boilers especially, than ordinary full-speed steaming. The run between stations must be made as quickly as practicable, and then the engines are slowed, stopped, and backed; if steaming head to the sea, the vessel must be turned stern to it by going ahead on one engine and backing the other, and to hold her in position first one engine and then the other is slowly backed. If running before wind and sea, it is not necessary to turn around, the engines being simply stopped and reversed until the vessel is brought to a standstill. In calm weather, smooth sea, and no current, soundings are sometimes made without moving the engines after getting into position, but as wind and sea increase the necessity for working them is enhanced until, in a gale, one or both are constantly moving, either in the same or opposite directions. Signal follows signal in rapid succession in order to maintain the position of the vessel over the sinker, for it is an invariable rule on board the *Albatross* that none but vertical soundings will be accepted.

The destructive effects of this peculiar service on the boilers is not apparent at first sight; but, remembering that constant and marked changes of temperature are taking place in them from the frequent opening and closing of the furnace doors, the introduction of cold fuel, and from other measures resorted to in order to control the pressure of steam without destroying the fires, it will be seen that rapid deterioration must ensue even were these the only hurtful agencies at work. If we add to this the frequent loss of fresh water by the unavoidable overflow of the hotwell while sounding or dredging, with the attendant evils arising from the introduction of an equal amount of salt feed, the extraordinary service required of the *Albatross* boilers will be appreciated.

Preparations for a third line of soundings—The following letter from the chief of the Bureau of Navigation, dated November 30, was received January 17:

In returning from Honolulu to San Francisco, after completing the soundings at close intervals along the direct line between Salinas landing and Honolulu, please take soundings at intervals of about 60 miles upon a line situated about as far to one side of the line just completed as the soundings taken in 1874 by the officers of the U. S. S. *Tuscarora* are to the other side.

This was the first intimation I received that a second line was contemplated by the Bureau of Navigation; it was expected that the order would reach us at Honolulu, but it probably arrived there after our departure. I replied to the Bureau's letter as follows:

Your letter of November 30, 1891, with reference to second line of soundings between Honolulu and California, was received this morning. In reply, I beg leave to say that the second line has been completed with average intervals of about 10 miles, and is, I think, much the better of the two. We arrived at the navy-yard yesterday and are now waiting orders. The report of survey will be forwarded as soon as possible.

It will be seen that we had anticipated the wishes of the Bureau. As before stated, I recognized the necessity for a second line before the first was completed, and, while engaged on the latter, it occurred to me that still another one, farther to the southward, might be required. In anticipation of such an event, I wrote to the hydrographer, on December 25, 1891, that the wear and tear had been very great, and in case a third line was to be run we would require about two weeks at the navy-yard to make the necessary repairs.

All the available force was put to work on the report of cable survey, which was completed and forwarded February 1. This report included sounding and meteorological records, charts, plans, photographs, etc.

Telegraphic orders were received from the Bureau of Navigation, through the commandant of the navy-yard, February 10, directing me to run a line of soundings from Point Concepcion to Hilo. I informed the commandant that it would take three weeks' time and the expenditure of $2,000 to make temporary repairs necessary for the completion of the work.

The repairs could have been made while we were preparing the report had the necessary instructions been received. There was some question as to the practicability of paying for the repairs from the appropriation for cable surveys; and it was not until February 15 that instructions were received to go ahead with the work, keeping an account of items chargeable to the U. S. Commission of Fish and Fisheries and the Navy Department, respectively.

The vessel went into dry dock the following day, and upon examination a rope was found wound around the starboard propeller shaft in such a manner as to give us the impression that the stern bushing was gone. A sixteenth of an inch of lignum-vitæ still remained in the bearing, however, and as it would require several days to renew it, we decided to risk the trip with the old bushing. Repairs were made to one of the sea connections, the ship's bottom was scrubbed, paint mended where it was broken, and on the 24th we left the dock.

The work progressed favorably and the expense came well within the estimates. We coaled ship from the 4th to the 8th of March, and tried the engines at the dock on the 10th, everything working satisfactorily. The vessel was then ready for sea, and would have sailed on the 11th to complete the cable survey had we not been detained by orders from Washington.

FUR-SEAL INVESTIGATIONS.

San Francisco to Cook Inlet, Alaska, etc.—A letter was received on the 7th from the Commissioner, intimating that the *Albatross* might be diverted from the survey, and outlining a proposed cruise in connection with investigations regarding seal life. The commandant of the navy-yard received a telegram from the Secretary of the Navy on the 8th to delay the sailing of the *Albatross* until further instructions. A telegram from the Commissioner on March 11 directed me to hold the vessel in readiness for sailing in accordance with the plans outlined in his letter of March 2, above referred to as having been received on the 7th. The Secretary of the Navy wired on the 12th that the services of the *Albatross* were no longer required in connection with the cable survey, directing stores to be turned over to the commandant of the navy-yard and the crew reduced to the complement allowed June 30, 1891.

A telegram was received from the Commissioner March 15, as follows:

> President orders *Albatross* placed in Revenue Marine Division under orders from the Secretary of the Treasury, as explained in letter of March 13. Expect you will be ordered to sail at once for Port Townsend. Alexander should be on board, photographic outfit should be complete, and a good supply of alcohol on hand. Expenses from date will be paid by Treasury Department.

A message was also received from the Assistant Secretary of the Treasury, saying that "sailing and definite instructions will be telegraphed to-morrow." March 16 I received a dispatch from the Secretary of the Treasury containing sailing orders and specific instructions for the cruise until the arrival of the vessel in Port Townsend. Several letters and messages were sent and received relative to the reduction of the crew and the absolute necessity of having the full number on board. The Commissioner wired on the 18th that "extra crew would be retained, but not as part of naval complement." The 14 men in question were accordingly transferred to the civilian roll.

We left the navy-yard at 1 p. m. March 19, and anchored off Saucelito, for the double purpose of avoiding a NW. gale and readjusting machinery. A disagreeable thump was developed in the starboard engine during the cable survey, which still continued in spite of our efforts to locate it, and was so marked during the run down the bay that we thought it advisable to make another effort to reduce it before proceeding to sea.

We were under way at daylight on the morning of the 20th, and steamed out through the Golden Gate en route to Port Townsend, where we arrived at 8:45 p. m. on the 24th, after a boisterous trip, which culminated in a moderate SW. gale off Cape Flattery with furious hail and snow squalls. Our instructions contemplated a careful observance of seal life as far as practicable without undue delay, and several traverses were run off and on the Oregon and Washington coasts with that object in view. Few seals were seen, however, owing largely to stormy weather.

We were instructed to procure two seal-hunters, an interpreter for the Chinook jargon, two otter boats, two Parker shotguns, etc., all of which were promptly secured in Port Townsend and Seattle.

Prof. B. W. Evermann reported for duty on the 27th, and Mr. A. B. Alexander, fishery expert, was ordered to temporary duty on board the United States revenue steamer *Corwin*. The coal bunkers were replenished at Seattle on the 29th, the vessel returning to Port Townsend the following day, when Mr. Joseph Murray, special U. S. Treasury agent, reported on board for duty connected with the investigation of seal life.

The *Albatross* left Port Townsend at 8:50 a. m., March 31, en route for Cook Inlet. There were on board, in addition to the regular complement of officers and crew, the following experts, viz: Joseph Murray, special U. S. Treasury agent; Prof. B. W. Evermann, naturalist; J. E. Lennan, hunter and Alaska pilot, and N. Hodgson, hunter and interpreter for Chinook jargon.

The weather, which was threatening at the time of our departure, culminated at 4 p. m. in a fresh gale from NE. to SE., with heavy cross seas after leaving the protection of the straits. It moderated about noon on the following day, but the swell continued to roll in from seaward. The course from Cape Flattery was intended to carry the vessel over the usual sealing-grounds off Vancouver Island in order to intercept the herd, observe the number of vessels, and general operations of the sealing fleet. Four schooners were observed during the day, all hove to on account of bad weather, and a solitary seal was seen about 1 p. m. off Cape Cook. A vigilant lookout was kept at all times during the cruise at the masthead during sealing weather.

Sealing weather, as understood in this report, included the interval from daylight until dark, whenever the weather and state of the sea would admit the lowering of boats and carrying on of the practical work of hunting.

Passing 30 miles from Cape St. James, a direct course was laid for the Barren Islands. The first seal, a single individual, was seen in latitude 55° 25′ north, and several were observed the following day

(April 5) in latitude 56° 01′ north, on the outer margin of Portlock Bank. A heavy northwesterly gale kept them moving constantly; they were seen by twos and threes during the afternoon, and while it was impossible to distinguish sex, there was no doubt whatever as to the absence of old bulls.

The Barren Islands and high lands of the Kenai Peninsula were sighted at 3:15 p. m., and as we did not wish to approach the coast until daylight next morning, the engines were slowed and finally stopped while an abortive attempt was made at cod-fishing in 28 fathoms—latitude 58° 22′ north, longitude 150° 09′ west. The depth was much less than had previously been found in that locality, and as we had ample time on our hands a line of soundings was extended across the bank during the night, the depths gradually increasing to 118 fathoms.

The officers and men on deck were startled about 10:30 p. m. by the passage of a brilliant meteor, which was followed a little later by a remarkable display of aurora borealis.

Steaming ahead at early daylight against a fresh breeze, we reached the landlocked harbor of Port Graham at 11:26 a. m. The entrance is narrow, tortuous, and to a stranger dangerous; but once inside ample room and perfect protection will be found. Fort Alexander, as the Aleut village here is called, lies on an exposed point near the southern approach to the harbor, and contains a population of 120 souls, all Aleuts except Mr. Cohen, agent of the Alaska Commercial Company. The whole face of the country was covered with snow, which buried the log cabins of the natives nearly to the eaves. The past winter was the most severe that has been known for many years, and there were few evidences of approaching spring at the time of our arrival. The usual winter's hunting was almost entirely prevented by inclement weather, and the people were very poor in consequence.

Mr. Cohen came on board soon after the anchor was down, and being informed of our mission, rendered valuable aid in getting the native hunters together and acting as interpreter. His experience of twenty-two years in the Territory, engaged in the fur trade, gave special value to his statements. His intimate acquaintance with the people and their language made free communication comparatively simple.

Affidavits relating to seal life were procured from Mr. Cohen and all of the native hunters, and at 2:45 p.m. on the 9th (April) the *Albatross* left the commodious harbor of Port Graham and anchored two hours later in Chesloknu or Soldovoi Bay. The village locally known as Soldovoi lies on the northern shore of the harbor, the log cabins in which the natives live being scattered irregularly from the beach over low wooded mounds, and fairly protected from prevailing winds. It has a population of 103 Aleuts and Kenai Indians and 4 white men. The North American Commercial Company has a station here in charge of Mr. John W. Smith, who has been twenty-four years in the Territory, most of the time connected with the fur trade. He reported an exceedingly hard winter and late spring, and the natives having been unable to follow their usual avocation of hunting the sea otter, were in consequence very poor.

The bay is only partially protected from westerly winds, the entrance is narrow and intricate, and the space available for vessels of 12 feet draft is limited. There is, however, an inner harbor, or basin, east of the village where small vessels find perfect protection, and a shingle beach affords an excellent place for hauling out to clean or repair. Three small schooners, the *Hope*, *Matinee*, and *Anna Matilda*, wintered there; the last two belong to the Cutting Packing Company, of San Francisco, and act as tenders to their cannery, located farther up Cook Inlet.

Our investigations were completed on the 10th, but we were detained by a snow storm until the following morning, when, the weather having cleared, we steamed well out into the inlet and swung ship under steam, observing azimuths on every point, for the purpose of ascertaining compass errors; then stood into Coal Bay and anchored at 10 a. m.

This bay is formed by a projecting point which juts out 5 or 6 miles, at right angles to the main land, forming an excellent natural breakwater; its extremity of gravel and shingle is called Coal Point. Representatives of the Alaska Coal and Commercial Company and the Cooper Coal and Commercial Company were found comfortably housed in wooden structures on the point, watching the interests of their respective corporations. There were 11 men at this place, all white. Some work had been done toward the development of the Alaska Coal Company's property, but not sufficient to demonstrate its value. They seemed to be holding possession pending the securing of titles to their claims.

The coal measures are located near the extremity of a peninsula extending from the mainland and separating Cook Inlet from Kachemak Bay. It is a tableland of moderate height and thickly wooded. As nearly as I could ascertain, the product may be classed among the brown coals, resembling those of the Puget Sound region.

Our investigations were prosecuted as usual, and some additional information obtained. The question as to whether fur seals were ever known to haul out in or near Cook Inlet was among the many interesting subjects presented for solution. Inquiries were made among men who have passed their lives in hunting over the region under discussion, and the fact that none of them ever saw a seal hauled out would seem to settle the question conclusively. The fur seals pass along the shores, and sometimes enter Cook Inlet in small numbers when they are on their way to Bering Sea. They sometimes loiter about a few days, and then an occasional one is killed, providing there are no sea otter about; but should the presence of the latter be suspected the seals will remain undisturbed by the otter hunters.

It was our original intention to visit the Kenai settlement, but upon inquiry it was learned that the river was still encumbered with ice, making communication difficult, if not impracticable, and also that the natives were not always to be found there so early in the season.

We were under way again at 2:15 p. m. (April 10), and steaming into Cook Inlet, several miles off Soldovoi, spent nearly an hour with trial lines on a bank tradition has stocked with endless numbers of codfish and halibut. The bottom indications were favorable, but we caught no fish, and failed to discover the slightest indication of their presence, but they may resort to deeper water during the winter season. The locality is worthy of examination, however, for should fish be found in paying quantities the advantages of secure harbors and native settlements, wood, water, and coal would make these banks a favorite resort for fishermen. The fine beach at Soldovoi for hauling out would be available for fishing schooners, and even with the limited resources of the place would prove invaluable in case of emergency. The wind increased rapidly during the afternoon, and when we resumed our course, at 4 p. m., it was blowing a moderate gale from WSW., veering to WNW. later, and increasing in force, giving us an uncomfortable night in the rough confused seas and strong currents in the region of the Barren Islands.

The anchor was dropped in the outer harbor of St. Paul at 7 next morning; we went to the wharf four hours later, and 102 tons of coal were taken on board during that and the following days.

St. Paul, Kadiak Island, has a population of 380, of whom 65 are whites; the inhabitants of Wood Island number 193, including 3 whites. We were informed that the winter here also had been unusually severe and the approach of spring was reported three weeks late. Mr. White, agent of the Alaska Commercial Company, rendered us great assistance in the prosecution of our investigations and in forwarding our work generally.

The following schooners were in port fitting out for sea-otter hunting: *Pearl*, *Lydia*, *St. Paul*, *Nor'west*, *Albert Walter*, *Mary*, and *Three Brothers*. The *Undaunted*, *Alexandria*, and *Rose* had already sailed.

We left St. Paul at 1:15 p. m. April 14 for Port Etches, Prince William Sound; the weather had been threatening all day, and the wind increased in force until at 8 p. m. it was blowing a fresh gale from NW. with a rough sea nearly abeam, which caused the vessel to labor heavily until we reached the Kenai Peninsula, which afforded partial protection. It moderated on the morning of the 15th, and we steamed along the base of the snow-clad heights of the peninsula in comparatively smooth water, anchoring in Port Etches at 11 p. m.

One fur-seal was seen during the trip from Kadiak to Port Etches, in latitude 59° 07′ north and longitude 148° 03′ west.

The Aleut village of Nutchek lies on a spit near the northern shore of the entrance to Port Etches. It is a postal station and has a native population of 180. The only white man in the settlement, Mr. Frank

C. Korth, agent of the Alaska Commercial Company, came on board soon after our arrival and was of great service to us in prosecuting our investigations, particularly in getting the native hunters together and acting as interpreter. An unusually severe winter and late spring was reported at this place also, which still confined the hunters to winter quarters. The capture of the sea otter affords the principal employment of the natives, although bears and other land animals are taken, but the value of their furs is insignificant in comparison with that of the former. There were one or more native boats codfishing in the upper bay whenever the weather permitted, and no doubt they have the means of taking herring, but we saw none caught by them, although they were plentiful in the bay and large numbers were taken in our collecting seine. Codfish were taken with hook and line from the rail, and, while rather small, they were found to be of good quality.

An easterly gale and heavy snowstorm sprung up on the afternoon of the 16th and continued with slight interruption until the following evening, detaining us in port meanwhile. It cleared during the night, however, and at 3:15 a. m. on the 18th we got under way and steamed to the eastward. Cape Hinchinbrook was abeam an hour later, 2 miles distant, and at noon Castle Rock, a conspicuous and unmistakable landmark, lying off Cape St. Elias, bore NE. $\frac{3}{4}$ E., magnetic, 20 miles distant. The weather was unusually clear and, tradition having given the region a bad name, more than usual precautions were taken not only for the safe navigation of the vessel, but to confirm the existence or nonexistence of reported dangers.

H. O. chart 527 shows a rock  ? in latitude 59° 31′ north, longitude 144° 43′ west; but a sounding in 377 fathoms, gravel and mud bottom, proves the nonexistence of the danger in that position. The following soundings, leading up to it, increase regularly in depth and seem to confirm its absence on that line or near it, for our masthead lookout would have seen discolored water at least 5 miles on either hand. In latitude 59° 34′ 45″ north, longitude 144° 58′ west, the lead indicated 81 fathoms, green mud; and in 59° 33′ north, 144° 52′ west, 97 fathoms with the same character of bottom. The rock is probably nearer Cape St. Elias, a dangerous locality, where obstructions of that description are to be expected. Three fur seals were seen between noon and 4 p. m., and six during the next two hours.

Our vicinity to one of the assigned positions of Pamplona Rocks toward evening was sufficient inducement for renewed vigilance, for we had already demonstrated their nonexistence in the offshore position given them on the charts, and where, in 1888, the *Albatross* ran a line of soundings in from 1,600 to 1,800 fathoms. At 8:30 p. m. a sounding was made in 156 fathoms, pebbles, latitude 59° 35′ north and longitude 143° 21′ west.

The presence of a few scattering seals so early in the season led us to suspect that the vanguard of the herd might be encountered not far away, and, fearing we might pass them in the night, the vessel was hove-to until 3 o'clock the following morning, when, the day breaking bright and clear, we started ahead with a man at the masthead looking out for seal life; also for indications of rocks or discolored water.

Steaming over one of the positions in which the Pamplona Rocks have been plotted on the charts, latitude 59° 35′ north, longitude 143° 04′ west, a sounding was made in 225 fathoms, blue mud and pebbles, in latitude 59° 36′ north, longitude 142° 57′ west; and another in 281 fathoms, same bottom, latitude 59° 37′ north, longitude 142° 45′ west. The course, which had been NE. by E. magnetic, was changed to ESE. $\frac{1}{8}$ E., and having steamed 26 miles, a sounding was taken in 504 fathoms, green mud; then running NE. $\frac{5}{8}$ E. for 12 miles, 114 fathoms, pebbles, was found in 59° 21′ north and 141° 51′ west. Changing the course to ESE. $\frac{5}{8}$ E., magnetic, an interval of 11 miles gave us 116 fathoms, gravel, in latitude 59° 14′ north and longitude 141° 35′ west. Steaming 27 miles ESE. $\frac{7}{8}$ E. magnetic, the last sounding of the series was made at 3:46 p. m. in 471 fathoms, green mud, in latitude 58° 56′ north, longitude 140° 56′ west.

The course was retained until 11:20 p. m., when a rising gale and rough sea forced us to heave to, head to wind. Mount St. Elias was visible until 6 p. m., but increasing clouds and mists obscured it from that time.

The various courses during the day practically paralleled those of 1888, when the *Albatross* made her first search for the rocks, and, both days being clear during the time of search, the masthead lookout would have noted anything *above* water at least 10 miles on either hand; hence, we may conclude that these vigias do not exist within the belt 40 miles in width and 100 in length, over which our reconnoissance extends. No sign of seal life was observed during the day, although a careful lookout was kept.

The gale continued until the morning of the 21st, when a small schooner and one seal were seen. Whales, wild geese, puffins, etc., were frequently observed. The engines were slowed to steerage way during the night, to avoid passing the sealing fleet or herd in the darkness.

Having passed the region of Sitka about 100 miles from land, we drew in to about 35 miles off Forrester Island, where a few scattering seals and a single schooner were seen. The usual April sealing-ground was said to be from the Columbia River to Dixon Entrance, and we were momentarily expecting to see indications of the herd and the sealing fleet, but not a sign of either was observed north of Cape Cook.

The date of arrival in Port Townsend was prescribed in orders from the Secretary of the Treasury, and, having a couple of days to spare, the time was utilized in cruising off Vancouver Island; but few seals were seen, however, and none taken. Several schooners were sighted. The *Mascot*, of Victoria, had her boats out. She had seen no seals nor sailing vessels since leaving port, and did not know whether the herd were north or south, but "would like to know just where they were."

We called at Neah Bay on the afternoon of the 27th to ascertain whether the ground had been covered during our absence, and incidentally to learn the whereabouts of the sailing fleet. We were informed that a Treasury agent had visited the reservation and had procured such information as was desired; he left only an hour or two before our arrival. Five sealing schooners were at anchor in the bay, four of them belonging to the Indians of the reservation. Capt. Quinn, of the *Teaser*, reported rather poor success on account of unfavorable weather; he did not know where the fleet were, but thought most of them were between the Columbia River and Cape Flattery. Subsequent information showed that the majority of the vessels were off Sitka at the time, and that we had passed them during the thick, blowing weather.

Leaving Neah Bay at 8 p. m., we reached Port Townsend early the following morning, four weeks from the time of our departure, and on the date specified in our orders for the trip to terminate.

The boilers were giving us trouble from leaky tubes, and it was necessary to change from one to the other whenever an opportunity occurred, in order to stop leaks and free them from accumulations of salt. The foremast developed a weakness at the hounds during the northern trip, and close examination resulted in the discovery that under a thin surface shell the wood was so much decayed that it was unfit for service. A new spar was immediately ordered. Telegraphic information was received from the Secretary of the Treasury that the Department had a contract with the Black Diamond Coal Mining Company, of Seattle, to furnish fuel for the revenue marine vessels, and that we would hereafter procure coal from them. It is not an economical or safe fuel for the boilers of the *Albatross*, although it gives good results in boilers specially constructed for its use.

Leaving Port Townsend early on the morning of the 4th of May, we moored alongside the bunkers at Seattle four hours later, and during that and the following day took on board 174 tons of coal, returning to Port Townsend on the 6th. The next day, May 7, was observed as a holiday in commemoration of the one hundredth anniversary of the discovery of Puget Sound by Vancouver. The event was celebrated in a notable manner on shore, and the men-of-war in the harbor participated by dressing ship and firing national salutes at 8 a. m., meridian, and sunset. The merchant shipping observed the day by dressing ship and joined, or rather led, in a general illumination in the evening. The *Albatross* participated as far as practicable. The new foremast was hoisted on board and stepped during the day.

Port Townsend to Unalaska.—We left Port Townsend for Unalaska at 8:55 a. m., May 10, via the inner channels of Vancouver Island, this route being taken in order that the light spars might be sent aloft, rigging set up, and the sails bent before reaching the open waters of the

Pacific. The weather was rainy, misty, and foggy at times, but we experienced little difficulty in running from point to point. We passed Seymour Narrows at 4:15 a. m. on the 11th, and reached Alert Bay at 2:05 p. m. the same day, where a stop of an hour was made to allow the engineers to effect some slight but necessary adjustments of valve gear, advantage being taken of the delay to send mail on shore.

Resuming our course, we stood through Johnstone Straits and Goletas Channel, finally taking our departure from Mexicana Point at 9:15 p. m. We had succeeded by energetic work in getting the spars all aloft, rigging set up, and the principal sails bent before we left the protection of the land, and other preparations were completed before we passed Cape St. James the following morning.

Our orders directed us to cross on the parallel of 52° north, and this was done, as nearly as wind and weather permitted, without undue delay. A southeast gale was encountered on the 13th and 14th, with rough sea and thick, misty weather, followed on the 16th and 17th by a gale from the southward and westward; thence to port light to moderate winds prevailed.

An accident occurred on the 15th from the use of Seattle coal, in which the vessel narrowly escaped a serious disaster. This coal contains a large percentage of gas, and burns quickly, with a long flame and intense heat, both commendable qualities with specially constructed boilers having large combustion chambers. The boilers of the *Albatross*, however, are designed for the use of anthracite and the slower burning of the bituminous coals, and consequently combustion takes place largely in the steam drum and smokestack when burning the highly inflammable varieties from the Puget Sound region, a red-hot funnel being of too frequent occurrence to attract special comment. On the occasion in question, without warning, the simultaneous ignition of soot in boiler tubes, steam drum, and smokestack superheated the steam to such an extent that solder on an extension joint of the main steam pipe began to melt, and the lower seams of the steam drum commenced to leak; the engine packing was burned out and the wooden casing protecting a small steam pipe which passes through a coal bunker was ignited, smouldering until the following day, when it was discovered and extinguished after the removal of many tons of coal. Leaks in the boilers increased to an alarming extent after the occurrence above related.

We reached the Fox Islands Passes on the evening of the 18th, lay to until daylight, and reached Unalaska at 11 o'clock next morning.

A constant and vigilant lookout was kept for seals during the trip, but none were seen. They follow a fairly well-defined route which, during the northern migration, is confined to the general direction of the shore line and does not depart very far from it. One sealing vessel was seen off the coast of Vancouver Island, within sight of land.

Application was made to the North American Commercial Company for coal immediately after our arrival, the Government having contracted with that corporation to supply fuel to its vessels during the season. The agent informed me that they were not prepared to deliver coal at that time. We then went to the wharf of the Alaska Commercial Company and took on board a supply, finishing on the evening of the 21st. The *Albatross* was the first Government vessel to reach Bering Sea, the U. S. S. *Yorktown* arriving a day later.

Aleutian Islands.—We left Unalaska at 3:25 a. m., May 22, to visit the inhabited islands of the Aleutian chain west of Umnak, and, skirting the northern shores of Unalaska, Umnak, and the islands of Four Mountains, we passed within 4 miles of Seguam, and thence direct to Nazan Bay, Atka Island, arriving at 7 p. m. May 24. The passes between Umnak and Seguam are resorted to by large numbers of seals in their migrations to and from Bering Sea, but we saw no sign of them between Unalaska and Atka.

We were fortunate in reaching Nazan Bay while the hunters were still at home. The settlement is admirably situated in a sheltered nook on the western shores of the bay, and has a population of 120 natives and 1 white man, Mr. Henry Dirks, who has been resident agent of the Alaska Commercial Company for seventeen years.

The natives are hunters, and follow the sea otter among the Andreanof and Kryei or Rat islands, which extend from the islands of Four Mountains to the Near Islands. Hunting parties are transported to their various stations by a vessel of the Alaska Commercial Company in the spring, and returned again to their winter homes after the season's hunting is over. Blue foxes are found on some of the islands within their field of operations, and are taken in greater or less numbers. A small revenue is also derived from the manufacture of basket work, which is of a superior quality.

The Atka mackerel, *Pleurogrammus monopterygius*, an excellent fish, is taken to a limited extent and forms an important item in the native food supply. The fish appears on the shores of the Aleutians from Atka westward, in the spring, in large schools, which hover closely about the kelp beds, particularly favoring the passes or exposed points where swift currents prevail. This habit prevents the use of purse seines in their capture, but they can be taken rapidly by hand, using any of the simple methods known to fishermen. The favorite device at Atka is a lath, or strip of board about 2½ inches wide, in which are driven a number of sharp-pointed nails at an angle pointing upwards. Reaching the fishing ground, the boat is usually secured to a piece of kelp and the apparatus above described is used as a gig, bringing up from one to half a dozen fish at a time. As soon as the barbed device enters the water it is surrounded by fish drawn toward it, apparently by curiosity; the water is clear and the school not more than 6 feet below the surface; hence every movement can be seen by the fisherman, who watches for a favorable moment to impale his unsuspecting prey.

The agent and several of the older and most intelligent hunters testified regarding the movements of fur seals, and were unanimous in the opinion that the herds do not use the passes between Amukta and Great Kyska islands in their migrations to and from Bering Sea. Only scattering seals have been seen by them in the Andreanof and Kryci islands, and they were mostly gray pups, which appear from September to November, usually after northerly gales; they are never seen during winter. They are captured whenever opportunity offers, and the flesh used for food, it being considered a great delicacy. The skins are either used for domestic purposes or sold to the company. A dozen seals a year would probably be a fair average for the Atka hunters.

We were ready to sail on the morning of the 25th, but a northwesterly gale was blowing with sufficient force to prevent our progress along the Bering Sea side of the islands, except at a large expenditure of fuel, which we could not afford; neither could we wait for it to subside, for the limit of the cruise was fixed at a date which admitted no delay. Our only resource was to enter the Pacific via Amlia Pass, a narrow passage between the island of that name and Atka; it had never been used by anything larger than a fishing schooner, and was practically unknown, but Mr. Dirks had frequently fished in the vicinity and believed it was free from hidden dangers.

Waiting until 9:55 a. m. for a favorable condition of tide, we left the snug anchorage of Nazan Bay and steamed through the pass without trouble or delay. There was an extensive ledge on the Atka side, but it showed above water. We favored the Amlia shore until up with the reef; then taking a midchannel course SSE., magnetic, we steamed through the pass, which was from 1 to 1½ miles in width, against an 8-knot current with heavy rips, swirls, eddies, etc. The hand leads failed to reach bottom, and there was no kelp in midchannel; hence it may be assumed that the pass is navigable for a full-powered steamer—a sailing vessel would only attempt it under favorable conditions.

Having cleared the pass, we ran offshore about 2 miles, then hauled up parallel with the general trend of the islands, and under storm-sail and steam made excellent progress in comparatively smooth water. The wind moderated during the following day, and thence to port the weather was all that could be desired. The 180th meridian was crossed at 11 a. m., and the date changed from Thursday, May 26, to Friday, May 27, to correspond with the date in east longitude.

The scene was enlivened while coasting along the Aleutian chain by the constant movements of birds, such as wild geese, little auks, guillemots, petrels, puffins, the albatross—both white and gray—gulls, etc.; porpoises were seen frequently, sometimes in large schools. Tide rips and the constant occurrence of kelp lent a certain air of danger until the latter was approached and recognized as growing or floating, the former being considered as a warning, while the latter drifts aimlessly over the whole region, and frequently makes long sea-voyages when taken up by one of the great ocean currents.

The highlands of Attu were sighted at 8:20 a. m. May 28, Agattu and the Semichi Islands appearing above the horizon about the same time. Arriving off Chichagof Harbor, Attu Island, we got the flag-staff on with Range Point, as directed for entering, but soon discovered a kelp patch off Middle Rocks lying directly ahead; we left it on the starboard hand, and, as it was not shown on the chart and no mention of it made in the sailing directions, we were led to distrust the accuracy of the survey, so, following our usual practice in unsurveyed regions, a boat was sent ahead to sound, the vessel following slowly at a convenient distance. We entered without difficulty and anchored at 5:13 p. m. in 7¼ fathoms, about the center of the harbor. The bay is rather small, but is landlocked and has good holding ground of stiff mud.

The U. S. S. *Mohican* visited the harbor during the summer of 1892, and, anchoring in the kelp patch above described as lying in the fair-way, soon swung upon a rock having 15 feet over it, with 3½ fathoms around it. The accident occurred from their failure to observe a well-established rule in navigating the waters of the North Pacific and Bering Sea, i. e., "Keep out of the kelp."

The village of Attu lies on a level tract of limited extent at the head of the bay, and has a population of between 80 and 90, all Aleuts. Filaret Prokopief, native storekeeper for the Alaska Commercial Company, said the winter had been very severe, and there had been much suffering in consequence. No sea-otter and very few foxes had been taken. The stock of provisions in his charge was practically exhausted in January, and the people had lived on smoked goose and fish. Dried salmon-berry leaves were used as a substitute for tea, and dried kelp took the place of tobacco. A civilized community can have no conception of the value these two articles, tea and tobacco, possess in the estimation of the Aleut. The tea-kettle, or samovar, is constantly simmering wherever a spark of fire can be kept, and a pot of the beverage is in order at any hour—2 or 3 gallons a day is not an excessive estimate for a man where the necessary ingredients can be procured. Tobacco is not counted a luxury, but occupies a prominent place among the necessities of life. The average Aleut will barter his most cherished possessions for it when a liberal offer of money is refused.

The condition of the people, especially the women and children, was so deplorable for lack of proper food that I ordered sufficient rations issued to relieve their necessities until the arrival of the supply vessel, sent to them at least once a year. The general condition of the natives of Attu contrasted strongly with those of Atka, where the superior intelligence of the white man was so apparent.

The men of Attu are hunters, their game consisting of sea-otters and blue foxes, their hunting-grounds embracing their own island of Attu, Agattu, and the Semichi group. This was formerly a rich station, but the sea-otter has been steadily decreasing in numbers until the hunter is hardly able to keep soul and body together. Agattu and the Semichis are favorite nesting-grounds for wild geese, and the natives of Attu secure large numbers of them annually, smoking them for winter use. The down is an article of trade.

Halibut are taken in small quantities in the spring, and cod are found at all seasons along the northern shores of Attu, in from 30 to 60 fathoms. The Atka mackerel is abundant from April to September, and is an important article of food, either fresh, dried, or salted. They school in and near the kelp beds, as at Atka, but run deeper and are taken with gigs. The *Annie*, a small schooner, took 40 barrels of this excellent fish in the summer of 1891, salting them as mackerel are salted on the Atlantic coast, and sailed in August for San Francisco.

The women are expert workers in grass, and the Attu baskets, etc., bring a good price. It would be a source of considerable revenue if they could be induced to manufacture it in sufficient quantities.

Good water is to be had at all seasons of the year, and Attu has become a favorite watering station for the western sealing fleet. In August, 1891, the schooners *City of San Diego*, *Allie I. Alger*, and *Katy Ann* put in here for water on their return from a raid on the rookeries of the Commander Islands. The former reported a partial success, but the others were driven off.

The native hunters were interrogated concerning the movements of fur seals, and were practically unanimous on the following points, viz:

Fur seals are seldom seen about Attu, Agattu, and the Semichi islands, and they have never been known to haul out except when wounded. Two or three instances are remembered of wounded seals having been shot while hauled out to rest. Twenty-five or thirty years ago the older hunters recollected seeing them in small squads about the kelp beds during the month of June, feeding on Atka mackerel. They never saw any seals east of the Semichis, nor had they ever seen any about during the winter season.

It will be remembered that the Atka hunters did not believe that the Pribilof herd used the passes west of Amukta Island; the Attu men never saw fur seals east of the Semichi Group; and the *Albatross* experience in traversing the whole length of the Aleutian Archipelago, from Unalaska to Attu, without seeing even a single individual, seems to confirm the native belief that the Commander Islands herd does not enter or leave the sea east of Attu and the Pribilof herd does not enter or leave west of the Four Mountain Pass.

Commander Islands.—The *Albatross* left Chichagof Harbor at 6:55 p. m., May 29, for the Commander Islands. No soundings had ever been made between the Aleutians and the latter group, and it was a mooted question whether they properly belonged to the Aleutian system or to Kamchatka. To settle this interesting point, we ran a line of soundings from Attu to Copper Island, the maximum depth of 1,996 fathoms being found about 30 miles from the latter, which lies on the eastern verge of the 100-fathom curve off the Kamchatka coast.

A southeast gale sprang up on May 30 with a rough sea and thick weather. The south end of Copper Island was made at 11:25 p. m., about 2 miles distant, a narrow strip of beach being seen under the fog. The high land of Bering Island was first seen at 5:30 a. m. on the 31st; then it shut in for a couple of hours, when Cape Manati, the southern extremity of the island, bore NNE. ½ E., magnetic, 9 miles distant. The snow-covered mountains presented a wintry aspect as we steamed along the west coast of the island. The weather gradually cleared, however, and at 1:15 p. m., when we arrived off the settlement and anchorage of Nikolski, it was blowing fresh from the NW., making it a lee shore, on which the surf was breaking so heavily that we hauled off to wait for more favorable weather.

We had only a general chart of the islands, which was on a scale too small to give detailed information. The positions of settlements were not even indicated, and the only information concerning the anchorage was obtained from a native of Unalaska who had previously visited the islands in the capacity of interpreter, having had nothing whatever to do with the navigation of the vessel; hence his knowledge was limited to a general idea of the surroundings above water.

A number of soundings were made and codfish were taken while lying-to. Later we swung ship for compass errors. The results were not accurate, but they answered our purposes, and it was the only opportunity we had for compass observations in that region.

Wind and sea moderated towards evening, and a few minutes before 8 p. m. we steamed slowly in, and an hour later came-to off the settlement in 7 fathoms, Mr. Waldemar Paetz, agent of the Russian Sealskin Company, having pointed out the best berth. He came on board after we anchored and expressed a desire to assist us in every way possible.

I called on the governor, Col. N. A. Grebnitzky, the following morning and informed him of our mission. He had been advised of our coming from St. Petersburg, and signified his readiness to do anything in his power to assist us.

A naturalist, hunter, and photographer were dispatched to the North Rookery at once, by dog teams, to examine the locality and procure specimens of the different categories of seals. In the meantime, the most experienced and intelligent of the native population were interrogated regarding the various phases of seal life on and about the Commander Islands. The governor kindly gave us valuable information, besides assisting in getting the natives together, numbers of them being on duty at the rookeries.

They were unanimously of the opinion that the Pribilof and Bering Islands herds do not mingle; that the latter spend the winters along the Kurile Islands; that their numbers are fast decreasing on the rookeries, and they attributed it to the indiscriminate slaughter of all ages and sexes by pelagic sealers. There were a few seals on the rookeries, mostly old bulls; a few specimens were procured, but not as many as we had hoped to get.

There are two rookeries on Bering Island; the North Rookery, already mentioned, near the northern extremity of the island and distant about 8 miles from Nikolski, and Poludenni, a small and unimportant rookery lying 17 miles south of the settlement.

An excellent skeleton of a sea-cow, *Rhytina stelleri*, was purchased from a native at Nikolski; it was the third, and he claimed the best, he had found.

A reconnoisance of Nikolski Bay was made during our stay, which, although incomplete, will prove of great assistance to a stranger in making the anchorage. The position of the Salt House on Vkhodni Point, by observations with artificial horizon, June 1, 1892, was found to be latitude 55° 10′ 30″ north, and longitude 166° 00′ 58.5″ east; variation, 3° 37′ east. The region is a dangerous one, and should be navigated with the greatest caution.

The governor visited the ship on the morning of June 3, and at 5:25 p. m. the same day we left for Copper Island, having on board a native pilot sent to us by the governor.

Arriving off the village of Preobrajenski at 9:15 the following morning, we were boarded by the agent of the Russian Seal-Skin Company, Mr. E. G. Kluge, who came out in a whaleboat with a crew of boys and the patriarch of the village as coxswain, the hunters all being absent, some guarding the rookeries and others on the sea-otter grounds. The village lies on the south shore of a small bay, 10 miles from the north end of the island, which is accessible to small craft only. A vessel may anchor outside in fine weather, but she would be exposed to all winds from the northwest to east and southeast.

It was our intention to interrogate the hunters of this island regarding seal life, but finding it impracticable, owing to their absence, we took the agent's boat in tow, and with himself and party on board started for the Polatka Rookery, which is the largest and most important on Copper Island. It lies on the west side, about 10 miles from its southern extremity and 40 miles from the settlement. Arriving at 2:30 p. m., a party consisting of the agent and his crew, the naturalists, hunters, and photographer visited the rookery, where they procured a couple of young males, made a general inspection of the locality, and took several photographs illustrating the character of the ground and numbers of seals. With the exception of the two bachelor seals before mentioned, there were none but old bulls hauled out, and they were distributed over the ground holding their claims.

The rookery extends several miles along a narrow rugged beach, backed by precipitous mountain slopes, mostly inaccessible. The four principal rookeries lie along this stretch of beach, and are practically continuous, all but one having driveways across the island, from 1 to 3 miles, surmounting elevations of 400 to 800 feet—much more trying than the Pribilof drives.

Returning to the village, the agents left the ship and we started immediately for Unalaska. We regretted not seeing the settlement of this, the wealthiest community in all the Bering Sea islands, but the lack of coal and the prescribed limit of the cruise admonished us of the necessity of promptly starting homeward.

The following notes concerning the Commander Islands may not be out of place, as, outside of parties interested in the sealing industry, they are almost unknown.

The group consists of two principal islands, Bering and Copper, with numerous outlying rocks and islets. Bering Island, the largest and most important, is about 50 miles in length, northwest and southeast, and 17 miles in breadth near its northern end, narrowing to a point at its southeastern extremity. A range of mountains extends through the center, reaching a height of 2,000 feet or more in the southern part, while they are much lower toward the northern extreme.

Copper Island is about 30 miles in length northwest and southeast, from 2 to 5 miles in width, and has a central mountain range upwards of 2,000 feet in height. The group belong to the Kamchatka system, Copper Island resting just within the 100-fathom curve from the Asiatic coast.

Neither island has a secure harbor for vessels of any size, Preobrajenski furnishing protection to small craft only. The "port," as Nikolski Bay is called, is open to westerly winds, subject to heavy ground swells, and is altogether an undesirable anchorage under the best conditions, and dangerous unless a vessel is prepared to go to sea at any moment.

The climate is not very severe, although the group lies in 55° north latitude, the benign influence of the Japan stream being evidenced by the absence of intensely cold weather. Heavy snows are not infrequent, and during the winter months northwest winds frequently bring in great fields of ice from the Asiatic shore. Driftwood from Kamchatka and Japan is depended upon for domestic purposes, and timber is reported to have drifted ashore which grows only on the American continent. Nutritious grasses grow over a large portion of Bering Island, and the natives cultivate some of the more hardy vegetables. Copper Island, on the contrary, has little level or arable land.

The population of Bering Island on July 1, 1892, was 354, 336 natives and 18 whites, the latter being members of the families of the governor and agent of the lessees.

Copper Island has a population of 300 natives and 2 whites, the agent of the lessees and the assistant to the governor.

The entire population of Bering Island is concentrated at Nikolski, and of Copper at Preobrajenski. They all came originally from the Aleutian Islands. They are housed in comfortable wooden cottages as a general rule, although a few still live in primitive "barabaras." The Greek church is the most prominent feature of the village.

Nikolski is admirably situated on a narrow strip of level land on the south and east shores of the bay of that name. Bluffs about 100 feet in height rise immediately back of the settlement, from which extend rolling table-lands affording excellent pasture. A small stream passes through the center of the village and empties into the bay; just beyond the settlement, in a northeasterly direction, a fine stream about 400 feet in width falls into the head of the bay. This stream forms the outlet to a series of lakes and marshes which occupy the interior of the northern portion of the island, and affords a bountiful supply of salmon, flounders, herring, trout, and other varieties of edible fish, which are taken by means of a seine in the open season, and speared through holes in the ice during winter. We witnessed the hauling of a seine and shared in the results, receiving a quantity of excellent salmon, sufficient for a meal for the whole ship's company.

The available men took the seine on their shoulders and carried it to the stream; a footbridge a few hundred yards above its mouth enabled them to carry it across, and after adjusting it properly the ropes were manned and the seine dragged down stream slowly against a young flood tide until, by the weight of the net, it was ascertained that a sufficient number had been taken, when the men on the north bank, who wore waterproof boots, waded the stream, carried the lines across, and landed the catch on the bank nearest the settlement, where the women were gathered to receive it.

The government of the group is vested in a governor appointed by the authorities in St. Petersburg, Col. N. A. Grebnitzky being the present incumbent; he has an assistant on Copper Island. The agents of the lessees are intermediaries between governor and natives; the priest of the Russian church also wields great power. A native chief and second chief are elected by the vote of the able-bodied men of the island, subject to the governor and agent, the former having the power to displace them at any time. They serve during good behavior.

The chief must superintend personally all work undertaken by the natives of whatever description, and is held in a measure responsible for its execution. There are certain privileges and slight pecuniary compensation attaching to the position. If two or more expeditions are to start at the same time, he puts the second chief in charge of one, and accompanies the most important himself. He has authority to appoint as many deputies as the occasion demands, and all natives are required to obey him explicitly.

Every member of the community without reference to age or sex has certain duties to perform, according to individual capacity. During the sealing season, all the able-bodied men and larger boys are employed on the rookeries; in the winter time they hunt the blue fox. The pay of the natives for all work is turned into a common fund; the lessees pay $1\frac{1}{2}$ rubles for every fur-seal skin taken, 14 rubles for each first-class blue-fox skin, and 7 rubles for second-class fox skins. The fund is divided per capita, a certain amount being withheld for the support of the church and for the additional compensation of the chief. The head of each family is the person to whom the money is given in charge, the amount he receives being according to the number of persons in his household. These need not be actual relatives, but may be invalids, aged, or otherwise nonsupporting persons under his protection. All community work is performed without pay. The young man is naturally anxious to handle the family fund; hence he marries early in order to take his place as head of a family as soon as possible.

A small guard is maintained for watching over the rookeries. The privates are selected from the native youths between the ages of 15 and 21; they serve three years without further compensation than their share of the family fund. The noncommissioned officers are Russians. While the guards are stationed at the rookeries, they occupy barabaras usually situated on the bluffs overlooking the beaches, and are not allowed to approach a rookery except to repel poachers. It is their first duty to give the alarm, in case boats are seen approaching, and warn them off; if the warning is not heeded, they are to drive the seals into the water, and if the poachers still persist in landing or do not depart they are to fire upon them, using sufficient force to drive them away.

Strict rules for the preservation of the seal herd are rigidly enforced on the rookeries; they are voluminous and cover every possible contingency. The following are a few that differ from those in vogue on the Pribilofs:

None but natives are allowed to work on the rookeries.

A fine of 100 golden rubles is imposed by the Government upon any one who kills a female fur-seal, and 10 rubles for killing a pup, and such additional fine shall be paid as shall be imposed by the natives themselves.

No person, native or otherwise, is allowed to wear boots with nails in them on the rookeries; rubber boots or tarbosas must be used.

Chewing or smoking tobacco, expectorating, or attending to the requirements of nature are strictly prohibited on the rookeries.

Knives may be carried, but a stick with a metal ferule is not permitted.

No small boys or females are allowed on the rookeries, and dogs must be left half a mile from the rookeries during the breeding season.

Transportation on the islands is by means of dog sleds, nearly every adult native having at least one team. The dogs are kept staked out or penned up on the bluff back of the village, each team forming a separate colony, and when all are howling and barking the noise is deafening. In summer, when there is little or no snow on the ground, a team usually consists of 12 to 14 dogs harnessed two and two, with a leader; in winter, 8 to 10, harnessed in pairs with a leader, complete a team. When the ground is covered with snow the latter team will easily travel 25 miles a day, drawing a sled with 3 men and a reasonable amount of baggage, while in summer it is considered good work for the larger team to travel 15 miles with 2 men and baggage. The dogs are fed on seal meat, fish, fresh or dried, sea birds, etc. The teams are allowed considerable liberty during the winter season, and roam about the settlement at will, but in summer they are more strictly confined.

In 1881 the Alaska Commercial Company, then lessees of these islands, imported 15 reindeer from Siberia and turned them loose on Bering Island; there were 5 bulls and 10 cows. They soon became acclimated, increasing to about 300 by the spring of 1892, and it is expected that the average ratio of increase will bring their numbers to 1,000 in about five years. The herd has been carefully protected by the governor, and it is his intention eventually to make it a regular source of food supply.

The natives have small herds of Siberian cattle which find subsistence on the island the year round; the milch cows are stabled during the winter, as it not only increases the milk supply but insures their being within reach at milking time. This hardy breed of cattle is small, short-horned, covered with a thick coat of long hair, and has proven self-supporting on the Commander Islands. The officers and crew of the *Albatross* can attest to the excellence of their flesh as an article of food.

It seems to me that these sturdy cattle might be advantageously introduced into the Aleutian Archipelago. The climate is not unlike that of Bering Island; there is ample food for them on most of the islands; no wild animals larger than a fox would interfere with them, and in fact there is no apparent reason why they should not thrive and increase rapidly, eventually furnishing the natives a much-needed food supply. The extinction of fur-bearing animals which have heretofore afforded them means of purchasing provisions is already making it exceedingly difficult for the hunters to procure the necessaries of life for their families; a few years more and another source of supply must be made available to them or they will disappear from the face of the earth. It would involve but little expense for the Government to place a couple of bulls and from four to eight cows on the principal islands of the archipelago, whether inhabited or not; if near a settlement the chief could be given charge of them and on uninhabited islands they could take care of themselves.

Mention has been made of the regulations concerning seal life on the Commander Islands, and the following translation of the sea-otter laws may be of interest, in view of the fact that under them this valuable fur-bearing animal has not only retained its numbers, but is reported to be actually increasing:

Translation of the sea-otter laws in vogue on the Commander Islands, June, 1892.

The date on which sea-otter hunting commences each year is February 1; the season lasts until June 1, by the Russian mode of computing time. It is unlawful to kill or hunt the sea-otter at any time other than that specified above.

In the vicinity of and on the sea-otter rookeries spears and nets only shall be used in taking sea otter.

Notice: Any person is permitted to use rifle or shotgun in pursuit of the sea-otter when 5 or more Russian versts (2½ English miles) removed from the rookeries; but any person or persons using firearms when hunting sea-otter at a distance less than 5 versts from a rookery is liable to imprisonment and the confiscation of his personal and real property by the Imperial Government.

Females and yearling pups, when caught in the nets, may not be killed, but shall be set free again.

All persons are forbidden to go on or near a sea-otter rookery during the breeding season; neither shall any person or persons make camp on or near a rookery during this period, nor build a fire, nor be the cause of any kind of smoke.

Children are not permitted on or near the sea-otter rookeries.

The numbers allowed to be taken each season are also prescribed.

Commander Islands to Unalaska and Port Townsend.—The trip to Unalaska was uneventful. Strong easterly winds prevailed until June 7, and slow progress was made against the head seas. The boilers were giving us trouble also, leaks and consequent salting being so great that we were obliged to use both, even with a reduced consumption of 12 tons of coal per day. Light variable winds and smooth seas enabled us to make better time from the 180th meridian to port, where we arrived at 1:30 p. m. June 9, one day ahead of the date prescribed as the limit of the cruise.

The U. S. S. *Yorktown* was lying in port and Commander R. D. Evans, senior naval officer in Bering Sea, informed me that he would probably send the *Albatross* to Puget Sound with dispatches, etc., and on the 12th the following order was received:

U. S. S. YORKTOWN (3D RATE),
Dutch Harbor, Unalaska, June 11, 1892.

Lieut. Commander Z. L. TANNER, U. S. Navy,
Commanding U. S. Fish Commission Steamer Albatross:

SIR: When you are ready for sea, proceed with dispatch to Port Townsend, Wash., giving passage to Maj. Williams and such other persons as he may direct, and transportation to such articles as he may wish to take. On arrival at Port Townsend wire the Department and send the inclosed cipher message to the Secretary of the Navy. Forward all specimens immediately, by express, to Dr. Merriam, Agricultural Department, Washington, D. C. You will then return, with dispatch, to Unalaska, and continue your work in Bering Sea as directed.

Very respectfully,

R. D. EVANS,
Commander, U. S. Navy, Commanding U. S. Naval Force in Bering Sea.

Mr. A. B. Alexander, fishery expert, reported on our arrival, having been on temporary duty on board the revenue steamer *Corwin*. The bunkers were replenished from the 11th to the 14th, work meanwhile being pushed day and night on the boilers. Capt. J. E. Lennan, one of our hunters, and an experienced Alaska pilot, was, at the request of Commander Evans, temporarily transferred to the *Yorktown* pending the trip of this vessel to Puget Sound.

In obedience to the order of the senior naval officer, the seal specimens from the Pribilof Islands, destined for Washington, were received from the *Rush*. An invalid, Alonzo Jones, seaman, was transferred from the *Yorktown* with instructions to forward him to the U. S. Naval Hospital at Mare Island. The following-named persons were received for passage to Port Townsend: U. S. Treasury Agent W. H. Williams and wife; U. S. Treasury Agent H. S. Nettleton, wife, and child; U. S.

Treasury Agent Milton Barnes; Government School-teacher J. A. Tuck.

Mail was received from vessels in the harbor and from shore, and at 9:30 p. m. June 14 we proceeded to sea, entering the Pacific through Unalga Pass. Nothing of moment occurred until next morning, when large numbers of seals were seen between Unimak Pass and the Sannaks. It is worthy of remark that, with the exception above mentioned, not a seal was seen in the water during the voyage of the *Albatross* from Puget Sound to Unalaska, the Aleutian Archipelago, the Commander Islands, and thence to Unalaska and back to Puget Sound, though a vigilant lookout was kept whenever the vessel was underway.

After passing the Shumagin group, a great-circle course was taken for Cape Flattery. A southeaster was encountered on the 15th and 16th, followed by a heavy southwest gale on the 18th and 19th; thence to port, moderate to brisk breezes from the northward and westward.

We arrived at Port Townsend at 5 p. m. June 23, having sustained no material damage during the rough trip except the disabling of the foreyard, which was immediately replaced by a new one.

The seal specimens from the Pribilof and Commander islands were landed at once and forwarded by express as directed; affidavits and other papers were dispatched by registered mail.

The boilers gave us much trouble during the trip, leaking so badly that salt deposits in the back connections completely cut off the draft from some of the furnaces; the engineer's force worked night and day after our arrival to get them in condition for further service. We went to Departure Bay on the 26th, filled up with coal, and returned on the 29th, when stores and mail were taken on board for the vessels in Bering Sea. All preparations were completed on the evening of June 30, and a little after midnight the *Albatross* sailed again for Unalaska.

Scientific results.—The scientific investigations during the northern cruise were confined largely to collecting information pertaining to the natural history of the fur seal, and the gathering of such other facts as might have a bearing upon the question at issue between the Government of the United States and that of Great Britain concerning that animal. The detailed report of these investigations will be made at the proper time by Prof. Evermann and Mr. Townsend.

Very little time or attention could be given to other lines of natural-history work; yet, by taking advantage of the occasional days when the regular work could not be carried on, the naturalists on board were able to make considerable collections of fishes, birds, and marine invertebrates. Important collections of fishes were made at Port Graham, Kadiak, Port Etches, Unalaska, Atka, Attu, Bering Island, and Puget Sound. Numerous specimens of birds were secured at each of these places, including a particularly interesting series of ptarmigan from Kadiak and the Aleutian Archipelago. Large and valuable collections of plants were made, especially from about Unalaska.

At Bering Island we received, through the kindness of Governor Grebnitzky, a tank of fishes and invertebrates, a large box of bird skins, and a series of skulls of the fur seal, all presented by him to the U. S. Fish Commission. The most important specimen obtained, however, was the skeleton of Steller's sea cow (*Rhytina stelleri*), purchased from a native of Bering Island. This skeleton was found in May, 1891, imbedded in the sand on the west side of Bering Island, and is believed to be, with one exception, the best-preserved and most perfect skeleton of this animal known.

Mention has already been made of the various species of fish taken from the rail with hook and line.

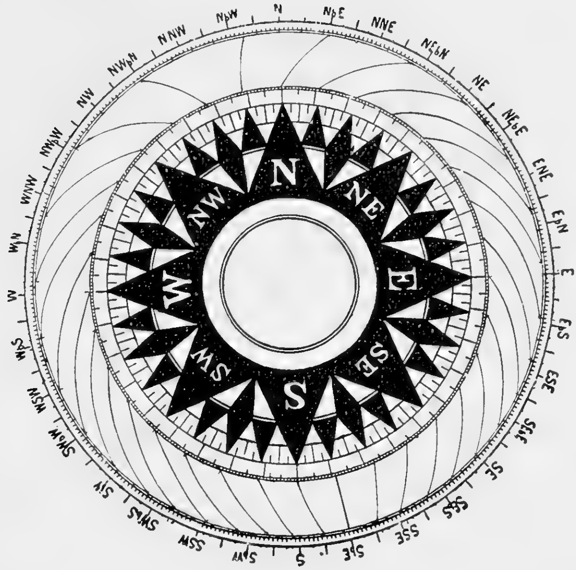
SUMMARY OF THE YEAR'S WORK.

The cruising ground of the *Albatross* during the year has been between the parallels of 21° and 60° north and the meridians of 122° west and 166° east. The following table gives the number of days under way, distances run, and object of each trip:

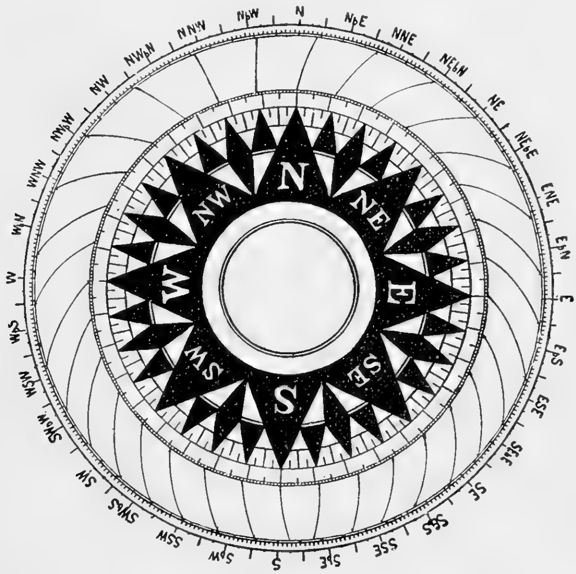
Date.	Distance.	Object.
1891.	*Knots.*	
July 8	26	San Francisco to Mare Island.
July 14	26	Mare Island to San Francisco.
July 16 to 25	2,145	San Francisco to Unalaska.
July 27 to 28	255	Unalaska to St. Paul via St. George Island.
July 30	68	Cruise off St. Paul Island for sealing vessels.
Aug. 3 and 4	52	Sounding and dredging.
Aug. 5	66	Taking commissioners around St. Paul Island.
Aug. 9 to 11	273	From St. Paul to Unalaska via St. George and Bogoslof.
Aug. 13 to 21	1,728	From Unalaska to Departure Bay, B. C.
Aug. 22 to 26	204	Departure Bay to Tacoma, Seattle, and Port Townsei
Aug. 27 to Sept. 10	455	Sounding, dredging, and fishing in Straits of Fuca.
Sept. 11 to 15	927	Departure Bay to Mare Island via Port Townsend.
Oct. 5	26	Mare Island to San Francisco.
Oct. 9 to 24	1,925	Preliminary trip: Cable Survey.
Oct. 25	26	San Francisco to Mare Island.
Nov. 1	30	Mare Island to San Francisco.
Nov. 4 to 22	2,186	Cable Survey: San Francisco to Honolulu, H. I.
Dec. 2 to 6	215	Cable Survey: Locating shore-end, Oahu.
Dec. 11 to 31	2,276	Cable Survey: Honolulu to San Francisco.
1892.		
Jan. 6 to 16	1,481	Cable Survey: Completion of rhumb line.
Mar. 19 to 25	938	Seal Investigation: Mare Island to Port Townsend.
Mar. 28 to 30	96	Port Townsend to Seattle and return.
Mar. 31 to Apr. 8	1,317	Seal Investigation: Port Townsend to Port Graham, Cook Inlet.
Apr. 9	17	Seal Investigation: Port Graham to Chesloknu Bay.
Apr. 11	26	Seal Investigation: Chesloknu Bay to Coal Bay.
Apr. 12	138	Seal Investigation: Coal Bay to Kadiak.
Apr. 14 to 15	257	Seal Investigation: Kadiak to Port Etches.
Apr. 18 to 28	1,435	Seal Investigation: Port Etches to Port Townsend.
May 4	42	Port Townsend to Seattle.
May 6	41	Seattle to Port Townsend.
May 10 to 19	1,924	Seal Investigation: Port Townsend to Unalaska.
May 22 and 23	342	Seal Investigation: Unalaska to Nazan Bay, Atka Island.
May 25 to 28	544	Seal Investigation: Nazan Bay to Chichagof Harbor, Attu Island.
May 29 to 31	336	Seal Investigation: Chichagof Harbor to Nikolski, Commander Islands.
June 3 and 4	119	Seal Investigation: Nikolski, Bering Island, to Preobrajenski, Copper Island.
June 4	81	Seal Investigation: To rookeries and return.
June 4 to 9	943	Seal Investigation: Copper Island to Unalaska.
June 14 to 23	1,808	Seal Investigation: Unalaska to Port Townsend.
June 26 and 27	107	Port Townsend to Departure Bay, B. C.
June 28 and 29	90	Departure Bay to Port Townsend.

At sea: 206 days; 24,991 knots steamed.

PLATE A.



Kachemak Bay, Cook Inlet, Alaska; Lat. 58° 30′ N., Long. 151° 45′ W. April 11, 1892. Variation, 25° East; annual decrease 7′ (approx.).



Off Santa Cruz, California; Lat. 35° 56′ N., Long. 121° 57′ W. October 9, 1891. Variation, 16° 15′ East; annual change inappreciable.

DEVIATION CARD, U. S. FISH COMMISSION STEAMER ALBATROSS.

PERSONNEL.

There have been ten changes among the officers during the year, as follows:

July 2, 1891. Assistant Paymaster John S. Carpenter reported for duty.
July 9, 1891. Assistant Paymaster C. S. Williams was detached.
July 10, 1891. Ensign H. B. Wilson reported for duty.
Oct. 1, 1891. Ensign J. E. Shindel reported for duty.
Oct. 7, 1891. Lieut. (junior grade) J. H. Holcombe was detached.
Oct. 25, 1891. Ensign W. B. Fletcher reported for duty.
Oct. 26, 1891. Passed-Assistant Surgeon F. W. F. Wieber reported for duty.
Oct. 27, 1891. Passed-Assistant Surgeon Nelson H. Drake was detached.
Oct. 31, 1891. Ensign William G. Miller reported for duty.
Nov. 3, 1891. Ensign J. E. Shindel was detached.

Following is a list of the officers attached to the *Albatross* June 30, 1892: Lieut. Commander Z. L. Tanner, U. S. Navy, commanding; Lieut. C. G. Calkins, U. S. Navy, executive and navigating officer; Ensign H. B. Wilson, U. S. Navy; Ensign W. B. Fletcher, U. S. Navy; Ensign E. A. Anderson, U. S. Navy; Ensign W. G. Miller, U. S. Navy; Passed Assistant Surgeon F. W. F. Wieber, U. S. Navy; Passed Assistant Paymaster J. S. Carpenter, U. S. Navy; Assistant Engineer A. M. Hunt, U. S. Navy.

The civilian staff was as follows: Prof. B. W. Evermann, assistant in charge of scientific department during the sealing investigation; Charles H. Townsend, resident naturalist; A. B. Alexander, fishery expert; N. B. Miller, assistant in scientific department; Harry Clifford Fassett, clerk to commanding officer.

The crew list of June 30, 1891, limiting the number to 53 men, has been in force during the year except when the vessel was engaged on the cable survey under the Navy Department, the original number, 68, having been allowed during the progress of that work. With this exception, civilians have been taken on temporarily to fill the vacancies; and while we have maintained the efficiency of the vessel in a general way, the practice of making up a mixed crew of enlisted men and civilian employés has been found very unsatisfactory, and it is to be hoped that arrangements may soon be made for a suitable number of men for the performance of the special work assigned the vessel.

The Commission is indebted to Rear-Admiral John Irwin, commandant, and the officers of the navy-yard at Mare Island, California, for their uniform courtesy to the officers of the *Albatross* personally, and for the facilities of the yard, which have been freely granted to us at all times for making repairs and refitting the vessel.

We are also indebted to Pay Inspector George A. Lyon, U. S. Navy, in charge of the navy pay-office at San Francisco, for taking charge of and forwarding our mails, a kindness which can only be fully appreciated by those who spend half the year in Bering Sea.

The Alaska Commercial Company have, as usual, rendered us material aid in our northern work.

We are under obligations to the North American Commercial Company for the transportation of Prof. B. W. Evermann and Mr. N. B. Miller, the photographer, from Unalaska to the Seal Islands and return, also for subsisting them on the islands and facilitating their investigations generally.

MEDICAL REPORT.

[By T. A. Berryhill, passed assistant surgeon, U. S. Navy.]

I have to report that during the fiscal year ending June 30, 1892, the ship being at sea 44 per cent of the time, there were admitted to the sick-list of this vessel 46 patients, of whom 42 were discharged to duty and 4 transferred to hospital. There were 243 working days lost by these patients, which is about 3½ per cent of the whole number of working days of the entire ship's company. The number of days' work lost on account of injuries was 93, leaving 137 days' work lost on account of diseases due to contagion and infection, and conditions of ship life. The remaining 13 days were lost by a patient sent for transfer to hospital.

At one time there threatened to be an epidemic of "grippe," 5 cases being admitted to the sick-list and many others being under treatment who continued at work, but it was averted or limited, probably by the sanitary precautions recommended by the medical officer and carried out by the commander.

The general health of the officers and crew during the year may be considered as having been excellent. During the cruises of the vessel on the cable survey to Honolulu nothing of medical interest was noted.

During the cruises to Alaska and Bering Sea medical attention and medicines were furnished the natives and the white settlers at Port Graham, Soldovoi, Coal Harbor, Kadiak, Port Etches, Atka, Attu, Unalaska, and Bering Island. At each place medicines were left for the treatment of cases seen by the medical officer, and in some cases medicines were left, with directions for using, to treat cases that might occur.

In none of these places could medical advice be obtained except from men-of-war or the revenue cutters. At Bering Island medical attention was given the Russian governor, there being no doctor there except when a Russian war vessel is in port. At Unalaska advice and medicines were given to the sailors on the whaling and merchant vessels whenever requested.

While in Bering Sea it was interesting to note the immunity the ship's company enjoyed from colds and catarrhal affections, not one case of respiratory disease occurring.

The system of ventilation on board has previously been described. By its use the ship can be kept dry and the air in the living quarters kept pure. The use of steam heat has been of great advantage from a sanitary standpoint, as it, together with the ventilation, prevents the "sweating," which is so objectionable in most iron ships, and keeps the berth-deck dry.

The water, which is distilled by the Baird apparatus, is all that can be desired.

REPORT ON BOTTOM SPECIMENS.

[By N. B. Miller, Assistant in Scientific Department.]

Having made a microscopical examination of each specimen brought up from the bottom by the sounding cup during the cable survey between Monterey Bay and Honolulu, I have to report that I found the specimens from the bay to consist of fine sand and mud, mixed with vegetable matter washed from the shore into the water. When station 31, latitude 36° 39′ 30″ N., longitude 122° 41′ W., in 1,424 fathoms, was reached, the sand disappeared and nothing but sticky brown mud was brought up. This continued until station 36, latitude 36° 28′ N., longitude 123° 44′ W., 2,061 fathoms, when the first ooze was encountered; it was gray in color and contained a few foraminifera. These conditions remained the same until, at station 40, latitude 36° 09′ N., longitude 124° 55′ 30″ W., in 2,434 fathoms, the ooze became mixed in color—brown and gray—containing few shells. From station 44, latitude 35° 47′ 30″ N., longitude 126° 05′ W., to station 72, latitude 33° 12′ N. and longitude 133° 34′ 30″ W., the depths from 2,566 to 2,895 fathoms, the ooze was of a dark-brown color and contained very few shells. At these great depths, the foraminifera had probably sunk deeper into the soft ooze than the specimen cup penetrated.

At station 73, latitude 33° 08′ N. and longitude 133° 46′ W., depth 2,678 fathoms, brown mud was again found; and at station 74, latitude 33° 04′ 30″ N., longitude 133° 56′ 30″ W., in 2,670 fathoms, the specimen cup brought up brown mud containing small pieces of lava. Brown mud and lava continued until station 81, latitude 32° 44′ 30″ N., longitude 134° 58′ W., depth 2,014 fathoms, when the cup brought up nothing but lava, there being no sign of mud having been in the cup; the largest piece of lava weighed a half ounce. The shot must have struck a large piece and shattered it, the specimen cup becoming detached before the mud was reached. From here to station 246, latitude 23° 11′ N., longitude 154° 34′ W., 1,783 fathoms, the character of the bottom remained the same, brown ooze containing few foraminifera. At this station the color changed to light gray, the ooze containing more foraminifera than had been found in any specimen previously examined. At the next station, 247, in latitude 23° 05′ N. and longitude 154° 45′ 30″ W., 2,411 fathoms, the color of specimen was brown and continued so up to station 256, latitude 22° 18′ N., longitude 155° 58′ 30″ W., 2,542 fathoms, when brown mud was again found; as we approached the island of Oahu, it became mixed with sand and sponge spicules.

At station 266, in 268 fathoms, the island of Oahu being then in sight, the specimen cup brought up about a pint of clean foraminifera, no mud or sand being present. The shells were globigerina and orbulina. From this station to the harbor of Honolulu the specimens examined consisted of fine sand, broken shells, small pieces of coral, and sponge spicules.

Returning over a line south of the other, the results were about the same.

We found no evidence of the red clay supposed to form the bottom of the ocean in the vicinity of the Hawaiian Islands.

REPORT ON THE MACHINERY.

[By A. M. Hunt, Assistant Engineer, U. S. N.]

(Abstract.)

Main engines.—During the year, the engines have been in operation 2,831 hours while the ship was on her course in free route. The time occupied in sounding and dredging at sea, when the engines were worked to signals, was 600 hours. The engines have been stopped for sounding and dredging, from full speed ahead, 640 times during the year, in addition to the number of stops incidental to her regular cruising. The ship has steamed 24,991 knots by log, an average of 8.85 knots per hour. The engines have made 10,592,556 revolutions, an average of 62.5 per minute. The maximum speed recorded during the year is 11.45 knots, and the highest average for six hours is 11.15 knots.

The run from San Francisco to Unalaska, in July, 1891, was made at high speed, and the wear on the crank-pin brasses was very excessive and abnormal. Babbitting the brasses, and changing the oiling gear, has reduced this wear to a minimum.

Such repairs have been made from time to time as to enable the ship to continue her work, but the engines are now in need of a thorough overhauling. The propeller shafts have worn down very much in the outboard bracket-bearings. The shafts are out of line and the starboard one shows signs of being sprung. Many parts are so worn as to require renewal, and much of the piping will have to be renewed. These repairs are fast becoming imperative.

Boilers.—Fires have been lit under the forward boiler, 5,128 hours; under the after one, 4,223 hours; under the donkey boiler, 471 hours. They have given a great deal of trouble during the year. The cast-iron check-valve chambers gave out in the second quarter, and have all been replaced by composition ones. Two hundred and forty-five new tubes were put in the boilers in June, 1891. Quite a number of these have pitted through, probably owing to imperfections in tubes. During the last two quarters, much trouble has been experienced from the tubes leaking at the back ends. This has become so aggravated during the last quarter that the tubes and connections become choked up with salt, very much diminishing the efficiency of the boilers. Rerolling the tubes has only a temporary effect in stopping these leaks. I have fitted wrought-iron ferules in a number of the leaking tubes, but have not found much good resulting from their use. The tube sheets have cracked in about half a dozen places, across the bridges between adjacent tube holes. I can assign no reason for these cracks occurring.

In May, 1892, by orders of the Treasury Department, we took on board about 170 tons of Seattle (black diamond) coal. The boilers of this vessel are entirely unsuited to burning this coal, and its use was attended by a serious injury to the boilers and machinery. The coal is really a lignite, and, in burning, it evolves large quantities of gas. This gas (if the fires are forced at all) can not burn in the small combustion chambers of our boilers. As a consequence, it passes unconsumed through the tubes, but, heated above the igniting point, and coming in contact with air in the uptakes and stack, bursts into a fierce flame. This happened repeatedly while using the black diamond coal, and has never occurred with any other coal that has been used during the year I have served on this vessel. The drum, which is an annular cylinder, forming the lower section of stack, became very much overheated, and all the joints in it were started leaking. The steam in the drum became very much superheated and passing to the engines burnt out the packing all around. The steam had such a high temperature that it melted the solder off an expansion joint in the main steam pipe. The coverings of many small steam pipes were charred and burnt off. The wooden casing around the auxiliary steam pipe in the port coal-bunker caught fire and ignited the surrounding coal. Since the use of this coal the leaking at the tube ends has been much worse.

The boilers are in much worse condition than is generally the case with boilers that have had a similar length of service. This is due to the abnormal conditions to which they are subjected. One year of such service as that just closed, during which the engines were stopped from full speed ahead 640 times in addition to the number of stops incidental to cruising, is fully equal to two if not three years of ordinary service in destructive effect.

TABLES.

Record of hydrographic soundings by the U. S. Fish Commission steamer Albatross from July 1, 1891, to June 30, 1892.

Serial No.	Date.	Time of day.	Position.		Depth.	Character of bottom.	Temperatures.			Sounding machine.	Weight of sinker used.
							Air.	Water at			
			Lat. N.	Long. W.			Dry bulb	Surface.	Bottom.		
	1891.		° ′ ″	° ′ ″	*Fms.*		° F.	° F.	° F.		*Lbs.*
2639	Aug. 3	11:40 a. m.	57 07 00	107 27 00	31	bk. P. Sh	49	46		Tanner	26
2640	...do...	5:56 p. m.	57 15 00	170 40 00	42	Rky	47	46		...do...	26
2641	Aug. 11	6:15 p. m.	53 59 00	166 38 30	24	bk. G. brk. Sh	50	48		...do...	26
2642	Aug. 28	7:25 a. m.	48 24 30	124 37 30	78	P	63	52		...do...	26
2643	...do...	8:22 a. m.	48 26 00	124 37 20	144	br. M	63	52		...do...	26
2644	...do...	9:13 a. m.	48 28 05	124 36 55	137	gy. S. G	63	52		...do...	26
2645	Aug. 29	5:53 a. m.	48 24 25	124 37 45	59	G. S	59	54		...do...	26
2646	...do...	6:39 a. m.	48 27 10	124 39 50	140	G	61	56		...do...	26
2647	Sept. 1	6:20 a. m.	48 25 30	124 42 15	74	R	57	52		...do...	26
2648	Sept. 2	12:18 p. m.	48 23 55	124 13 30	93	S. P	60	55		...do...	26
2649	...do...	12:30 p. m.	48 24 50	124 11 40	73	gy. S	60	55		...do...	26
2650	...do...	1:35 p. m.	48 25 30	124 08 00	44	gy. S	61	56		...do...	26
2651	Sept. 3	6:25 a. m.	48 13 30	123 58 00	64	Sp	58	53		...do...	26
2652	...do...	9:18 a. m.	48 18 00	123 49 40	95	rky	59	53		...do...	26
2653	Sept. 4	12:10 p. m.	48 19 00	123 18 20	55	gy. S. G. Sh	62	58		...do...	26
2654	...do...	1:03 p. m.	48 18 00	123 14 00	19	rky	62	58		...do...	26
2655	Oct. 11	9:48 a. m.	36 48 10	121 47 50	52	fne. bk. S	50	55	49	Sigsbee	35
2656	...do...	10:03 a. m.	36 48 14	121 47 38	24½	gn. M	50	55		Hand	14
2657	...do...	10:05 a. m.	36 48 15	121 47 34	20¼	gn. M	50	55		...do...	14
2658	...do...	10:07 a. m.	36 48 16	121 47 30	15¼	gn. M	50	55		...do...	14
2659	...do...	10:09 a. m.	36 48 17	121 47 28	12	gn. M	50	55		...do...	14
2660	...do...	10:11 a. m.	36 48 18	121 47 26	10	gn. M	50	55		...do...	14
2661	...do...	10:13 a. m.	36 48 14	121 47 26	9¾	gn. M	50	55		...do...	14
2662	...do...	10:15 a. m.	36 48 10	121 47 25	4½	gn. M	50	55		...do...	14
2663	...do...	10:18 a. m.	36 48 06	121 47 27	7½	gn. M	50	55		...do...	14
2664	...do...	10:20 a. m.	36 48 03	121 47 28	9	gn. M	50	55		...do...	14
2665	...do...	10:21 a. m.	36 48 04	121 47 30	15	gn. M	50	55		...do...	14
2666	...do...	10:23 a. m.	36 48 05	121 47 34	18½	gn. M	50	55		...do...	14
2667	...do...	10:25 a. m.	36 48 06	121 47 38	23½	gn. M	50	55		...do...	14
2668	...do...	10:40 a. m.	36 48 10	121 47 50	54	bk. M	52	55		Sigsbee	35
2669	...do...	10:54 a. m.	36 47 53	121 49 06	75	gn. M	53	56		...do...	35
2670	...do...	11:09 a. m.	36 47 34	121 50 20	124	gn. M	53	57	47·5	...do...	35
2671	...do...	11:22 a. m.	36 47 16	121 51 20	165	gn. M	53	56		...do...	35
2672	...do...	11:36 a. m.	36 47 01	121 52 45	213	gn. M	53	56	46·1	...do...	35
2673	...do...	11:51 a. m.	36 46 50	121 53 50	266	br. M	53	56		...do...	60
2674	...do...	12:07 p. m.	36 46 40	121 55 10	352	br. M. S	54	53	53·5	...do...	60
2675	...do...	12:24 p. m.	36 46 25	121 56 50	388	br. M. S	54	53		...do...	60
2676	...do...	12:45 p. m.	36 46 15	121 57 30	442	fne. gy. S	54	53	39·5	...do...	60
2677	...do...	1:13 p. m.	36 45 45	122 00 00	377	gy. S	55	56		...do...	60
2678	...do...	1:40 p. m.	36 45 25	122 02 30	618	br. M. S	55	55	39	...do...	60
2679	...do...	2:14 p. m.	36 45 00	122 05 30	548	br. M. S	55	55	40	...do...	60
2680	...do...	2:58 p. m.	36 44 40	122 09 30	868	br. M. S	55	55	37	...do...	60
2681	...do...	3:46 p. m.	36 44 00	122 13 00	486	gy. S	55	55		...do...	60
2682	...do...	4:32 p. m.	36 43 00	122 17 00	663	br. M. S	55	55	38	...do...	60
2683	...do...	5:29 p. m.	36 42 30	122 22 00	770	br. M. S	54	55		...do...	60
2684	...do...	6:39 p. m.	36 41 30	122 28 00	1,122	br. M. S	54	54	35·5	...do...	60
2685	...do...	8:42 p. m.	36 39 30	122 41 00	1,424	br. M	55	55	35·1	...do...	60
2686	...do...	10:46 p. m.	36 37 00	122 54 00	1,597	br. M	55	55	35	...do...	60
2687	Oct. 12	12:50 a. m.	36 35 00	123 06 00	1,661	br. M	55	55	35	...do...	60
2688	...do...	4:21 a. m.	36 32 30	123 19 00	1,907	br. M. S	56	54	35	...do...	60
2689	...do...	6:34 a. m.	36 30 30	123 32 00	1,983	(Lost Cup)	55	55	35	...do...	60
2690	...do...	8:45 a. m.	36 28 00	123 44 00	2,061	gy. Oz	55	54	35	...do...	60
2691	...do...	11:32 a. m.	36 25 30	124 02 50	2,112	gy. Oz	57	56	34·8	...do...	60
2692	...do...	2:16 p. m.	36 20 00	124 20 30	2,333	gy. Oz	55	55	35	...do...	60
2693	...do...	5:09 p. m.	36 14 30	124 37 30	2,330	gy. Oz	59	56	35	...do...	60
2694	...do...	8:55 p. m.	36 09 00	124 55 30	2,434	br. and gy. Oz	58	59	35	...do...	60
2695	...do...	11:47 p. m.	36 03 00	125 13 00	2,430	br. Oz	58	57	35	...do...	60
2696	Oct. 13	2:42 a. m.	35 58 00	125 31 00	2,547	br. and gy. Oz	58	57	35	...do...	60
2697	...do...	5:43 a. m.	35 52 30	125 48 00	2,576	br. and gy. Oz	58	57	35	...do...	60
2698	...do...	8:55 a. m.	35 47 30	126 05 00	2,566	br. Oz	62	62	35	...do...	60
2699	...do...	11:26 a. m.	35 41 50	126 22 20	2,574	br. Oz	61	62	34·9	...do...	60
2700	...do...	2:15 p. m.	35 37 00	126 41 00	2,569	br. Oz	62	62	34·9	...do...	60
2701	...do...	5:03 p. m.	35 33 00	126 59 30	2,654	br. Oz	62	62	35	...do...	60
2702	...do...	7:57 p. m.	35 28 30	127 17 00	2,577	br. Oz	61	62	35	...do...	60
2703	...do...	10:50 p. m.	35 24 00	127 36 00	2,533	bn. Oz	61	62		...do...	60
2704	Oct. 14	1:38 a. m.	35 20 00	127 54 00	2,600	bn. Oz	63	64	35·0	...do...	60
2705	...do...	4:52 a. m.	35 15 30	128 12 00	2,701	bn. Oz	63	64		...do...	60
2706	...do...	8:14 a. m.	35 11 30	128 29 00	2,666	bn. Oz	65	65	35·0	...do...	60
2707	...do...	11:10 a. m.	35 07 00	128 48 30	2,720	bn. Oz	65	65	35·0	...do...	60
2708	...do...	3:33 p. m.	35 03 30	129 05 00	2,645	bn. Oz	67	66	35·0	...do...	60
2709	...do...	6:18 p. m.	34 56 30	129 20 00	2,689	bn. Oz	66	65	35·0	...do...	60
2710	...do...	9:00 p. m.	34 49 00	129 37 00	2,707	(Lost Cup)	65	65		...do...	60

Record of hydrographic soundings from July 1, 1891, to June 30, 1892—Continued.

Serial No.	Date.	Time of day.	Position.		Depth.	Character of bottom.	Temperatures.			Sounding machine.	Weight of sinker used.
							Air.	Water at			
			Lat. N.	Long. W.			Dry bulb	Surface.	Bottom.		
	1891.		° ′ ″	° ′ ″	Fms.		° F.	° F.	° F.		Lbs.
2711	Oct. 14	11:75 p.m.	34 42 00	129 52 30	2,701	br. Oz	64	65		Sigsbee.	60
2712	Oct. 15	2:19 a.m.	34 35 00	130 08 00	2,751	br. Oz	64	64	35·1	...do...	60
2713	...do...	5:11 a.m.	34 28 00	130 24 00	2,768	br. Oz	63	64		...do...	60
2714	...do...	7:52 a.m.	34 21 00	130 40 00	2,789	br. Oz	66	65		...do...	60
2715	...do...	10:41 a.m.	34 14 00	130 56 00	2,869	br. Oz	67	65	35·4	...do...	60
2716	...do...	1:34 p.m.	34 07 30	131 12 00	2,895	br. Oz	66	65		...do...	60
2717	...do...	4:31 p.m.	34 01 00	131 28 00	2,791	br. Oz	66	65		...do...	60
2718	...do...	7:12 p.m.	33 54 30	131 45 00	2,772	br. Oz	66	65	35·4	...do...	60
2719	...do...	10:04 p.m.	33 48 30	132 01 00	2,806	br. Oz	66	66		...do...	60
2720	Oct. 16	12:58 a.m.	33 41 30	134 17 00	2,793	br. Oz	66	66		...do...	60
2721	...do...	3:57 a.m.	33 35 00	132 33 30	2,833	br. Oz	65	66	35·3	...do...	60
2722	...do...	6:45 a.m.	33 28 30	132 50 00	2,700	br. Oz	65	67		...do...	60
2723	...do...	8:50 a.m.	33 24 00	133 01 00	2,731	br. Oz	67	67	35·5	...do...	60
2724	...do...	10:51 a.m.	33 20 00	133 12 00	2,661	br. Oz	68	67		...do...	60
2725	...do...	12:42 p.m.	33 15 30	133 24 00	2,662	br. Oz	68	67		...do...	60
2726	...do...	2:42 p.m.	33 12 00	133 34 30	2,685	br. M	68	67	35·5	...do...	60
2727	...do...	4:56 p.m.	33 08 00	133 46 00	2,678	br. M	67	66		...do...	60
2728	...do...	6:55 p.m.	33 04 30	133 56 30	2,670	br. M. Lava	67	67		...do...	60
2729	...do...	8:59 p.m.	33 01 00	134 08 00	2,641	br. M. bk. Sp	67	67	35·1	...do...	60
2730	...do...	11:04 p.m.	32 57 30	134 18 30	2,667	br. M	67	66		...do...	60
2731	Oct. 17	1:07 a.m.	32 54 00	134 30 00	2,796	br. M	67	68		...do...	60
2732	...do...	3:19 a.m.	32 50 00	134 40 30	2,834	br. M	67	68	35·2	...do...	60
2733	...do...	5:45 a.m.	32 46 30	134 52 00	2,461	br. M	67	68		...do...	60
2734	...do...	7:00 a.m.	32 46 00	134 54 00	2,322	br. M. Lava	69	68	35·3	...do...	60
2735	...do...	8:23 a.m.	32 44 40	134 58 00	2,014	Lava	69	68		...do...	60
2736	...do...	9:16 a.m.	32 44 00	135 00 00	2,406	br. M. Lava	69	68		...do...	60
2737	...do...	10:34 a.m.	32 42 00	135 05 00	2,529	br. M	69	68	35·3	...do...	60
2738	...do...	11:39 a.m.	32 41 30	135 07 20	2,463	br. M	69	68		...do...	60
2739	...do...	1:00 p.m.	32 39 30	135 12 00	2,463	br. M	70	69		...do...	60
2740	...do...	3:07 p.m.	32 35 30	135 22 00	2,375	br. Oz	70	69	35·2	...do...	60
2741	...do...	5:14 p.m.	32 31 00	135 33 00	2,739	br. Oz	69	69	35	...do...	60
2742	...do...	7:34 p.m.	32 27 00	135 43 30	2,506	br. Oz	69	69		...do...	60
2743	...do...	9:35 p.m.	32 22 30	135 54 00	2,442	br. Oz	69	69		...do...	60
2744	...do...	11:48 p.m.	32 18 00	136 04 30	2,276	br. Oz	69	69	34·9	...do...	60
2745	Oct. 18	2:04 a.m.	32 14 00	136 15 00	2,557	br. Oz	68	69		...do...	60
2746	...do...	4:27 a.m.	32 10 00	136 26 00	2,492	(Lost cup.)	69	69		...do...	60
2747	...do...	6:58 a.m.	32 05 30	136 36 30	2,421	br. Oz	69	69	35	...do...	60
2748	...do...	9:41 a.m.	32 01 30	136 47 30	2,417	br. Oz	69	69		...do...	60
2749	...do...	12:25 p.m.	31 57 00	136 58 30	2,601	br. Oz	62	69		...do...	60
2750	...do...	4:10 p.m.	31 52 30	137 09 00	2,547	br. Oz	61	68	34·9	...do...	60
2751	...do...	6:31 p.m.	31 48 00	137 19 30	2,654	br. Oz	63	69		...do...	60
2752	...do...	8:50 p.m.	31 43 00	137 30 30	2,670	br. Oz	65	69		...do...	60
2753	Oct. 23	11:51 a.m.	36 47 45	121 50 54	136	gn. M	68	60		...do...	35
2754	...do...	12:04 p.m.	36 47 40	121 52 10	173	gn. M	68	60		...do...	35
2755	...do...	12:18 p.m.	36 47 32	121 53 20	223	gn. M	68	60		...do...	35
2756	...do...	12:33 p.m.	36 47 25	121 54 35	202	gn. M. S	68	60		...do...	35
2757					Void.						
2758	...do...	12:46 p.m.	36 47 20	121 55 45	277	gn. M	68	60		...do...	35
2759	...do...	1:02 p.m.	36 47 10	121 57 05	302	gn. M	63	60		...do...	35
2760	...do...	1:20 p.m.	36 47 10	121 58 15	255	gn. M	64	60		...do...	35
2761	...do...	1:36 p.m.	36 47 10	121 59 30	418	gn. M	63	60		...do...	35
2762	...do...	1:53 p.m.	36 47 10	122 00 50	502	gn. M	63	60		...do...	35
2763	...do...	2:14 p.m.	36 47 10	122 02 05	495	gn. M	60	59	39·4	...do...	60
2764	...do...	2:31 p.m.	36 47 10	122 03 20	122	gy. S	60	59		...do...	60
2765	...do...	2:45 p.m.	36 47 10	122 04 35	441	gn. M. S	60	59		...do...	60
2766	...do...	3:06 p.m.	36 47 10	122 05 50	196	gn. M. S	60	58		...do...	60
2767	...do...	3:22 p.m.	36 47 10	122 07 95	202	gn. M. S	60	58	44·8	...do...	60
2768	...do...	3:37 p.m.	36 47 10	122 08 20	373	gn. M. S	60	58		...do...	60
2769	...do...	3:56 p.m.	36 47 10	122 09 35	440	gn. M	59	58		...do...	60
2770	...do...	4:19 p.m.	36 47 10	122 10 50	271	fne. gy. S	59	58		...do...	60
2771	...do...	4:38 p.m.	36 47 10	122 12 05	291	gn. M. S	59	57	42	...do...	60
2772	...do...	4:56 p.m.	36 47 10	122 13 20	343	gn. M. S	59	58		...do...	60
2773	...do...	5:13 p.m.	36 47 10	122 14 35	395	gn. M. S	59	57		...do...	60
2774	...do...	5:31 p.m.	36 47 10	122 15 50	469	gn. M. S	59	56		...do...	60
2775	...do...	5:52 p.m.	36 47 10	122 17 05	607	gn. M. S	58	56	37·7	...do...	60
2776	...do...	6:13 p.m.	36 46 10	122 18 20	621	gn. M. S	58	57		...do...	60
2777	...do...	6:40 p.m.	36 47 10	122 19 35	979	gn. M. S	58	56		...do...	60
2778	Nov. 7	11:25 p.m.	33 07 00	133 46 15	2,239	bn. M. Lava	66	68		...do...	60
2779	Nov. 8	1:41 a.m.	33 02 30	133 57 00	2,520	bn. M	66	67	35·1	...do...	60
2780	...do...	3:52 a.m.	32 58 30	134 08 30	2,648	bn. Oz	64	67		...do...	60
2781	...do...	6:15 a.m.	32 54 00	134 18 30	2,512	bn. Oz	64	67		...do...	60
2782	...do...	8:35 a.m.	32 49 30	134 29 30	2,721	bn. Oz	66	68	35·1	...do...	60
2783	...do...	10:49 a.m.	32 45 00	134 40 00	2,425	br. Oz. bk. Sp	66	68		...do...	60
2784	...do...	11:49 a.m.	32 43 40	134 42 30	2,442	br. M. Lava	68	68	35·1	...do...	60
2785	...do...	2:50 p.m.	32 41 00	134 49 30	2,415	br. M. Lava	68	68		...do...	60
2786	...do...	4:02 p.m.	32 40 00	134 51 30	2,482	br. M	69	68	35·1	...do...	60

Record of hydrographic soundings from July 1, 1891, to June 30, 1892—Continued.

Serial No.	Date.	Time of day.	Position.		Depth.	Character of bottom.	Temperatures.			Sounding machine.	Weight of sinker used.
							Air.	Water at			
			Lat. N.	Long. W.			Dry bulb	Surface.	Bottom.		
	1891.		° ′ ″	° ′ ″	*Fms.*		° F.	° F.	° F.		*Lbs.*
2787	Nov. 8	5:45 p. m.	32 37 30	134 57 00	2,564	br. Oz	69	68		Sigsbee	60
2788	...do...	7:25 p. m.	32 35 00	135 03 00	2,470	br. Oz	69	68		...do...	60
2789	...do...	9:11 p. m.	32 33 00	135 09 00	2,378	br. M. Lava Sp.	66	68	35·0	...do...	60
2790	...do...	10:50 p. m.	32 30 30	135 15 00	2,441	br. M	64	67		...do...	60
2791	Nov. 9	1:56 a. m.	32 26 00	135 26 30	2,474	br. M	64	67		...do...	60
2792	...do...	4:12 a. m.	32 21 30	135 38 00	2,600	br. M	64	67		...do...	60
2793	...do...	6:24 a. m.	32 17 00	135 49 00	2,413	br. M	65	67	35·1	...do...	60
2794	...do...	8:31 a. m.	32 12 30	136 00 30	2,619	br. Oz	67	68		...do...	60
2795	...do...	10:51 a. m.	32 08 00	136 11 30	2,606	br. Oz	68	68		...do...	60
2796	...do...	1:01 p. m.	32 04 00	136 22 30	2,484	(Lost cup.)	64	67		...do...	60
2797	...do...	3:29 p. m.	31 59 30	136 33 00	2,879	br. Oz	64	67	35·1	...do...	60
2798	...do...	6:01 p. m.	31 54 30	136 44 00	3,186	(Lost cup.)	65	67		...do...	60
2799	...do...	8:43 p. m.	31 50 00	136 54 30	2,504	br. Oz	65	67		...do...	60
2800	...do...	11:12 p. m.	31 45 30	137 05 00	2,591	br. Oz	68	68	35·1	...do...	60
2801	Nov. 10	1:41 a. m.	31 41 00	137 15 30	2,550	br. Oz	68	69		...do...	60
2802	...do...	4:01 a. m.	31 36 00	137 26 00	2,629	br. Oz	67	69		...do...	60
2803	...do...	6:32 a. m.	31 31 30	137 36 30	2,614	br. Oz	67	69		...do...	60
2804	...do...	8:47 a. m.	31 27 00	137 47 00	2,719	br. Oz	67	68	35·1	...do...	60
2805	...do...	11:04 a. m.	31 23 00	137 58 00	2,700	br. Oz	66	67		...do...	60
2806	...do...	1:10 p. m.	31 18 30	138 08 30	2,702	br. Oz	70	69		...do...	60
2807	...do...	3:16 p. m.	31 14 30	138 19 00	2,587	br. Oz	70	69		...do...	60
2808	...do...	5:37 p. m.	31 10 00	138 29 30	2,546	br. Oz	70	70	35·1	...do...	60
2809	...do...	7:42 p. m.	31 05 00	138 40 00	2,500	br. Oz	68	70		...do...	60
2810	...do...	9:56 p. m.	31 01 30	138 50 00	2,412	br. Oz	68	69		...do...	60
2811	...do...	11:59 p. m.	30 57 30	139 00 30	2,072	br. Oz. S	68	69	35·1	...do...	60
2812	Nov. 11	1:01 a. m.	30 56 30	139 02 30	2,199	br. Oz	69	69		...do...	60
2813	...do...	2:51 a. m.	30 52 00	139 12 30	2,749	br. Oz	68	69		...do...	60
2814	...do...	5:04 a. m.	30 48 00	139 23 00	2,567	br. Oz	68	69	35·1	...do...	60
2815	...do...	7:10 a. m.	30 44 00	139 34 00	2,752	br. Oz	68	69		...do...	60
2816	...do...	9:16 a. m.	30 40 00	139 44 30	2,646	br. Oz. Lava	69	69		...do...	60
2817	...do...	11:13 a. m.	30 36 00	139 55 00	2,723	br. Oz. S	70	69		...do...	60
2818	...do...	1:10 p. m.	30 31 30	140 05 30	2,637	br. Oz	71	69		...do...	60
2819	...do...	4:11 p. m.	30 27 00	140 16 00	2,591	br. Oz	72	70	35·2	...do...	60
2820	...do...	6:15 p. m.	30 23 00	140 26 30	2,650	br. Oz	69	69		...do...	60
2821	...do...	8:33 p. m.	30 18 00	140 38 30	2,655	br. Oz	69	69		...do...	60
2822	...do...	10:50 p. m.	30 13 00	140 50 30	2,671	br. Oz	68	69	35	...do...	60
2823	Nov. 12	1:03 a. m.	30 08 00	141 03 00	2,691	br. Oz	67	69		...do...	60
2824	...do...	3:17 a. m.	30 03 00	141 15 00	2,747	br. Oz	68	69		...do...	60
2825	...do...	5:37 a. m.	29 58 30	141 27 30	2,720	br. Oz	68	67	35·2	...do...	60
2826	...do...	7:58 a. m.	29 53 30	141 40 00	2,723	br. Oz	69	70		...do...	60
2827	...do...	10:09 a. m.	29 48 30	141 52 00	2,738	br. Oz	69	70	35·2	...do...	60
2828	...do...	12:20 p. m.	29 43 00	142 04 30	2,741	br. Oz	72	70		...do...	60
2829	...do...	2:43 p. m.	29 38 00	142 17 00	2,791	br. Oz	72	70		...do...	60
2830	...do...	5:34 p. m.	29 31 30	142 32 00	2,820	br. Oz	71	70	35·4	...do...	60
2831	...do...	8:24 p. m.	29 25 00	142 47 00	2,785	br. Oz	71	70		...do...	60
2832	...do...	11:01 p. m.	29 18 00	143 02 00	2,827	br. Oz	70	70		...do...	60
2833	Nov. 13	1:34 a. m.	29 11 30	143 17 30	2,085	br. Oz	71	72		...do...	60
2834	...do...	2:31 a. m.	29 10 30	143 20 00	2,280	br. Oz	71	72	35·1	...do...	60
2835	...do...	4:15 a. m.	29 13 00	143 15 00	2,379	br. Oz	70	70		...do...	60
2836	...do...	5:39 a. m.	29 15 00	143 09 30	2,727	br. Oz. Lava	70	70		...do...	60
2837	...do...	8:34 a. m.	29 08 30	143 25 00	2,733	br. Oz	70	70	35·3	...do...	60
2838	...do...	11:08 a. m.	29 03 30	143 36 00	2,744	br. Oz	73	72		...do...	60
2839	...do...	1:16 p. m.	28 58 00	143 48 00	2,698	br. Oz	72	72		...do...	60
2840	...do...	3:34 p. m.	28 52 00	144 00 00	2,784	br. Oz	72	72	35·3	...do...	60
2841	...do...	5:57 p. m.	28 46 00	144 12 00	2,510	br. Oz	72	71		...do...	60
2842	...do...	6:59 p. m.	28 45 00	144 14 00	2,530	br. Oz	72	71		...do...	60
2843	...do...	9:20 p. m.	28 39 30	144 25 30	2,719	br. Oz	71	71	35·2	...do...	60
2844	...do...	11:56 p. m.	28 33 30	144 37 00	2,821	br. Oz	70	71		...do...	60
2845	Nov. 14	2:25 a. m.	28 27 30	144 48 30	2,570	br. Oz. Lava	69	71	35·1	...do...	60
2846	...do...	3:31 a. m.	28 26 30	143 50 30	2,770	br. Oz	69	71		...do...	60
2847	...do...	9:42 a. m.	28 20 00	145 03 30	2,801	br. Oz	72	72		...do...	60
2848	...do...	12:00 m.	28 12 20	145 13 00	2,728	br. Oz	72	72		...do...	60
2849	...do...	2:13 p. m.	28 06 30	145 24 00	2,707	br. Oz	74	72		...do...	60
2850	...do...	5:15 p. m.	28 00 30	145 35 00	2,635	br. Oz	73	73		...do...	60
2851	...do...	7:29 p. m.	27 54 00	145 45 30	2,782	br. Oz	72	72	35·2	...do...	60
2852	...do...	9:43 p. m.	27 48 00	145 56 30	2,848	br. Oz	72	72		...do...	60
2853	Nov. 15	12:01 a. m.	27 42 00	146 07 30	2,860	br. Oz	72	73		...do...	60
2854	...do...	2:19 a. m.	27 36 00	146 19 00	2,910	br. Oz	72	73	35·4	...do...	60
2855	...do...	5:07 a. m.	27 30 00	146 30 00	2,914	br. Oz	72	73		...do...	60
2856	...do...	7:42 a. m.	27 24 00	146 41 00	2,837	br. Oz	72	73		...do...	60
2857	...do...	9:55 a. m.	27 18 00	146 51 30	2,629	br. Oz	73	73	35·2	...do...	60
2858	...do...	11:59 a. m.	27 12 00	147 02 40	2,795	br. Oz	75	74		...do...	60
2859	...do...	2:13 p. m.	27 06 00	147 14 00	2,929	br. Oz	75	74		...do...	60
2860	...do...	4:40 p. m.	27 00 00	147 25 30	2,815	br. Oz	75	74	35·3	...do...	60
2861	...do...	6:54 p. m.	26 54 00	147 36 30	2,898	br. Oz	72	74		...do...	60
2862	...do...	9:07 p. m.	26 48 00	147 47 30	2,896	br. Oz	72	74		...do...	60

Record of hydrographic soundings from July 1, 1891, to June 30, 1892—Continued.

Serial No.	Date.	Time of day.	Position.		Depth.	Character of bottom.	Temperature.			Sounding machine.	Weight of sinker used.
			Lat. N.	Long. W.			Air.	Water at			
							Dry bulb	Surface.	Bottom.		
	1891.		° ′ ″	° ′ ″	*Fms.*		°F.	°F.	°F.		*Lbs.*
2863	Nov. 15	11:31 p. m.	26 42 00	147 59 00	2,925	br. Oz	71	74	35·3	Sigsbee	60
2864	Nov. 16	1:58 a. m.	26 35 30	148 10 00	2,894	br. Oz	71	74	.....	...do	60
2865	...do	4:22 a. m.	26 29 00	148 21 30	2,942	br. Oz	71	74	.....	...do	60
2866	...do	6:47 a. m.	26 23 00	148 33 00	2,985	br. Oz	72	74	35·3	...do	60
2867	...do	9:22 a. m.	26 17 00	148 44 00	3,003	br. Oz	73	75	.....	...do	60
2868	...do	11:53 a. m.	26 10 15	148 55 00	2,864	br. Oz	73	75	.....	...do	60
2869	...do	2:20 a. m.	26 04 30	149 06 30	2,992	br. Oz	75	75	35·3	...do	60
2870	...do	4:48 a. m.	25 58 00	149 18 30	3,039	br. Oz	74	75	.....	...do	60
2871	...do	7:17 a. m.	25 52 00	149 30 00	3,008	br. Oz	74	75	.....	...do	60
2872	...do	9:42 a. m.	25 46 00	149 41 30	2,982	br. Oz	74	75	35·3	...do	60
2873	Nov. 17	12:07 a. m.	25 39 30	149 53 00	3,037	br. Oz	74	74	.....	...do	60
2874	...do	2:30 a. m.	25 33 00	150 05 00	2,993	br. Oz	73	74	.....	...do	60
2875	...do	4:57 a. m.	25 26 30	150 16 30	3,027	br. Oz	73	74	35·4	...do	60
2876	...do	7:32 a. m.	25 20 00	150 28 00	3,073	(Lost cup.)	73	74	.....	...do	60
2877	...do	9:59 a. m.	25 14 00	150 39 00	2,952	br. Oz	73	74	.....	...do	60
2878	...do	1:18 p. m.	25 08 00	150 50 00	2,910	br. Oz	75	75	35·3	...do	60
2879	...do	3:48 p. m.	25 02 00	151 01 00	2,978	br. Oz	75	75	.....	...do	60
2880	...do	6:16 p. m.	24 56 00	151 13 00	2,910	br. Oz	75	75	.....	...do	60
2881	...do	8:45 p. m.	24 50 00	151 24 30	2,985	br. Oz	74	75	35·4	...do	60
2882	...do	11:39 p. m.	24 43 30	151 36 00	2,936	br. Oz	74	75	.....	...do	60
2883	Nov. 18	2:08 a. m.	24 37 00	151 47 30	3,023	br. Oz. Lava	75	75	.....	...do	60
2884	...do	4:34 a. m.	24 31 00	151 59 30	2,967	br. Oz	75	76	35·3	...do	60
2885	...do	7:07 a. m.	24 24 30	152 11 30	2,959	br. Oz	76	76	.....	...do	60
2886	...do	9:32 a. m.	24 18 00	152 22 30	2,950	(No specimen; defective cup.)	76	76	.....	...do	60
2887	...do	11:49 a. m.	24 11 30	152 34 00	2,953	br. Oz	76	76	35·4	...do	60
2888					Void.						
2889	...do	2:14 p. m.	24 06 00	152 46 00	2,907	br. Oz. S.	76	76	.....	...do	60
2890	...do	4:32 p. m.	24 00 30	152 57 00	2,864	br. Oz. S.	76	76	.....	...do	60
2891	...do	6:53 p. m.	23 55 00	153 08 30	2,811	br. Oz	76	76	35·4	...do	60
2892	...do	9:16 p. m.	23 49 00	153 20 00	2,801	(No specimen; defective cup.)	75	74	.....	...do	60
2893	...do	11:42 p. m.	23 43 00	153 31 30	2,748	br. Oz	75	74	.....	...do	60
2894	Nov. 19	2:02 a. m.	23 37 30	153 43 00	2,627	(No specimen; defective cup.)	75	75	35·3	...do	60
2895	...do	4:20 a. m.	23 32 00	153 54 00	2,610	br. Oz	75	76	.....	...do	60
2896	...do	6:36 a. m.	23 26 00	154 06 00	2,600	br. Oz	76	76	35·3	...do	60
2897	...do	8:52 a. m.	23 20 00	154 17 30	2,453	br. Oz	76	76	.....	...do	60
2898	...do	10:55 a. m.	23 14 30	154 28 30	1,265	br. Oz	76	76	.....	...do	60
2899	...do	11:25 a. m.	23 13 30	154 30 00	1,531	br. Oz	76	76	35·4	...do	60
2900	...do	12:44 p. m.	23 15 30	154 27 00	1,663	br. Oz	77	76	.....	...do	60
2901	...do	1:56 p. m.	23 17 30	154 23 30	2,502	br. Oz	78	77	.....	...do	60
2902	...do	4:20 p. m.	23 11 00	154 34 00	1,783	gy. Oz	78	77	35·5	...do	60
2903	...do	5:53 p. m.	23 05 00	154 42 30	2,411	(No specimen; defective cup.)	78	77	.....	...do	60
2904	...do	7:46 p. m.	23 00 30	154 51 00	2,464	br. Oz	77	77	.....	...do	60
2905	...do	9:49 p. m.	22 55 30	154 59 00	2,368	br. Oz. Lava	77	77	35·3	...do	60
2906	Nov. 20	12:02 a. m.	22 49 30	155 09 00	2,420	br. Oz	76	76	.....	...do	60
2907	...do	2:17 a. m.	22 43 30	155 18 30	2,272	br. Oz	75	76	.....	...do	60
2908	...do	3:15 a. m.	22 42 30	155 20 30	2,341	br. Oz	75	76	35·5	...do	60
2909	...do	5:25 a. m.	22 36 30	155 30 30	2,408	br. Oz	75	76	.....	...do	60
2910	...do	7:34 a. m.	22 30 00	155 40 00	2,426	br. Oz	75	76	.....	...do	60
2911	...do	9:44 a. m.	22 24 30	155 49 00	2,468	br. Oz	75	76	32·4	...do	60
2912	...do	11:44 a. m.	22 18 00	155 58 30	2,542	br. M	77	77	.....	...do	60
2913	...do	2:45 p. m.	22 11 00	156 09 00	2,640	br. M	77	77	35·4	...do	60
2914	...do	5:02 p. m.	22 03 30	156 19 00	2,766	br. M	78	77	.....	...do	60
2915	...do	7:26 p. m.	21 55 30	156 29 30	2,868	br. M	78	77	.....	...do	60
2916	...do	9:49 p. m.	21 47 30	156 39 00	2,878	br. M	77	77	35·3	...do	60
2917	Nov. 21	12:15 a. m.	21 39 00	156 48 30	2,615	br. M. fne. S	76	77	.....	...do	60
2918	...do	1:26 a. m.	21 37 30	156 50 00	2,576	br. M. fne. S	76	77	.....	...do	60
2919	...do	3:41 a. m.	21 29 30	156 59 30	2,056	br. M. fne. S	75	77	35·5	...do	60
2920	...do	5:50 a. m.	21 21 00	157 09 00	570	br. M. fne. S	76	77	.....	...do	60
2921	...do	6:46 a. m.	21 19 00	157 13 30	347	br. M. fne. S	76	77	.....	...do	60
2922	...do	7.32 a. m.	21 18 30	157 19 00	268	gy. S	76	77	44·8	...do	60
2923	...do	8:19 a. m.	21 18 00	157 24 30	392	gy. S	77	78	.....	...do	60
2924	...do	9:04 a. m.	21 16 48	157 30 00	301	gy. S. Co	77	78	.....	...do	28
2925	...do	9:47 a. m.	21 15 24	157 35 05	105	gy. S. Co	77	78	.....	...do	28
2926	...do	10:28 a. m.	21 13 38	157 39 32	304	fne. wh. S	78	78	43·8	...do	28
2927	...do	11:11 a. m.	21 12 50	157 44 32	293	M	78	78	.....	...do	28
2928	...do	11:32 a. m.	21 13 00	157 50 20	295	fne. wh. S	78	78	.....	...do	28
2929	Dec. 2	12:10 p. m.	21 15 13	157 50 58	10	(No specimen).	79	78	.....	Hand	14
2930	...do	2:47 p. m.	21 15 30	157 40 56	22	wh. S. Co	76	75	.....	Sigsbee	38
2931	...do	2:58 p. m.	21 15 20	157 40 28	47	S. brk. Sh	76	75	.....	...do	38
2932	...do	3:09 p. m.	21 14 59	157 40 10	189	fne. wh. S	76	75	.....	...do	38
2933	...do	3:21 p. m.	21 14 38	157 39 53	276	wh. S	76	75	.....	...do	38
2934	...do	3:32 p. m.	21 14 16	157 39 40	285	fne. wh. S	76	75	.....	...do	38

Record of hydrographic soundings from July 1, 1891, to June 30, 1892—Continued.

Serial No.	Date.	Time of day.	Position. Lat. N.	Position. Long. W.	Depth.	Character of bottom.	Temperatures. Air. Dry bulb	Temperatures. Water at Surface.	Temperatures. Water at Bottom.	Sounding machine.	Weight of sinker used.
	1891.		° ′ ″	° ′ ″	*Fms.*		° F.	° F.	° F.		*Lbs.*
2935	Dec. 2	3:42 p.m.	21 14 02	157 39 28	303	S. Co	76	75	.....	Sigsbee	38
2936	...do...	4:06 p.m.	21 13 55	157 41 23	255	fne. wh. S. Lava	76	75	.....	...do...	38
2937	...do...	4:21 p.m.	21 14 06	157 42 42	47	wh. S. Co	76	75	.....	...do...	38
2938	...do...	4:34 p.m.	21 14 30	157 43 24	142	fne. wh. S	76	75	.....	...do...	38
2939	...do...	4:47 p.m.	21 14 56	157 44 05	21	wh. S. Sh. Co	76	75	.....	...do...	38
2940	...do...	4:58 p.m.	21 15 32	157 44 32	10	wh. S	76	75	.....	Hand	14
2941	...do...	5:00 p.m.	21 15 49	157 44 27	7	wh. S	76	75	.....	...do...	14
2942	Dec. 3	9:40 a.m.	21 15 54	157 44 22	7¼	wh. S	74	77	.....	...do...	14
2943	...do...	9:38 a.m.	21 15 57	157 44 20	7¼	wh. S	74	77	.....	...do...	14
2944	...do...	9:36 a.m.	21 16 01	157 44 17	6½	wh. S	74	77	.....	...do...	14
2945	...do...	9:34 a.m.	21 16 05	157 44 14	6	wh. S	74	77	.....	...do...	14
2946	...do...	9:32 a.m.	21 16 08	157 44 10	4¼	wh. S	74	77	.....	...do...	14
2947	...do...	9:30 a.m.	21 16 11	157 44 06	4	wh. S	74	77	.....	...do...	14
2948	...do...	9:28 a.m.	21 16 14	157 44 01	5	wh. S	74	77	.....	...do...	14
2949	...do...	9:22 a.m.	21 16 18	157 43 56	2¾	wh. S	74	77	.....	...do...	14
2950	...do...	10:18 a.m.	21 15 40	157 43 47	7½	wh. S. Sh. Co	75	77	.....	...do...	14
2951	...do...	10:52 a.m.	21 15 48	157 43 49	7½	wh. S	76	77	.....	...do...	14
2952	...do...	10:50 a.m.	21 15 56	157 43 50	6	wh. S	76	77	.....	...do...	14
2953	...do...	10:48 a.m.	21 16 04	157 43 51	5¼	wh. S	76	77	.....	...do...	14
2954	...do...	10:46 a.m.	21 16 12	157 43 52	3¼	wh. S	76	77	.....	...do...	14
2955	...do...	10:44 a.m.	21 16 19	157 43 55	2¼	wh. S	76	77	.....	...do...	14
2956	...do...	1:19 p.m.	21 15 08	157 43 46	13	wh. S. Co	75	76	.....	...do...	14
2957	...do...	1:27 p.m.	21 14 37	157 43 45	53	wh. S. Co	75	76	.....	Sigsbee	26
2958	...do...	1:38 p.m.	21 14 06	157 43 43	222	fne. wh. S	75	76	.....	...do...	26
2959	...do...	1:50 p.m.	21 13 30	157 43 40	275	fne. wh. S	75	76	45·3	...do...	38
2960	...do...	4:28 p.m.	21 15 49	157 41 23	10½	rky	76	76	.....	Hand	14
2961	...do...	4:30 p.m.	21 15 52	157 41 28	7¼	bk. S	76	76	.....	...do...	14
2962	...do...	4:32 p.m.	21 15 54	157 41 32	6	bk. S	76	76	.....	...do...	14
2963	...do...	4:33 p.m.	21 15 57	157 41 37	3¾	rky	76	76	.....	...do...	14
2964	...do...	4:36 p.m.	21 15 58	157 41 40	2¼	wh. S. P	76	76	.....	...do...	14
2965	...do...	5:38 p.m.	21 15 40	157 43 47	7	wh. S. Co	76	76	.....	...do...	14
2966	...do...	4:34 a.m.	21 15 08	157 51 01	12½	wh. S. Co	76	75	.....	...do...	14
2967	...do...	4:43 a.m.	21 15 13	157 50 58	10¼	wh. S	76	75	.....	...do...	14
2968	...do...	4:51 a.m.	21 15 17	157 50 46	8¾	wh. S	76	75	.....	...do...	14
2969	...do...	4:57 a.m.	21 15 18	157 50 39	7	wh. S	76	75	.....	...do...	14
2970	...do...	5:02 a.m.	21 15 21	157 50 31	2¾	wh. S	76	75	.....	...do...	14
2971	...do...	5:08 a.m.	21 15 24	157 50 27	2	wh. S. Co	76	75	.....	...do...	14
2972	...do...	5:11 a.m.	21 15 27	157 50 22	2	wh. S. Co	76	75	.....	...do...	14
2973	...do...	3:09 p.m.	21 15 22	157 51 48	7¼	Co	75	76	.....	...do...	14
2974	...do...	3:14 p.m.	21 15 23	157 50 43	5	wh. S	75	76	.....	...do...	14
2975	...do...	3:20 p.m.	21 15 24	157 50 39	3	wh. S	75	76	.....	...do...	14
2976	...do...	3:27 p.m.	21 15 25	157 50 32	2	wh. S	75	76	.....	...do...	14
2977	...do...	9:03 a.m.	21 16 09	157 50 38	0¾	wh. S	75	75	.....	...do...	14
2978	...do...	9:07 a.m.	21 15 59	157 50 42	2¾	wh. S	75	75	.....	...do...	14
2979	...do...	9:09 a.m.	21 15 52	157 50 44	3¾	wh. S	75	75	.....	...do...	14
2980	...do...	9:11 a.m.	21 15 46	157 50 46	5	wh. S	75	75	.....	...do...	14
2981	...do...	9:13 a.m.	21 15 40	157 50 49	4¼	wh. S	75	75	.....	...do...	14
2982	...do...	9:15 a.m.	21 15 35	157 50 51	5¾	wh. S	75	75	.....	...do...	14
2983	...do...	9:18 a.m.	21 15 30	157 50 54	7¼	Co	76	76	.....	...do...	14
2984	...do...	11:01 a.m.	21 14 53	157 51 10	50	wh. S. bk. Sp	77	76	.....	Sigsbee	38
2985	...do...	11:10 a.m.	21 14 27	157 51 22	206	fne. wh. S	77	76	.....	...do...	38
2986	...do...	11:21 a.m.	21 13 57	157 51 29	271	fne. wh. S	77	76	.....	...do...	38
2987	...do...	11:52 a.m.	21 13 17	157 48 29	224	fne. wh. S	77	76	48·1	...do...	38
2988	...do...	12:08 p.m.	21 13 32	157 48 52	133	wh. S. Sh. Co	77	76	.....	...do...	38
2989	...do...	12:16 p.m.	21 13 48	157 49 29	164	wh. S. Co	77	76	.....	...do...	38
2990	...do...	12:26 p.m.	21 14 00	157 49 58	201	fne. wh. S	77	76	50·4	...do...	38
2991	Dec. 4	12:39 p.m.	21 14 26	157 50 49	252	fne. wh. S	77	76	.....	...do...	38
2992	...do...	12:51 p.m.	21 14 40	157 51 17	153	fne. wh. S	77	76	.....	...do...	38
2993	Dec. 5	7:51 a.m.	21 14 30	157 34 30	153	fne. wh. S. Co	76	76	.....	...do...	38
2994	...do...	8:05 a.m.	21 15 00	157 33 00	305	fne. wh. S	76	76	44·3	...do...	38
2995	...do...	8:50 a.m.	21 18 00	157 29 00	398	fne. wh. S	76	76	.....	...do...	38
2996	...do...	9:36 a.m.	21 20 30	157 25 00	407	fne. gy. S	76	76	.....	...do...	38
2997	...do...	10:23 a.m.	21 23 30	157 21 00	372	gy. S. Co	77	76	50·7	...do...	38
2998	...do...	11:26 a.m.	21 26 00	157 17 00	508	fne. gy. S	77	76	.....	...do...	38
2999	...do...	11:54 a.m.	21 27 00	157 15 00	549	fne. gy. S	77	76	.....	...do...	38
3000	...do...	1:09 p.m.	21 29 30	157 12 00	1,557	gy. M. fne. S	77	76	.....	...do...	60
3001	...do...	2:24 p.m.	21 32 30	157 08 00	1,792	gy. M. fne. S	76	74	35·1	...do...	60
3002	...do...	3:41 p.m.	21 35 00	157 04 00	2,156	br. M. fne. S	75	75	.....	...do...	60
3003	...do...	5:34 p.m.	21 40 30	156 56 00	1,951	br. M. Lava	75	75	.....	...do...	60
3004	...do...	6:32 p.m.	21 41 20	156 54 00	2,325	fne. S. Lava	75	75	35·1	...do...	60
3005	...do...	8:50 p.m.	21 47 00	156 46 00	2,612	br. M. S	75	75	.....	...do...	60
3006	Dec. 12	8:25 a.m.	21 18 00	157 23 00	329	wh. and gy. S	68	74	42·5	...do...	60
3007	...do...	9:17 a.m.	21 20 00	157 19 00	323	fne. gy. S	68	74	.....	...do...	60
3008	...do...	10:09 a.m.	21 23 00	157 14 30	547	gy. M. fne. S	72	74	.....	...do...	60
3009	...do...	10:46 a.m.	21 24 00	157 12 00	603	gy. M. fne. S	72	74	.....	...do...	60
3010	...do...	11:24 a.m.	21 25 00	157 10 00	1,116	gy. M. fne. S	72	74	36·1	...do...	60
3011	...do...	12:24 p.m.	21 26 17	157 08 30	1,781	(No specimen)	72	74	.....	...do...	60

Record of hydrographic soundings from July 1, 1891, to June 30, 1892—Continued.

Serial No.	Date.	Time of day.	Position. Lat. N.	Position. Long. W.	Depth.	Character of bottom.	Temperatures. Air. Dry bulb	Temperatures. Water at Surface.	Temperatures. Water at Bottom.	Sounding machine.	Weight of sinker used.
	1891.		° ′ ″	° ′ ″	*Fms.*		°F.	°F.	°F.		*Lbs.*
3012	Dec. 12	1:44 p. m.	21 28 30	157 04 00	2,067	br. M. fne. S	70	73	......	Sigsbee	60
3013	...do...	4:11 p. m.	41 32 30	156 54 00	1,807	br. M. S	70	73	35·3	...do...	60
3014	...do...	6:22 p. m.	21 36 30	156 44 00	2,767	br. M. fne. S	71	74	......	...do...	60
3015	...do...	9:12 p. m.	21 41 00	156 32 30	2,966	br. M. fne. S	68	73	......	...do...	60
3016	...do...	11:59 p. m.	21 46 00	156 21 00	3,017	br. M. fne. S	69	73	35·3	...do...	60
3017	Dec. 13	3:11 a. m.	21 51 00	156 09 00	3,027	(No specimen)	70	73	......	...do...	60
3018	...do...	6:03 a. m.	21 56 00	155 57 30	2,915	br. Oz	69	74	......	...do...	60
3019	...do...	8:53 a. m.	22 00 30	155 46 00	2,782	br. Oz	73	75	35·2	...do...	60
3020	...do...	11:36 a. m.	22 05 30	155 34 30	2,654	br. Oz	74	74	......	...do...	60
3021	...do...	2:20 p. m.	22 10 00	155 23 30	2,545	br. Oz	74	75	......	...do...	60
3022	...do...	4:52 p. m.	22 15 00	155 12 30	2,475	br. Oz	72	75	35·2	...do...	60
3023	...do...	7:29 p. m.	22 20 00	155 01 00	2,463	br. Oz	72	75	......	...do...	60
3024	...do...	10:07 p. m.	22 25 00	154 49 30	2,477	br. Oz	71	74	......	...do...	60
3025	Dec. 14	12:43 a. m.	22 30 00	154 38 30	2,485	br. Oz	71	75	35·3	...do...	60
3026	...do...	3:27 a. m.	22 35 00	154 27 00	2,453	br. Oz	69	74	......	...do...	60
3027	...do...	6:07 a. m.	22 40 00	154 16 00	2,500	br. Oz	69	74	......	...do...	60
3028	...do...	8:42 a. m.	22 45 00	154 04 30	2,587	br. Oz	73	74	35·7	...do...	60
3029	...do...	11:15 a. m.	22 50 00	153 53 00	2,555	br. Oz	74	74	......	...do...	60
3030	...do...	1:48 p. m	22 55 30	153 42 00	2,602	br. Oz	74	74	......	...do...	60
3031	...do...	4:20 p. m.	23 01 00	153 31 00	2,649	br. Oz	73	74	35·2	...do...	60
3032	...do...	6:49 p. m.	23 06 00	153 20 30	2,696	br. Oz	72	74	......	...do...	60
3033	...do...	9:19 p. m.	23 11 00	153 09 30	2,822	br. Oz	72	74	......	...do...	60
3034	...do...	11:58 p. m.	23 16 00	152 59 00	2,827	br. Oz	72	74	35·2	...do...	60
3035	Dec. 15	2:50 a. m.	23 21 30	152 48 00	2,910	br. Oz	70	73	......	...do...	60
3036	...do...	5:51 a. m.	23 27 00	152 37 00	2,894	br. Oz. S	70	73	......	...do...	60
3037	...do...	8:41 a. m.	23 32 30	152 26 00	2,927	br. Oz. S	70	74	35.2	...do...	60
3038	...do...	11:32 a. m.	23 38 00	152 15 00	3,006	br. Oz	71	74	......	...do...	60
3039	...do...	2:28 p. m.	23 43 30	152 05 00	2,976	br. Oz	69	74	......	...do...	60
3040	...do...	5:13 p. m.	23 49 00	151 55 00	2,985	br. Oz	70	74	41·1	...do...	60
3041	...do...	8:45 p. m.	23 56 00	151 42 00	3,030	br. Oz	69	74	38·9	...do...	60
3042	Dec. 16	12:18 a. m.	24 03 00	151 29 30	3,016	(No specimen)	69	73	......	...do...	60
3043	...do...	3:42 a. m.	24 10 00	151 17 00	3,038	br. Oz	70	73	......	...do...	60
3044	...do...	7:00 a. m.	24 17 00	151 04 00	2,979	br. Oz	70	73	......	...do...	60
3045	...do...	10:27 a. m.	24 24 00	150 51 30	2,907	br. Oz	71	73	35·3	...do...	60
3046	...do...	1:40 p. m.	24 31 00	150 37 00	2,747	br. Oz	74	74	......	...do...	60
3047	...do...	4:43 p. m.	24 37 00	150 23 00	2,916	br. Oz	72	73	......	...do...	60
3048	...do...	7:50 p. m.	24 43 00	150 09 00	2,980	br. Oz	71	72	37·6	...do...	60
3049	...do...	11:00 p. m.	24 49 00	149 55 00	2,912	br. Oz	72	73	......	...do...	60
3050	Dec. 17	2:14 a. m.	24 55 00	149 41 00	2,984	br. Oz	70	73	......	...do...	60
3051	...do...	5:27 a. m.	25 01 00	149 27 00	3,034	br. Oz	71	73	35·4	...do...	60
3052	...do...	8:36 a. m.	25 07 30	149 13 00	2,957	br. Oz	71	73	......	...do...	60
3053	...do...	11:37 a. m.	25 13 30	148 59 00	2,930	br. Oz	72	73	......	...do...	60
3054	...do...	2:35 p. m.	25 20 00	148 44 30	2,938	(No specimen)	71	73	......	...do...	60
3055	...do...	5:34 p. m.	25 26 30	148 30 00	2,881	br. Oz	69	73	35	...do...	60
3056	...do...	8:36 p. m.	25 33 00	148 16 00	2,642	(No specimen)	69	73	......	...do...	60
3057	...do...	11:42 p. m.	25 39 30	148 01 30	2,903	br. Oz	69	73	......	...do...	60
3058	Dec. 18	2:51 a. m.	25 46 00	147 47 00	2,893	br. Oz	69	72	35·1	...do...	60
3059	...do...	5:56 a. m.	25 53 00	147 32 30	2,923	br. Oz	69	72	......	...do...	60
3060	...do...	8:57 a. m.	26 00 00	147 18 00	2,787	(No specimen)	72	72	......	...do...	60
3061	...do...	12:12 p. m.	26 06 36	147 03 16	2,884	br. Oz	72	72	35·2	...do...	60
3062	...do...	3:16 p. m.	26 13 00	146 49 00	2,838	br. Oz	74	73	......	...do...	60
3063	...do...	6:25 p. m.	26 19 30	146 34 30	2,777	br. Oz	71	72	......	...do...	60
3064	...do...	9:33 p. m.	26 26 00	146 20 00	2,829	br. Oz	69	72	35·1	...do...	60
3065	Dec. 19	12:54 a. m.	26 32 30	146 05 30	2,779	br. Oz	68	71	......	...do...	60
3066	...do...	4:12 a. m.	26 39 00	145 51 00	2,854	br. Oz	68	72	......	...do...	60
3067	...do...	7:35 a. m.	26 45 00	145 36 30	2,346	br. Oz	68	72	35·1	...do...	60
3068	...do...	9:05 a. m.	26 44 00	145 38 30	2,682	br. Oz	69	72	......	...do...	60
3069	...do...	11:01 a. m.	26 46 00	145 33 30	2,677	br. Oz	70	72	......	...do...	60
3070	...do...	1:57 p. m.	26 50 30	145 24 00	2,825	br. Oz	69	72	......	...do...	60
3071	...do...	5:38 p. m.	26 57 00	145 09 30	2,739	br. Oz	69	72	35·1	...do...	60
3072	...do...	9:54 p. m.	27 03 30	144 54 30	2,714	br. Oz	68	71	......	...do...	60
3073	Dec. 20	3:20 a. m.	27 10 00	144 39 30	2,697	br. Oz	66	71	......	...do...	60
3074	...do...	8:27 a. m.	27 16 30	144 24 30	2,750	br. Oz	68	70	35·2	...do...	60
3075	...do...	1:29 p. m.	27 23 00	144 10 00	2,506	br. Oz	68	70	......	...do...	60
3076	...do...	6:30 p. m.	27 33 00	143 55 30	2,716	br. Oz	67	70	......	...do...	60
3077	...do...	11:50 p. m.	27 42 30	143 41 30	2,375	br. Oz	67	70	35	...do...	60
3078	Dec. 21	5:20 a. m.	27 52 00	143 27 00	2,827	br. Oz	67	70	......	...do...	60
3079	...do...	10:46 a. m.	28 02 00	143 12 30	2,736	br. Oz	69	70	......	...do...	60
3080	...do...	3:52 p. m.	28 08 00	142 57 00	2,731	br. Oz	69	71	......	...do...	60
3081	...do...	8:55 p. m.	28 14 00	142 40 00	2,560	br. Oz	65	69	35·1	...do...	60
3082	Dec. 22	1:30 a. m.	28 20 00	142 22 30	2,684	br. Oz	67	69	......	...do...	60
3083	...do...	6:48 a. m.	28 26 00	142 05 00	2,711	br. Oz	67	69	......	...do...	60
3084	...do...	11:12 a. m.	28 31 30	141 47 30	2,668	br. Oz. Lava	69	69	35·1	...do...	60
3085	...do...	3:21 p. m.	28 37 30	141 33 00	2,678	br. Oz. Lava	69	69	......	...do...	60
3086	...do...	8:00 p. m.	28 43 00	141 19 00	2,700	br. Oz	68	69	......	...do...	60
3087	Dec. 23	12:55 a. m.	28 48 30	141 04 30	2,702	br. Oz	68	69	35·1	...do...	60
3088	...do...	4:46 a. m.	28 54 30	140 49 30	2,735	(No specimen)	66	69	......	...do...	60

Record of hydrographic soundings from July 1, 1891, to June 30, 1892—Continued.

Serial No.	Date.	Time of day.	Position. Lat. N.	Position. Long. W.	Depth.	Character of bottom.	Temperatures. Air. Dry bulb	Temperatures. Water at Surface.	Temperatures. Water at Bottom.	Sounding machine.	Weight of sinker used.
	1891.		° ′ ″	° ′ ″	Fms.		°F.	°F.	°F.		Lbs.
3089	Dec. 23	8:31 a. m.	29 00 30	140 35 00	2,664	br. Oz	66	68	.....	Sigsbee	60
3090	...do...	12:28 p. m.	29 06 24	140 28 48	2,741	br. Oz	68	69	35·1	...do...	60
3091	...do...	4:11 p. m.	29 12 00	140 06 30	2,729	br. Oz	65	68	.....	...do...	60
3092	...do...	8:49 p. m.	29 17 30	139 52 00	2,687	br. Oz	65	68	.....	...do...	60
3093	Dec. 24	12:36 a. m.	29 23 00	139 38 00	2,631	br. Oz	64	68	35·1	...do...	60
3094	...do...	3:53 a. m.	29 28 30	139 23 30	2,608	br. Oz	64	68	.....	...do...	60
3095	...do...	6:55 a. m.	29 34 00	139 09 00	2,668	br. Oz	63	68	.....	...do...	60
3096	...do...	10:04 a. m.	29 40 00	138 55 00	2,620	br. Oz	64	67	35·1	...do...	60
3097	...do...	1:15 p. m.	29 46 00	138 40 00	2,572	br. Oz	66	68	.....	...do...	60
3098	...do...	4:08 p. m.	29 52 30	138 24 00	2,653	br. Oz	63	67	.....	...do...	60
3099	...do...	6:59 p. m.	29 59 00	138 08 00	2,556	br. Oz. Lava	63	67	35·1	...do...	60
3100	...do...	9:41 p. m.	30 05 30	137 52 00	2,404	br. Oz. Lava	62	67	.....	...do...	60
3101	Dec. 25	12:28 a. m.	30 12 00	137 36 30	2,672	br. Oz. Lava	63	66	.....	...do...	60
3102	...do...	3:11 a. m.	30 18 30	137 21 00	2,626	br. Oz	61	65	35·1	...do...	60
3103	...do...	5:41 a. m.	30 23 30	137 09 00	2,201	br. Oz. Lava	61	66	.....	...do...	60
3104	...do...	6:33 a. m.	30 24 00	137 07 00	1,924	(No specimen)	62	66	35	...do...	60
3105	...do...	8:03 a. m.	30 25 00	137 05 00	2,023	gy. Oz. fne. S	62	66	.....	...do...	60
3106	...do...	8:59 a. m.	30 26 00	137 03 00	2,248	(No specimen)	63	66	.....	...do...	60
3107	...do...	10:10 a. m.	30 27 00	137 00 30	2,604	br. Oz. S. Lava	63	66	35·2	...do...	60
3108	...do...	11:39 a. m.	30 30 01	137 05 06	2,521	br. Oz	64	67	.....	...do...	60
3109	...do...	1:07 p. m.	30 29 30	137 10 30	2,422	br. Oz	64	67	33·2	...do...	60
3110	...do...	2:44 p. m.	30 25 00	137 15 00	1,779	gy. Oz. fne. S	64	67	.....	...do...	60
3111	...do...	4:00 p. m.	30 19 30	137 15 00	2,298	br. Oz. Lava	64	67	.....	...do...	60
3112	...do...	5:24 p. m.	30 15 00	137 10 30	2,309	(No specimen)	65	66	35·1	...do...	60
3113	...do...	6:53 p. m.	30 15 30	137 04 30	2,551	br. Oz	63	66	.....	...do...	60
3114	...do...	8:26 p. m.	30 19 30	137 00 30	2,573	br. Oz. Lava	62	60	.....	...do...	60
3115	...do...	10:32 p. m.	30 28 00	136 53 00	2,291	br. Oz. Lava	62	66	35	...do...	60
3116	...do...	11:23 p. m.	30 29 00	136 51 00	1,932	br. Oz	62	66	.....	...do...	60
3117	Dec. 26	12:09 a. m.	30 30 00	136 49 00	1,858	br. Oz	62	66	.....	...do...	60
3118	...do...	1:01 a. m.	30 31 00	136 47 00	2,131	br. Oz	62	66	.....	...do...	60
3119	...do...	2:10 a. m.	30 33 00	136 42 30	2,220	br. Oz	62	66	.....	...do...	60
3120	...do...	4:06 a. m.	30 38 00	136 33 00	2,612	br. Oz	62	66	42·3	...do...	60
3121	...do...	6:10 a. m.	30 43 00	136 23 00	2,502	br. Oz	62	66	.....	...do...	60
3122	...do...	8:49 a. m.	30 49 30	136 08 30	2,411	(No specimen)	63	66	.....	...do...	60
3123	...do...	9:46 a. m.	30 50 30	136 06 30	2,473	br. Oz	59	66	.....	...do...	60
3124	...do...	11:58 a. m.	30 54 45	135 56 35	2,505	br. Oz	62	65	.....	...do...	60
3125	...do...	2:00 p. m.	30 59 00	135 47 00	2,581	br. Oz	66	66	35·2	...do...	60
3126	...do...	3:58 p. m.	31 04 00	135 37 00	2,565	br. Oz	66	66	.....	...do...	60
3127	...do...	6:05 p. m.	31 08 00	135 26 30	2,480	(No specimen)	63	66	.....	...do...	60
3128	...do...	8:03 p. m.	31 12 00	135 17 00	2,413	br. Oz. Lava	63	65	35	...do...	60
3129	...do...	10:03 p. m.	31 16 00	135 07 00	2,572	br. Oz	64	65	.....	...do...	60
3130	Dec. 27	12:03 a. m.	31 20 00	134 57 00	2,574	br. Oz	64	65	.....	...do...	60
3131	...do...	2:07 a. m.	31 24 00	134 47 00	2,602	br. Oz	64	65	35·2	...do...	60
3132	...do...	4:13 a. m.	31 28 00	134 36 30	2,482	br. Oz. Lava	64	65	.....	...do...	60
3133	...do...	6:14 a. m.	31 32 30	134 26 30	2,611	br. Oz	63	65	.....	...do...	60
3134	...do...	8:15 a. m.	31 37 00	134 16 00	2,566	br. Oz	65	65	35	...do...	60
3135	...do...	10:21 a. m.	31 41 00	134 06 00	2,598	br. Oz	68	66	.....	...do...	60
3136	...do...	12:26 a. m.	31 45 14	133 56 00	2,589	br. Oz	69	66	.....	...do...	60
	1892.										
3137	Jan. 10	12:39 p. m.	31 49 23	133 45 32	2,550	br. Oz	61	63	35·1	...do...	60
3138	...do...	2:42 p. m.	31 53 30	133 36 00	2,516	br. Oz	61	63	.....	...do...	60
3139	...do...	4:33 p. m.	31 57 30	133 26 00	2,619	br. Oz	61	63	.....	...do...	60
3140	...do...	6:32 p. m.	32 01 30	133 16 00	2,611	br. Oz	60	62	35·2	...do...	60
3141	...do...	8:36 p. m.	32 06 00	133 06 00	2,619	br. Oz	59	63	.....	...do...	60
3142	...do...	10:49 p. m.	32 10 00	132 56 00	2,686	br. Oz	60	63	.....	...do...	60
3143	Jan. 11	12:55 a. m.	32 14 00	132 46 00	2,637	br. Oz	59	62	35·2	...do...	60
3144	...do...	2:54 a. m.	32 18 00	132 36 00	2,527	br. Oz	58	62	.....	...do...	60
3145	...do...	4:50 a. m.	32 22 00	132 26 00	2,656	br. Oz	59	62	.....	...do...	60
3146	...do...	6:45 a. m.	32 26 00	132 16 00	2,341	br. Oz	59	62	35·1	...do...	60
3147	...do...	7:40 a. m.	32 27 00	132 14 00	2,223	br. Oz	59	62	.....	...do...	60
3148	...do...	8:42 a. m.	32 28 00	132 12 00	2,560	br. Oz	59	63	.....	...do...	60
3149	...do...	10:07 a. m.	32 29 30	132 06 30	2,175	br. Oz. Lava	59	62	35·1	...do...	60
3150	...do...	11:13 a. m.	32 30 00	132 04 30	2,548	br. Oz. bk. Sp	59	62	.....	...do...	60
3151	...do...	12:43 p. m.	32 32 30	131 59 30	2,458	br. Oz	60	62	.....	...do...	60
3152	...do...	2:42 p. m.	32 36 00	131 49 30	2,583	br. Oz	59	62	35·3	...do...	60
3153	...do...	4:38 p. m.	32 39 00	131 40 00	2,525	br. Oz	59	62	.....	...do...	60
3154	...do...	6:35 p. m.	32 43 30	131 30 00	2,379	br. Oz	58	62	.....	...do...	60
3155	...do...	8:30 p. m.	32 47 00	131 20 00	2,519	br. Oz	58	61	35·3	...do...	60
3156	...do...	10:39 p. m.	32 51 00	131 10 00	2,535	br. Oz	58	61	.....	...do...	60
3157	Jan. 12	12:36 a. m.	32 55 00	131 00 00	2,572	br. Oz. Lava	58	61	.....	...do...	60
3158	...do...	2:32 a. m.	32 58 30	130 50 00	2,361	br. Oz. Lava	58	61	35·2	...do...	60
3159	...do...	3:37 a. m.	32 59 30	130 48 00	2,531	br. Oz	58	61	.....	...do...	60
3160	...do...	5:32 a. m.	33 03 30	130 38 00	2,483	br. Oz	58	60	.....	...do...	60
3161	...do...	7:30 a. m.	33 07 00	130 28 00	2,541	br. Oz	58	60	35·1	...do...	60
3162	...do...	9:27 a. m.	33 10 30	130 18 00	2,542	(No specimen)	59	62	.....	...do...	60
3163	...do...	11:23 a. m.	33 14 00	130 08 30	2,551	br. Oz	60	62	.....	...do...	60
3164	...do...	1:29 p. m.	33 18 00	129 58 00	2,584	br. Oz. Lava	59	61	35·1	...do...	60
3165	...do...	4:35 p. m.	33 23 00	129 45 00	2,773	br. Oz	58	61	35 1	...do...	60

Record of hydrographic soundings from July 1, 1891, to June 30, 1892—Continued.

Serial No.	Date.	Time of day.	Position. Lat. N.	Position. Long. W.	Depth.	Character of bottom.	Temperatures. Air. Dry bulb	Temperatures. Water at Surface.	Temperatures. Water at Bottom.	Sounding machine.	Weight of sinker used.
	1892.		° ′ ″	° ′ ″	*Fms.*		° F.	° F.	° F.		*Lbs.*
3166	Jan. 12	7:14 p. m.	33 28 00	129 32 00	2,701	br. Oz	58	61	.....	Sigsbee	60
3167	...do...	9:25 p. m.	33 33 00	129 18 30	2,572	br. Oz	58	61	.....	...do...	60
3168	...do...	11:31 p. m.	33 38 00	129 05 30	2,572	br. Oz	58	61	35·2	...do...	60
3169	Jan. 13	1:42 a. m.	33 43 00	128 52 00	2,612	br. Oz	58	60	.....	...do...	60
3170	...do...	3:47 a. m.	33 48 00	128 39 30	2,619	(No specimen)	57	61	.....	...do...	60
3171	...do...	5:54 a. m.	33 53 00	128 26 00	2,637	br. Oz	56	59	35·1	...do...	60
3172	...do...	7:59 a. m.	33 58 00	128 13 00	2,568	br. Oz	56	58	.....	...do...	60
3173	...do...	10:08 a. m.	34 03 00	128 00 00	2,632	br. Oz	58	58	.....	...do...	60
3174	...do...	12:26 p. m.	34 08 10	127 46 41	2,665	br. Oz	60	59	35·1	...do...	60
3175	...do...	2:33 p. m.	34 14 30	127 34 30	2,588	br. Oz	64	60	.....	...do...	60
3176	...do...	4:38 p. m.	34 20 30	127 22 30	2,657	br. Oz	58	59	.....	...do...	60
3177	...do...	6:47 p. m.	34 26 30	127 10 30	2,680	br. Oz	58	58	35·1	...do...	60
3178	...do...	8:55 p. m.	34 32 30	126 58 00	2,649	br. Oz	57	58	.....	...do...	60
3179	...do...	11:07 p. m.	34 38 30	126 46 00	2,637	br. Oz	59	58	.....	...do...	60
3180	Jan. 14	1:20 a. m.	34 44 30	126 34 00	2,626	br. Oz	57	58	35·1	...do...	60
3181	...do...	3:27 a. m.	34 50 30	126 22 00	2,606	br. Oz	56	57	.....	...do...	60
3182	...do...	5:32 a. m.	34 56 00	126 09 30	2,586	br. Oz	57	57	.....	...do...	60
3183	...do...	7:37 a. m.	35 02 00	125 57 30	2,585	br. and gy. Oz	57	58	35·1	...do...	60
3184	...do...	9:40 a. m.	35 08 00	125 45 30	2,572	br. Oz	58	57	.....	...do...	60
3185	...do...	11:46 a. m.	35 14 07	125 33 18	2,560	br. and gy. Oz	59	57	.....	...do...	60
3186	...do...	1:58 p. m.	35 19 30	125 21 30	2,529	gy. and yl. Oz	62	58	35	...do...	60
3187	...do...	5:17 p. m.	35 25 30	125 09 30	2,496	br. and gy. Oz	50	57	34·9	...do...	60
3188	...do...	7:19 p. m.	35 31 00	124 57 30	2,445	br. and gy. Oz	57	56	.....	...do...	60
3189	...do...	9:27 p. m.	35 36 30	124 45 30	2,413	br. and gy. Oz	56	56	.....	...do...	60
3190	...do...	11:31 p. m.	35 42 00	124 33 30	2,312	br. and gy. Oz	53	59	34·9	...do...	60
3191	Jan. 15	1:35 a. m.	35 47 30	124 21 30	2,223	br. and gy. Oz	54	54	.....	...do...	60
3192	...do...	3:28 a. m.	35 53 00	124 09 30	2,149	br. and gy. Oz	54	54	.....	...do...	60
3193	...do...	5:25 a. m.	35 58 30	123 57 30	2,169	gy. Oz	54	54	34·9	...do...	60
3194	...do...	7:23 a. m.	36 04 00	123 46 00	2,107	gy. Oz	54	55	.....	...do...	60
3195	...do...	9:18 a. m.	36 09 30	123 34 00	1,974	gy. Oz	54	54	.....	...do...	60
3196	...do...	11:06 a. m.	36 15 00	123 22 00	1,895	gy. Oz	54	52	35	...do...	60
3197	...do...	1:09 p. m.	36 21 00	123 10 00	1,797	gy. Oz	59	52	.....	...do...	60
3198	...do...	2:39 p. m.	36 25 00	123 00 00	1,725	gy. Oz	59	52	.....	...do...	60
3199	...do...	4:12 p. m.	36 29 30	122 59 30	1,666	gy. Oz	53	52	35	...do...	60
3200	...do...	5:42 p. m.	36 34 00	122 41 00	1,513	gn. M	53	52	.....	...do...	60
3201	...do...	7:15 p. m.	36 38 00	122 31 00	1,417	gn. M.	51	52	.....	...do...	60
3202	...do...	8:14 p. m.	36 40 00	122 26 00	1,053	gn. M. fne. S.	52	52	36·1	...do...	60
3203	Apr. 7	4:31 p. m.	58 22 00	150 09 00	29	brk. Sh	34	38	.....	Tanner	26
3204	...do...	5:51 p. m.	58 25 00	150 18 00	30	Sh	34	38	.....	...do...	26
3205	...do...	6:43 p. m.	58 28 00	150 26 00	38	Sh	33	37	.....	...do...	26
3206	...do...	7:39 p. m.	58 31 00	150 34 00	47	crs. S. Sh	33	37	.....	...do...	26
3207	...do...	8:40 p. m.	58 34 00	150 42 00	49	bk. S. brk. Sh	33	38	.....	...do...	26
3208	...do...	9:42 p. m.	58 37 00	150 50 00	85	gy. S. bk. Sp	33	38	.....	...do...	26
3209	...do...	11:59 p. m.	58 39 00	150 58 00	103	M. bk. S	33	38	.....	...do...	26
3210	Apr. 8	1:05 a. m.	58 40 00	151 01 00	107	M. S.	33	38	.....	...do...	26
3211	...do...	2:03 a. m.	58 43 00	151 09 00	118	bl. M. bk. Sp	33	38	.....	...do...	26
3212	...do...	3:03 a. m.	58 46 00	151 17 00	102	bl. M. bk. Sp	33	38	.....	...do...	26
3213	...do...	4:00 a. m.	58 49 00	151 25 00	93	bl. M. bk. Sp	33	38	.....	...do...	26
3214	Apr. 11	4:25 p. m.	59 32 00	151 55 00	20	gy. S	37	36	.....	...do...	26
3215	Apr. 18	8:45 a. m.	59 56 00	145 56 00	55	S. M.	40	41	.....	Tanner	26
3215*a*	...do...	2:19 p. m.	59 34 45	144 58 00	81	gn. M	43	42	.....	...do...	26
3216	...do...	2:56 p. m.	59 33 00	144 52 00	97	P. M	43	43	.....	...do...	26
3217	...do...	3:32 p. m.	59 31 00	144 43 00	377	G. M.	43	43	.....	...do...	38
3218	...do...	8:35 p. m.	59 35 00	143 21 00	156	P.	38	40	.....	...do...	26
3219	Apr. 19	3:03 a. m.	59 35 00	143 18 00	140	M. P	38	41	.....	...do...	38
3220	...do...	4:56 a. m.	59 36 00	142 57 00	225	bl. M	38	41	.....	...do...	38
3221	...do...	5:40 a. m.	59 37 00	142 45 00	281	bl. M. G	39	41	.....	...do...	38
3222	...do...	8:55 a. m.	59 19 00	142 10 00	504	gn. M	40	42	37·4	Sigsbee	60
3223	...do...	10:28 a. m.	59 21 00	141 50 00	114	P	40	42	.....	...do...	60
3224	...do...	11:56 a. m.	59 14 00	141 35 00	116	S. G	41	42	.....	...do...	38
3225	...do...	3:46 p. m.	58 56 00	140 56 00	471	gn. M	41	42	37·9	...do...	38
3226	Apr. 24	6:45 p. m.	50 25 00	129 15 00	1,141	gn. M	46	46	35·3	...do...	60
3227	Apr. 25	7:31 p. m.	49 42 00	127 53 00	848	gn. M	49	48	37·5	...do...	38
3228	Apr. 26	8:05 p. m.	48 35 00	126 42 00	746	gn. M	48	48	37	...do...	38
3229	Apr. 27	1:01 p. m.	48 29 30	124 56 30	51	P. rky	52	51	.....	Tanner	26
3230	...do...	1:24 p. m.	48 29 00	124 55 00	53	P. rky	52	51	.....	...do...	26
				East.							
3231	May 29	10:40 p. m.	53 13 00	172 38 00	1,447	yl. M. fne. S.	41	40	.....	Sigsbee	60
3232	May 30	5:43 a. m.	53 38 00	171 28 00	1,818	(No specimen)	38	39	.....	...do...	60
3233	...do...	11:35 a. m.	54 02 00	170 17 00	1,853	fne. bk. S	42	40	.....	...do...	60
3234	...do...	6:12 p. m.	54 19 00	169 03 00	1,996	yl. M. S.	40	40	35·6	...do...	60
3235	May 31	12:03 p. m.	54 30 00	168 07 00	47	fne. gy. S	40	40	.....	...do...	60
3236	...do...	1:34 p. m.	55 09 00	165 51 00	25	rky	40	40	.....	Tanner	26
3237	...do...	3:10 p. m.	55 10 00	165 47 00	33	rky. M	39	40	.....	...do...	26
3238	...do...	4:33 p. m.	55 08 00	165 48 00	36	gy. S	39	39	.....	...do...	26
3239	...do...	5:34 p. m.	55 10 30	165 45 00	32	gy. S	39	39	.....	...do...	26

Record of dredging and trawling stations of U. S. Fish Commission steamer Albatross from July 1, 1891, to June 30, 1892.

Serial No.	Date.	Time.	Position. Latitude N.	Position. Longitude W.	Temperatures. Air.	Temperatures. Surface.	Temperatures. Bottom.	Depth.	Character of bottom.	Wind. Direction.	Wind. Force.	Drift. Direction.	Drift. Distance.	Instrument used.
	1891.		° ′ ″	° ′ ″	° F.	° F.	° F.	Fms.					Miles.	
3438	Aug. 3	11:04 a. m.	57 06 30	170 22 30	49	45	......	20	fne. gy. S. Sh.	East	1	SW. by W	·5	S. B. T.
3439	...do	12:29 p. m.	57 06 00	170 35 00	50	44	44	41	fne. bk. S	East	1	SW. by W	·8	S. B. T.
3440	...do	1:39 p. m.	57 05 00	170 41 00	49	46	......	48	bk. M. Sh	SE	1	SW. by W	1	S. B. T.
3441	...do	3:12 p. m.	57 01 20	170 52 30	49	48	39	51	bk. M. Sh	SE	1·2	SW	1	S. B. T.
3442	...do	4:43 p. m.	57 10 00	170 47 15	50	50	40	47	bl. M. Sh	ESE	2	NW. ½ W	·7	S. B. T.
3443	Aug. 27	2:09 p. m.	48 13 30	123 11 20	65	57	46	97	gn. M. P	SW	1	SW. by W	1	L. B. T.
3444	...do	3:54 p. m.	48 16 30	123 29 40	66	56	45	80	gn. M. P	Calm	0	SW. by W	·7	L. B. T.
3445	...do	5:34 p. m.	48 16 [illegible]0	123 45 05	66	65	44	100	Rky	Calm	0	W. ½ S	2	L. B. T.
3446	...do	7:29 p. m.	48 18 50	123 58 20	68	53	44·5	100	bu. M	SW. by S	1	SW	1·5	L. B. T.
3447	Aug. 28	10:35 a. m.	48 30 15	124 36 20	61	54	44	116	gy. S	ENE	1	NNW	1·5	L. B. T.
3448	...do	3:13 p. m.	48 31 40	124 39 00	59	55	44	98	gy. S	SW	3	SSW	1	L. B. T.
3449	...do	4:14 p. m.	48 29 40	124 40 10	60	55	......	135	gy. S. G	SW	2	E. by S	1	L. B. T.
3450	...do	5:15 p. m.	48 26 50	124 39 35	54	53	44	151	G	SW	2	ENE. ½ E	·7	L. B. T.
3451	...do	6:29 p. m.	48 25 10	124 37 50	58	53	45	106	G. St	SW	2	ESE. ½ E	·6	L. B. T.
3452	Aug. 29	11:41 a. m.	48 24 40	124 29 10	57	53	44·5	125	Rky. bk. G	NW	1	E. by S	1	L. B. T.
3453	...do	4:46 p. m.	48 20 00	124 13 40	61	57	44·4	120	gy. S. bk. Sp	WNW	2	ENE	1·6	L. B. T.
3454	Sept. 1	9:30 a. m.	48 27 50	124 42 40	58	54	44·2	152	gy. S. Rky	NNE	1	NW. by N	·3	L. B. T.
3455	...do	10:38 a. m.	48 28 40	124 43 50	59	54	44·3	152	gy. S. Rky	ENE	2	N. by W	·5	L. B. T.
3456	...do	12:00 m.	48 31 15	124 43 15	59	55	44·2	136	gy. S	ENE	2	NNW	1	L. B. T.
3457	...do	3:30 p. m.	48 28 20	124 52 05	63	54	44·2	142	gy. S	NNE	2	S. by W	·7	L. B. T.
3458	Sept. 2	7:30 a. m.	48 21 50	124 24 00	57	51	......	115	dk. S. St	NE	3	West	·3	L. B. T.
3459	...do	9:30 a. m.	48 24 20	124 24 40	59	53	44·5	123	gy. S. P	NE	2	N. by E	·5	L. B. T.
3460	...do	12:00 m.	48 25 05	124 10 00	59	53	46·8	53	gy. S	East	4	NE. by E	2	L. B. T.
3461	...do	3:30 p. m.	48 17 20	124 07 25	60	54	44·4	114	gy. S G. Rks	Calm	0	East	1·5	L. B. T.
3462	Sept. 3	12:38 p. m.	48 15 00	123 35 50	59	53	44·8	92	dk. S. Rky	West	1	NE	·5	L. B. T.
3463	Sept. 4	9:50 a. m.	48 09 30	123 23 30	56	52	47·8	45	gy. S	South	1	NW	·5	L. B. T.
3464	...do	11:00 a. m.	48 14 00	123 20 40	61	55	47·8	40	gy. S. P	SW	1	NW	·3	L. B. T.
3465	...do	1:56 p. m.	48 21 00	123 14 00	59	55	49·9	48	Rky	Calm	0	NNE	·3	L. B. T.
3466	...do	3:53 p. m.	48 18 30	123 22 00	58	53	48·5	56	gy. S. Sh. Rky	SSW	2	South	·5	L. B. T.
3467	Dec. 3	1:58 p. m.	21 13 00	157 43 37	75	76	......	310	fne. wh. S. bk. Sp	NNW	1	E. by S	2	S. B. T.
3468	...do	4:22 p. m.	21 15 36	157 41 10	75	76	......	17	S. Co	NE	2	NE. ½ E	·7	Tangles.
3469	...do	5:15 p. m.	21 14 51	157 43 30	76	76	......	14	S. Co	ENE	2·3	NE. ½ E	·4	Tangles.
3470	Dec. 4	1:50 p. m.	21 08 30	157 49 00	77	76	43·3	343	Wh. S	East	3	NE	·8	L. B. T.
3471	...do	3:29 p. m.	21 10 30	157 48 30	77	76	......	337	fne. Wh. S	ENE	3	NW. by N	2	L. B. T.
3472	...do	4:59 p. m.	21 12 00	157 49 00	77	78	......	295	fne. Wh. S	ENE	2·3	NNW. by W	1·5	L. B. T.
3473	Dec. 6	6:04 a. m.	21 15 00	157 30 00	75	76	43·8	313	fne. gy. S	NE	4	S. by E. ½ E	·5	L. B. T.
3474	...do	8:18 a. m.	21 12 00	157 38 30	70	77	......	375	fne. Wh. S	NE	4	S. by W	2	L. B. T.
3475	...do	10:35 a. m.	21 08 00	157 43 00	77	76	......	351	fne. Wh. S	NE	4	W. by N	1·8	L. B. T.
3476	...do	1:04 p. m.	21 09 00	157 53 00	77	76	......	298	fne. Wh. S	North	2·3	W. ⅛ N	1·8	L. B. T.

Record of tow-net stations of the U. S. Fish Commission steamer Albatross from July 1, 1891, to June 30, 1892.

[Serial numbers indicate cable survey numbers of stations, where Tanner submarine and surface tow nets were used.]

Serial No.	Date.	Time.	Position.		Temperatures.			Depth at which used.	Condition of sea.	Wind.		Drift.		Appearance of sky.	Remarks.
			Latitude N.	Longitude W.	Air.	Surface.	Bottom.			Direction.	Force.	Direction.	Distance.		
	1891.		° ′ ″	° ′ ″	°F.	°F.	°F.						Miles.		
45	Oct. 13	11:26 a. m.	35 41 50	126 22 20	61	62	34·9	Surface.	Moderate.	WNW ...	2	SW. ½ S.....	·5	Cloudy ...	Surface tow net.
54	Oct. 14	3:33 p. m.	35 03 30	129 05 00	67	66	35	...do	Smooth...	West	1	SW. ¼ S.....	·5	Clear	Do.
64	Oct. 15	7:12 p. m.	33 54 30	131 45 00	66	65	35	...do	...do	West	3	SW. ⅞ S.....	·5	...do	Do.
69	Oct. 16	8:50 a. m.	33 24 00	133 61 00	67	67	35·5	...do	...do	Calm	0	SW. ⅞ S.....	·5	Showery..	Do.
74	...do	6:55 p. m.	30 04 30	133 56 30	67	67	......	...do	...do	SSE	2	SW. by S	·5	Clear	Do.
129	Nov. 8	11.49 a. m.	32 43 40	134 42 30	68	68	35·1	...do	...do	ENE	2	SSW. ⅞ W ..	·5	...do	Do.
130	...do	2:50 p. m.	32 41 00	134 49 30	68	68	......	...do	...do	ENE	2	SSW. ⅝ W ..	·5	...do	Do.
133	...do	7:25 p. m.	32 35 00	135 03 00	69	68	......	...do	...do	East......	2	SSW. ⅝ W ..	·5	...do	Do.
144	Nov. 9	8:43 p. m.	31 50 00	136 54 30	65	67	......	...do	...do	East......	2	SW. by S	·5	Cloudy ...	Do.
149	Nov. 10	8:47 a. m.	31 27 00	137 47 00	67	68	35·1	...do	...do	ESE	2	SW. by S	·5	...do	Do.
150	...do	11:04 a. m.	31 23 00	137 58 00	66	67	......	...do	...do	ESE	1	SW. by S	·5	Clear	Do.
152	...do	3:16 p. m.	31 14 30	138 19 00	70	69	......	330 fath .	...do	East......	2	SW. by S	·5	...do	Tanner submarine net.
153	...do	6:09 p. m.	31 10 00	138 29 30	70	70	35	Surface .	...do	East......	2	SW. by S	·5	...do	Surface tow net.
154	...do	7:42 p. m.	31 05 00	138 40 00	68	70	......	...do	...do	East......	2	SW. by S	·5	...do	Do.
163	Nov. 11	1:10 p. m.	30 31 30	140 05 30	71	69	......	330 fath .	...do	East......	2	SW. by S	·5	...do	Tanner submarine net.
165	...do	6:00 p. m.	30 23 00	140 26 30	69	69	......	Surface .	...do	East......	2	SW. by S	·5	...do	Surface tow net.
174	Nov. 12	2:43 p. m.	29 38 00	142 17 00	72	70	......	330 fath .	...do	SE	1	SW. by S	·5	...do	Tanner submarine net.
185	Nov. 13	3:34 p. m.	28 52 00	144 00 00	72	72	35·3	Surface .	...do	SE........	2	SSW. ¾ W ..	·5	Cloudy ...	Surface tow net.
192	Nov. 14	9:42 a. m.	28 20 00	145 03 30	72	72	......	...do	...do	SE........	2	SSW. ¾ W ..	·5	Clear	Do.
195	...do	6:00 p. m.	28 00 30	145 35 00	73	73	......	...do	...do	SE........	1	SSW. ¾ W ..	·5	...do	Do.
196	...do	7:29 p. m.	27 54 00	145 45 30	72	72	35·2	...do	...do	ESE	1	SSW. ¾ W ..	·5	...do	Do.
204	Nov. 15	2:13 p. m.	27 06 00	147 14 00	75	74	......	100 fath .	...do	ESE	1	SSW. ¾ W ..	·5	Cloudy ...	Tanner submarine net.
257	Nov. 20	2:45 p. m.	22 11 00	156 09 00	77	77	35·4	Surface .	...do	NNW	2	SSW. ⅝ W ..	·5	Clear	Surface tow net.
259	...do	7:26 p. m.	21 55 30	156 29 30	78	77	......	...do	...do	West	1	SSW. ⅝ W ..	·5	...do	Do.
286	Dec. 2	5:00 p. m.	21 15 49	157 44 27	76	75	......	...do	...do	NE	1·2	WNW	·5	...do	Do.
452	Dec. 24	4:00 p. m.	29 52 30	138 24 00	63	67	......	...do	...do	ENE	3	NE. by E. ⅜ E	·5	Cloudy ...	Do.
	1892.														
540	Jan. 14	1:58 p. m.	35 19 30	125 21 30	62	58	35·1	300 fath .	...do	North	2	NE. ¾ E.....	·5	Clear	Tanner subm. net.
541	...do	5:17 p. m.	35 25 30	125 09 30	59	57	......	Surface and 300 fath.	...do	NNE	1	NE. ¾ E.....	·5	...do	Tanner submarine net and surface tow net.
542	...do	7:19 p. m.	35 31 00	124 57 30	57	56	......	Surface .	...do	NNE	2	NE. ¾ E.....	·5	Moonlight.	Surface tow net.
543	...do	9:28 p. m.	35 36 30	124 45 30	56	56	......	...do	...do	NNN	2	NE. ¾ E.....	·5	...do	Do.

Record of ocean temperatures and specific gravities by the U. S. Fish Commission steamer Albatross, July 1, 1891, to June 30, 1892.

[Each specimen was taken at about 1 foot below the surface. For observations which have been reduced to 60° F., indicating densities referred to pure water at 60° F., the constant 0·82 has been subtracted from the result in order to convert the latter into absolute densities at 15° C.]

Date.	Time of day.	Station.	Lat. N.	Long. W.	Depth.	Temperature by attached thermometer.	Temperature of the air.	Temp. of specimen at time specific gravity was taken.	Specific gravity observed.	Specific gravity reduced to 15° C., with pure water at 4° C. as standard
1891.			° ′ ″	° ′ ″	*Fms.*	°	°	°		
July 16	8 p. m.	Point Reyes, Cal			Surface	57	55	64	1·0234	1·023128
16	12 p. m.		38 07 00	123 55 00	...do	53	53	64	1·0240	1·023728
17	6 a. m.		38 15 00	124 35 00	...do	50	53	64	1·0250	1·024728
17	12 m		38 36 30	125 00 00	...do	56	57	64	1·0250	1·024728
17	6 p. m.		39 01 00	126 03 00	...do	58	59	64	1·0248	1·024528
17	12 p. m.		39 25 30	126 59 00	...do	59	60	64	1·0246	1·024328
18	6 a. m.		39 50 00	128 04 00	...do	60	61	64	1·0246	1·024328
18	12 m		40 15 00	129 00 00	...do	62	62	64	1·0246	1·024328
18	6 p. m.		40 46 30	130 10 00	...do	61	62	64	1·0246	1·024328
18	12 p. m.		41 28 00	131 30 00	...do	61	62	64	1·0246	1·024328
19	6 a. m.		41 59 00	132 50 00	...do	61	62	64	1·0245	1·024228
19	12 m		42 21 00	133 40 00	...do	63	63	64	1·0245	1·024228
19	6 p. m.		42 55 00	134 47 00	...do	60	60	64	1·0246	1·024328
19	12 p. m.		43 28 00	135 52 00	...do	58	59	64	1·0248	1·024528
20	6 a. m.		44 01 00	137 03 00	...do	57	61	64	1·0246	1·024328
20	12 m		44 36 00	138 08 30	...do	58	60	64	1·0246	1·024328
20	6 p. m.		45 08 00	139 20 00	...do	59	56	64	1·0246	1·024328
20	12 p. m.		45 40 00	140 28 00	...do	51	54	64	1·0256	1·024328
21	6 a. m.		46 12 00	141 49 00	...do	55	54	64	1·0246	1·024328
21	12 m		46 43 00	142 55 00	...do	55	55	64	1·0245	1·024228
21	6 p. m.		47 14 00	144 09 00	...do	54	55	64	1·0244	1·024128
21	12 p. m.		47 45 00	145 26 00	...do	53	57	64	1·0244	1·024128
22	6 a. m.		48 16 00	146 34 00	...do	52	51	64	1·0243	1·024028
22	12 m		48 47 00	147 51 00	...do	53	57	64	1·0242	1·023928
22	6 p. m.		49 13 00	149 12 00	...do	53	52	64	1·0243	1·024048
22	12 p. m.		49 38 00	150 30 00	...do	51	51	64	1·0243	1·024048
23	6 a. m.		50 05 00	151 57 00	...do	51	51	64	1·0243	1·024048
23	12 p. m.		50 30 00	153 17 00	...do	50	50	64	1.0242	1·023928
23	6 p. m.		51 00 00	154 46 00	...do	51	50	64	1·0242	1·023928
23	12 p. m.		51 31 00	156 12 00	...do	50	50	69	1·0238	1·024267
24	6 a. m.		52 01 00	157 42 00	...do	50	51	69	1·0238	1·024267
24	12 m		52 30 00	159 13 00	...do	51	54	69	1·0236	1·024067
24	6 p. m.		52 52 00	160 51 00	...do	51	51	69	1·0236	1·024067
24	12 p. m.		53 14 00	162 30 00	...do	50	50	69	1·0236	1·024067
25	6 a. m.		53 36 00	164 07 00	...do	49	49	69	1·0236	1·024067
25	12 m		53 58 00	165 48 00	...do	45	52	69	1·0236	1·024067
26	12 m	Unalaska, Alaska			...do	53	55	69	1·0232	1·023667
27	12 m		54 31 00	167 09 00	...do	50	50	69	1·0236	1·024067
27	6 p. m.		55 32 00	167 46 00	...do	50	51	69	1·0236	1·024067
27	12 p. m.		56 34 00	168 23 00	...do	49	50	69	1·0238	1·024267
28	6 a. m.		57 33 00	169 01 00	...do	48	49	69	1·0234	1·023867
28	12 m	St. George Island			...do	48	48	69	1·0234	1·023867
Aug. 1	12 m	St. Paul Island			...do	45	47	69	1·0232	1·023667
9	12 m		56 53 40	170 01 30	...do	46	48	69	1·0234	1·023867
10	12 m		56 26 00	169 22 00	...do	47	51	69	1·0234	1·023867
11	1 p. m.	Bogoslof Volcano			...do	48	56	69	1·0234	1·023867
13	6 p. m.	Off Unimak Pass			...do	48	53	69	1·0232	1·023667
13	12 p. m.		54 03 00	163 40 00	...do	50	50	69	1·0232	1·023667
14	6 a. m		53 45 00	162 20 00	...do	50	52	69	1·0232	1·023667
14	12 m		53 27 00	161 09 00	...do	54	56	69	1·0234	1·023867
14	6 p. m.		53 12 00	159 43 00	...do	54	55	69	1·0234	1·023867
14	12 p. m.		53 05 00	158 17 00	...do	52	54	69	1·0234	1·023867
15	6 a. m		52 56 00	156 51 00	...do	53	54	69	1·0234	1·023867
15	12 m		52 49 00	155 24 00	...do	53	59	69	1·0236	1·024067
15	6 p. m.		52 44 00	153 59 00	...do	54	56	69	1·0236	1·024067
15	12 p. m.		52 38 00	152 34 00	...do	55	57	66	1·0244	1·024420
16	6 a. m		52 35 00	151 10 00	...do	55	56	66	1·0244	1·024420
16	12 m		52 27 00	149 45 00	...do	52	57	66	1·0242	1·024220
16	6 p. m.		52 21 00	148 13 00	...do	55	57	66	1·0242	1·024220
16	12 p. m.		52 16 00	146 41 00	...do	56	57	66	1·0242	1·024220
17	6 a. m		52 09 00	145 09 00	...do	56	57	66	1·0242	1·024220
17	12 m		52 04 00	143 38 00	...do	58	50	66	1·0240	1·024020
17	6 p. m.		51 56 00	142 08 00	...do	57	59	66	1·0240	1·024020

Record of ocean temperatures and specific gravities by the U. S. Fish Commission steamer Albatross, July 1, 1891, to June 30, 1892—Continued.

Date.	Time of day.	Station.	Lat. N.	Long. W.	Depth.	Temperature by attached thermometer.	Temperature of the air.	Temp. of specimen at time specific gravity was taken.	Specific gravity observed.	Specific gravity reduced to 15° C., with pure water at 4° C. as standard.
1891.			° ′ ″	° ′ ″	*Fms.*	°	°	°		
Aug. 17	12 p. m.		51 49 00	140 38 00	Surface	56	58	66	1·0240	1·024020
18	6 a. m.		51 41 00	139 10 00	...do	57	56	66	1·0240	1·024020
18	12 m.		51 33 00	137 37 00	...do	59	61	66	1·0240	1·024020
18	6 p. m.		51 29 00	136 05 00	...do	59	60	66	1·0242	1·024220
18	12 p. m.		51 26 00	134 33 00	...do	57	59	66	1·0242	1·024220
19	6 a. m.		51 22 00	133 01 00	...do	59	58	66	1·0240	1·024020
19	12 m.		51 17 00	131 30 00	...do	60	64	66	1·0236	1·023620
19	6 p. m.		51 05 00	130 11 00	...do	60	69	66	1·0230	1·023020
19	12 p. m.		50 52 00	128 52 00	...do	58	59	66	1·0226	1·022620
20	6 a. m.		50 43 00	127 33 00	...do	55	57	66	1·0216	1·021620
20	12 m.		50 29 45	126 28 45	...do	61	58	66	1·0224	1·022420
24	12 m.	Tacoma, Wash			...do	62	67	66	1·0154	1·015420
25	8 a. m.	Seattle, Wash			...do	58	63	66	1·0196	1·021620
28	8 a. m.	Neah Bay, Washington			...do	53	60	66	1·0234	1·023420
29	12 m.		48 24 40	124 29 10	...do	54	59	66	1·0228	1·022820
Sept. 1	5 p. m.	Cape Flattery			...do	54	59	66	1·0230	1·023020
2	8 p. m.	Pillar Point			...do	50	58	66	1·0232	1·023220
4	9 a. m.	Port Angeles			...do	53	60	66	1·0232	1·023220
6	12 m.	Esquimalt Harbor			...do	57	60	66	1·0230	1·023020
9	2 p. m.	Active Pass			...do	54	56	66	1·0188	1·018820
9	8 p. m.	Departure Bay			...do	55	57	66	1·0198	1·019820
11	8 a. m.	Port Townsend			...do	54	55	69	1·0224	1·022867
11	12 p. m.		47 32 00	125 05 00	...do	57	57	69	1·0228	1·023267
12	6 a. m.		46 41 00	125 11 00	...do	59	58	69	1·0232	1·023667
12	12 m.		45 45 00	125 09 00	...do	61	61	69	1·0232	1·023667
12	6 p. m.		44 52 00	125 03 00	...do	62	60	69	1·0230	1·023467
12	12 p. m.		43 46 00	124 57 00	...do	56	57	69	1·0232	1·023667
13	6 a. m.		42 58 00	124 52 00	...do	56	57	69	1·0234	1·023867
13	12 m.		42 11 00	124 43 00	...do	55	57	69	1·0236	1·024067
13	6 p. m.		41 17 00	124 24 00	...do	58	61	69	1·0236	1·024067
13	12 p. m.		40 23 00	124 05 00	...do	59	59	69	1·0240	1·024467
14	6 a. m.		39 29 00	123 46 00	...do	55	56	69	1·0240	1·024467
14	12 m.		38 25 00	123 26 00	...do	54	56	69	1·0242	1·024667
14	7 p. m.	San Francisco Bar			...do	55	58	69	1·0240	1·024467
Oct. 11	10 a. m.	Salinas Landing			...do	55	52	70	1·0242	1·024830
11	12 m.		36 46 50	121 53 00	...do	56	54	70	1·0244	1·025030
11	6 p. m.		36 42 30	122 22 00	...do	55	54	70	1·0244	1·025030
11	12 p. m.		36 35 00	123 06 00	...do	55	55	70	1·0244	1·025030
12	6 a. m.		36 30 30	123 32 00	...do	54	55	70	1·0242	1·024830
12	12 m.		36 25 30	124 02 30	...do	56	58	70	1·0240	1·024630
12	6 p. m.		36 14 30	124 37 30	...do	56	59	70	1·0240	1·024630
12	12 p. m.		36 03 00	125 13 00	...do	57	57	70	1·0240	1·024630
13	6 a. m.		35 52 30	125 48 00	...do	59	59	70	1·0240	1·024630
13	12 m.		35 41 50	126 22 00	...do	62	61	70	1·0240	1·024630
13	6 p. m.		35 33 00	126 59 30	...do	63	62	70	1·0240	1·024630
13	12 p. m.		35 25 00	127 36 00	...do	62	61	70	1·0240	1·024630
14	6 a. m.		35 15 30	128 12 00	...do	64	63	70	1·0242	1·024830
14	12 m.		35 06 45	128 48 45	...do	65	65	70	1·0242	1·024830
14	6 p. m.		34 56 30	129 20 00	...do	65	66	70	1·0242	1·024830
14	12 p. m.		34 42 00	129 52 30	...do	65	64	70	1·0242	1·024830
15	6 a. m.		34 28 00	130 24 00	...do	65	65	70	1·0240	1·024630
15	12 m.		34 12 50	130 59 00	...do	66	66	70	1·0240	1·024630
15	6 p. m.		33 54 30	131 45 00	...do	66	67	70	1·0240	1·024630
15	12 p. m.		33 41 30	132 17 00	...do	66	66	70	1·0242	1·024830
16	6 a. m.		33 28 30	132 50 00	...do	67	65	70	1·0242	1·024830
16	12 m.		34 18 00	133 15 35	...do	67	67	70	1·0244	1·025030
16	6 p. m.		33 04 30	133 56 30	...do	69	67	70	1·0244	1·025030
16	12 p. m.		32 57 30	134 18 30	...do	68	67	70	1·0244	1·025030
17	6 a. m.		32 46 30	134 51 30	...do	68	68	70	1·0244	1·025030
17	12 m.		32 41 30	135 06 50	...do	68	69	70	1·0244	1·025030
17	6 p. m.		32 31 00	135 33 00	...do	68	69	70	1·0244	1·025030
17	12 p. m.		32 18 00	136 04 30	...do	69	69	70	1·0246	1·025230
18	6 a. m.		32 10 00	136 26 00	...do	69	69	70	1·0248	1·025430
18	12 m.		31 58 00	136 56 00	...do	69	65	70	1·0248	1·025430
18	6 p. m.		31 52 30	137 09 00	...do	69	65	70	1·0248	1·025430
18	10 p. m.		31 43 00	137 30 30	...do	68	64	70	1·0248	1·025430
Nov. 8	12 m.		32 43 40	134 42 50	...do	68	68	76	1·0240	1·025622

Record of ocean temperatures and specific gravities by the U. S. Fish Commission steamer Albatross, July 1, 1891, to June 30, 1892—Continued.

Date.	Time of day.	Station.	Lat. N.	Long. W.	Depth.	Temperature by attached thermometer.	Temperature of the air.	Temp. of specimen at time specific gravity was taken.	Specific gravity observed.	Specific gravity reduced to 15° C., with pure water at 4° C. as standard.
1891.			° ′ ″	° ′ ″	*Fms.*	°	°	°		
Nov. 8	6 p. m		32 37 30	134 57 00	Surface	68	69	76	1·0240	1·025622
8	12 p. m		32 30 30	135 15 00	...do	67	64	76	1·0240	1·025622
9	6 a. m		32 17 00	135 49 00	...do	67	65	76	1·0240	1·025622
9	12 p. m		32 07 30	136 13 20	...do	68	68	76	1·0240	1·025622
9	6 p. m		31 54 30	136 44 00	...do	69	67	76	1·0242	1·025822
9	12 p. m		31 45 30	137 05 00	...do	67	66	76	1·0242	1·025822
10	6 a. m		31 31 30	137 36 30	...do	68	67	76	1·0242	1·025822
10	12 m		31 22 20	137 59 30	...do	68	68	76	1·0242	1·025822
10	6 p. m		31 10 00	138 29 30	...do	70	68	76	1·0244	1·026022
10	12 p. m		30 57 30	139 00 30	...do	69	68	76	1·0244	1·026022
11	6 a. m		30 48 00	139 23 00	...do	69	67	76	1·0244	1·026022
11	12 m		30 35 30	139 36 45	...do	69	70	76	1.0244	1·026022
11	6 p. m		30 23 00	140 26 30	...do	69	69	76	1·0244	1·026022
11	12 p. m		30 13 00	140 50 30	...do	69	67	76	1·0244	1·026022
12	6 a. m		29 58 30	141 27 30	...do	68	68	76	1·0244	1·026022
12	12 m		29 44 30	142 02 00	...do	70	72	76	1·0244	1·026022
12	6 p. m		29 31 30	142 32 00	...do	70	70	76	1·0244	1·026022
13	6 a. m		29 15 00	143 09 30	...do	70	70	76	1·0246	1·026222
13	12 m		29 03 00	143 37 50	...do	72	73	76	1·0246	1·026222
13	6 p. m		28 46 00	144 12 00	...do	71	72	76	1·0246	1·026222
13	12 p. m		28 33 30	144 37 00	...do	71	70	76	1·0246	1·026222
14	6 a. m		28 20 00	145 03 00	...do	71	69	76	1·0246	1·026222
14	12 m		28 12 20	145 13 07	...do	72	72	76	1·0246	1·026222
14	6 p. m		28 00 30	145 35 00	...do	73	73	76	1·0246	1·026222
14	12 p. m		27 42 00	146 07 30	...do	72	72	76	1·0244	1·026022
15	6 a. m		27 30 00	146 30 00	...do	73	72	76	1·0244	1·026022
15	12 m		27 12 00	127 03 42	...do	74	75	76	1·0240	1·025622
15	6 p. m		27 00 00	147 25 30	...do	74	72	76	1·0242	1·025822
15	12 p. m		26 42 00	147 59 00	...do	74	71	76	1·0242	1·025822
16	6 a. m		26 29 00	148 21 30	...do	74	72	76	1·0242	1·035822
16	12 m		26 10 15	148 56 10	...do	75	73	76	1·0242	1·025822
16	6 p. m		25 58 00	149 18 30	...do	75	74	80	1·0242	1·026540
16	12 p. m		25 39 30	149 53 00	...do	74	74	80	1·0242	1·026540
17	6 a. m		25 26 30	150 16 30	...do	74	73	80	1·0240	1·026340
17	12 m		25 10 08	150 46 36	...do	75	75	80	1·0240	1·026340
17	6 p. m		24 56 00	151 13 00	...do	75	75	80	1·0240	1·026340
17	12 p. m		24 43 30	151 36 00	...do	75	74	80	1·0240	1·026340
18	6 a. m		24 31 00	151 57 30	...do	76	76	80	1·0240	1·026340
18	12 m		24 11 26	152 35 05	...do	76	76	80	1·0240	1·026340
18	7 p. m		23 55 00	153 08 30	...do	76	76	80	1·0240	1·026340
18	12 p. m		23 43 00	153 31 30	...do	73	75	80	1·0238	1·026140
19	7 a. m		23 26 00	154 06 00	...do	76	75	80	1·0238	1·026140
19	12 m		23 13 22	154 31 33	...do	76	76	80	1·0240	1·026340
19	6 p. m		23 05 00	154 42 30	...do	77	77	80	1·0238	1·026140
19	12 p. m		22 49 30	155 09 00	...do	76	76	80	1·0238	1·026140
20	6 a. m		22 36 30	155 30 30	...do	75	75	80	1·0238	1·026140
20	12 m		22 18 07	155 59 50	...do	77	77	80	1·0236	1·025940
20	6 p. m		22 03 30	156 19 00	...do	77	78	80	1·0236	1·025940
20	12 p. m		21 39 00	156 48 30	...do	77	76	80	1·0238	1·026140
21	6 a. m		21 21 00	157 09 00	...do	77	76	80	1·0236	1·025940
21	1 p. m	Honolulu, H. I			...do	78	78	80	1·0236	1·025940
Dec. 3	12 m	Monoloa Bay, H. I			...do	76	76	71	1·0250	1·025786
4	8 a. m	Wiekiki, H. I			...do	76	76	71	1·0250	1·025786
12	12 m		21 26 17	157 08 30	...do	74	71	71	1·0250	1·025786
12	6 p. m		21 36 30	156 44 00	...do	74	70	71	1·0252	1·025986
12	12 p. m		21 46 00	156 21 00	...do	73	70	71	1·0252	1·025986
13	6 a. m		21 56 00	155 57 30	...do	74	69	71	1·0250	1·025786
13	12 m		22 05 36	155 33 38	...do	74	71	71	1·0252	1·025986
13	7 p. m		22 20 00	155 01 00	...do	74	70	71	1·0252	1·025986
13	12 p. m		22 30 00	154 38 30	...do	75	71	71	1·0252	1·025986
14	6 a. m		22 40 00	154 16 00	...do	74	70	71	1·0252	1·025986
14	12 m		22 51 31	144 49 53	...do	74	73	71	1·0252	1·025986
14	6 p. m		23 06 00	153 20 30	...do	74	72	71	1·0252	1·025986
14	12 p. m		13 16 00	152 59 00	...do	74	72	71	1·0252	1·025986
15	6 a. m		23 27 00	152 37 00	...do	73	70	71	1·0254	1·026186
15	12 m		23 38 00	152 14 44	...do	74	72	71	1·0254	1·026186
15	6 p. m		23 49 00	151 55 00	...do	74	70	71	1·0252	1·025986

Record of ocean temperatures and specific gravities by the U. S. Fish Commission steamer Albatross, July 1, 1891, to June 30, 1892—Continued.

Date.	Time of day.	Station.	Lat. N.	Long. W.	Depth.	Temperature by attached thermometer.	Temperature of the air.	Temp. of specimen at time specific gravity was taken.	Specific gravity observed.	Specific gravity reduced to 15° C., with pure water at 4° C. as standard.
1891.			° ′ ″	° ′ ″	*Fms.*	°	°	°		
15	12 p. m	....	24 03 00	151 29 30	Surface	73	68	71	1·0252	1·025986
16	6 a. m	....	24 17 00	151 04 00	...do	73	70	71	1·0250	1·025786
16	12 m	....	24 27 56	150 44 17	...do	74	74	71	1·0250	1·025786
16	7 p. m	....	24 43 00	150 09 00	...do	72	71	71	1·0252	1·025986
17	1 a. m	....	24 55 00	149 41 00	...do	73	72	71	1·0252	1·025986
17	6 a. m	....	25 01 00	149 27 00	...do	73	71	71	1·0252	1·025986
17	12 m	....	25 13 44	148 58 03	...do	73	72	71	1·0252	1·025986
17	6 p. m	....	25 26 30	148 30 00	...do	73	69	71	1·0250	1·025786
17	12 p. m	....	25 39 30	148 01 30	...do	73	69	71	1·0250	1·025786
18	6 a. m	....	25 53 00	147 32 30	...do	72	70	71	1·0250	1·025786
18	12 m	....	26 06 30	147 03 00	...do	72	72	71	1·0250	1·525786
18	6 p. m	....	26 19 30	146 34 30	...do	72	71	71	1·0250	1·025786
18	12 p. m	....	26 32 30	146 05 30	...do	71	68	71	1·0252	1·025986
19	7 a. m	....	26 45 00	145 36 30	...do	72	68	71	1·0252	1·025986
19	12 m	....	26 47 20	145 30 00	...do	72	71	71	1·0252	1·025986
19	6 p. m	....	26 57 00	145 09 30	...do	72	69	71	1·0252	1·025986
19	12 p. m	....	27 06 30	145 17 30	...do	71	68	71	1·0252	1·025986
20	7 a. m	....	27 16 30	145 24 30	...do	70	68	71	1·0252	1·025986
20	12 m	....	27 20 30	144 12 54	...do	70	68	71	1·0252	1·025986
20	6 p. m	....	27 33 00	143 55 30	...do	70	67	71	1·0250	1·025786
20	12 p. m	....	27 42 30	143 41 30	...do	70	66	71	1·0250	1·025786
21	6 a. m	....	27 52 00	143 27 00	...do	70	67	71	1·0250	1·025786
21	12 m	....	28 03 42	143 10 05	...do	70	70	71	1·0250	1·025786
21	8 p. m	....	28 14 00	142 40 00	...do	69	65	71	1·0250	1·025786
22	1 a. m	....	28 20 00	142 22 30	...do	69	67	71	1·0252	1·025986
22	6 a. m	....	28 26 00	142 05 00	...do	69	67	71	1·0254	1·026186
22	12 m	....	28 31 55	141 45 01	...do	69	69	71	1·0254	1·026186
22	7 p. m	....	28 43 00	141 19 00	...do	69	68	71	1·0254	1·026186
22	12 p. m	....	28 48 30	141 04 30	...do	69	68	71	1·0254	1·026186
23	8 a. m	....	29 00 30	140 35 00	...do	68	66	71	1·0254	1·026186
23	12 m	....	29 06 24	140 20 21	...do	69	68	71	1·0254	1·026186
23	8 p. m	....	29 17 30	139 52 00	...do	68	65	71	1·0254	1·026186
24	1 a. m	....	29 23 00	139 38 00	...do	68	65	71	1·0254	1·026186
24	7 a. m	....	29 34 00	139 09 00	...do	68	63	71	1·0254	1·026186
24	12 m	....	29 44 08	138 45 07	...do	67	64	71	1·0256	1·026406
24	7 p. m	....	29 59 00	138 08 00	...do	67	63	67	1·0260	1·026167
24	12 p. m	....	30 12 00	137 36 30	...do	66	63	67	1·0260	1·026167
25	6 a. m	....	30 23 30	137 09 00	...do	66	61	67	1·0260	1·026167
25	12 m	....	30 30 00	137 04 30	...do	65	64	67	1·0260	1·026167
25	6 p. m	....	30 15 00	137 10 30	...do	66	63	67	1·0260	1·026167
25	12 p. m	....	30 30 00	136 49 00	...do	66	62	67	1·0260	1·026167
26	6 a. m	....	30 43 00	136 23 00	...do	66	62	67	1·0258	1·025967
26	12 m	....	30 54 45	135 56 35	...do	55	62	67	1·0258	1·025967
26	6 p. m	....	31 08 00	135 26 30	...do	66	63	67	1·0258	1·025967
26	12 p. m	....	31 20 00	134 57 00	...do	65	64	67	1·0258	1·025967
27	6 a. m	....	31 32 30	134 26 30	...do	65	63	67	1·0256	1·025767
27	12 m	....	31 45 14	133 56 00	...do	66	69	67	1·0256	1·025767
1892										
Jan. 10	12 m	....	31 49 23	133 45 32	...do	63	61	67	1·0252	1·025367
10	6 p. m	....	32 01 30	133 16 00	...do	62	60	67	1·0252	1·025367
10	12 p. m	....	32 14 00	132 46 00	...do	62	59	67	1·0250	1·025167
11	6 a. m	....	32 26 00	132 16 00	...do	62	59	67	1·0250	1·025167
11	12 m	....	32 31 24	132 01 43	...do	62	60	67	1·0250	1·025167
11	6 p. m	....	32 43 30	131 30 00	...do	62	58	67	1·0250	1·025167
11	12 p. m	....	32 55 00	131 00 00	...do	61	58	67	1·0246	1·024767
12	6 a. m	....	33 03 30	130 38 00	...do	60	58	67	1·0246	1·024767
12	12 m	....	33 14 46	130 07 06	...do	62	60	67	1·0246	1·024767
12	7 p. m	....	33 28 00	129 32 00	...do	61	58	67	1·0246	1·024767
12	12 p. m	....	33 38 00	129 05 30	...do	61	58	67	1·0246	1·024767
13	6 a. m	....	33 53 00	128 26 00	...do	59	56	67	1·0244	1·024567
13	12 m	....	34 08 10	127 46 21	...do	59	60	67	1·0244	1·024567
13	6 p. m	....	34 26 30	127 10 30	...do	58	58	67	1·0242	1·024367
13	12 p. m	....	34 44 30	126 34 00	...do	58	57	67	1·0242	1·024367
14	6 a. m	....	34 56 00	126 09 30	...do	58	57	67	1·0240	1·024167
14	12 m	....	35 14 07	125 33 18	...do	57	60	67	1·0240	1·024167
14	7 p. m	....	35 31 00	124 57 30	...do	56	57	63	1·0246	1·024191
14	12 p. m	....	35 42 00	124 33 30	...do	59	53	63	1·0246	1·024191

Record of ocean temperatures and specific gravities by the U. S. Fish Commission steamer Albatross, July 1, 1891 to June 30, 1892—Continued.

Date.	Time of day.	Station.	Lat. N.	Long. W.	Depth.	Temperature by attached thermometer.	Temperature of the air.	Temp. of specimen at time specific gravity was taken.	Specific gravity observed.	Specific gravity reduced to 15° C., with pure water at 4° C. as standard.
1892.			° ′ ″	° ′ ″	*Fms.*	°	°	°		
Jan. 15	6 a. m		35 58 30	123 57 30	Surface	54	54	63	1·0246	1·024191
15	12 m		36 17 42	123 17 30	...do	52	54	63	1·0246	1·024191
15	6 p. m		36 34 00	122 41 00	...do	52	53	63	1·0246	1·024191
Mar. 31	6 p. m	Cape Flattery			...do	45	44	64	1·0236	1·023328
Apr. 1	12 m		49 39 00	128 16 00	...do	47	43	64	1·0236	1·023328
2	12 m		51 59 00	132 07 30	...do	45	43	64	1·0238	1·013528
3	12 m		53 48 00	136 13 00	...do	43	41	64	1·0244	1·024128
4	12 m		55 17 00	141 00 00	...do	40	36	64	1·0244	1·024128
5	12 m		55 44 00	142 24 00	...do	39	35	64	1·0244	1·024128
6	12 m		57 00 00	144 42 00	...do	38	36	64	1·0244	1·024128
7	12 m		58 01 00	149 16 00	...do	39	37	64	1·0236	1·023328
8	4 p. m	Port Graham, Cook Inlet			...do	36	34	64	1·0234	1·023128
10	9 a. m	Soldovoi, Cook Inlet			...do	36	33	64	1·0236	1·023328
11	12 m	Coal Point, Cook Inlet			...do	37	37	64	1·0234	1·023128
14	2 p. m	St. Paul, Kadiak			...do	38	39	64	1·0240	1·023728
15	12 m		59 23 00	148 37 00	...do	41	43	64	1·0240	1·023728
16	12 m	Port Etches, Prince Wm. Sound			...do	39	41	64	1·0234	1·023128
18	12 m	Off Cape St. Elias			...do	40	40	64	1·0238	1·023528
19	12 m		59 14 00	141 35 00	...do	41	41	64	1·0238	1·023528
20	12 m		57 57 00	139 43 00	...do	40	40	64	1·0240	1·023728
21	12 m		56 15 00	137 47 00	...do	42	38	64	1·0240	1·023728
22	12 m		54 31 00	134 14 30	...do	44	41	64	1·0240	1·023728
23	12 m		52 07 30	133 59 30	...do	45	43	64	1·0240	1·023728
24	12 m		50 45 00	130 33 00	...do	46	48	64	1·0240	1·023728
25	12 m		49 58 00	128 42 00	...do	49	52	64	1·0238	1·023528
26	12 m		49 17 00	127 16 30	...do	49	50	64	1·0236	1·023328
May 11	3 p. m	Alert Bay, British Columbia			...do	48	58	61	1·0232	1·022510
12	12 m		51 32 00	130 48 00	...do	47	47	60	1·0242	1·023380
13	12 m		51 51 42	136 03 37	...do	49	48	60	1·0246	1·023780
14	12 m		51 46 00	142 23 30	...do	44	46	60	1·0250	1·024180
15	12 m		51 08 00	148 07 30	...do	42	41	60	1·0250	1·024180
16	12 m		51 24 00	152 36 30	...do	41	40	60	1·0250	1·024180
17	12 m		51 57 00	157 04 42	...do	42	42	60	1·0248	1·023980
18	12 m		52 59 00	162 34 30	...do	42	41	60	1·0244	1·023580
22	12 m		53 48 30	167 59 00	...do	42	45	60	1·0250	1·024180
23	12 m		52 24 30	172 45 00	...do	41	39	60	1·0252	1·024380
24	12 m	Atka Island			...do	41	41	60	1·0248	1·023980
25	12 m		52 02 38	174 11 00	...do	41	41	60	1·0248	1·023980
				East.						
27	12 m		51 09 00	179 40 00	...do	40	38	60	1·0248	1·023980
28	12 m		52 29 30	174 07 00	...do	41	41	60	1·0250	1·024180
29	12 m	Attu Island			...do	42	45	60	1·0246	1·023780
30	12 m		54 02 00	170 17 00	...do	40	42	60	1·0250	1·024180
June 2	12 m	Nikolski, Bering Island			...do	42	45	60	1·0244	1·023580
4	12 m	Off Copper Island			...do	38	38	60	1·0252	1·024380
5	12 m		55 03 30	170 15 00	...do	40	38	60	1·0250	1·024180
6	12 m		54 48 00	173 24 00	...do	40	41	60	1·0250	1·024180
7	12 m		54 38 00	177 06 20	...do	40	40	62	1·0246	1·024050
				West.						
7	12 m		54 45 00	178 03 38	...do	40	40	62	1·0246	1·024050
8	12 m		54 36 42	172 16 40	...do	42	42	62	1·0246	1·024050
15	12 m		53 52 00	163 26 00	...do	45	45	67	1·0242	1·024367
16	12 m		54 21 00	158 23 00	...do	47	45	67	1·0242	1·024367
17	12 m		54 37 00	154 00 00	...do	47	46	67	1·0242	1·024367
18	12 m		53 36 30	149 46 30	...do	46	46	67	1·0242	1·024367
19	12 m		53 37 60	143 30 00	...do	47	45	67	1·0240	1·024167
20	12 m		52 38 00	137 32 00	...do	50	50	67	1·0240	1·024167
21	12 m		51 21 00	132 26 30	...do	52	53	67	1·0238	1·023967
22	12 m		49 41 30	127 27 30	...do	54	55	67	1·0236	1·023767

INDEX TO INVESTIGATIONS OF THE ALBATROSS.

2.—THE MYXOSPORIDIA, OR PSOROSPERMS OF FISHES, AND THE EPIDEMICS PRODUCED BY THEM.

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TABLE OF CONTENTS.

INTRODUCTION.

Up to the present time very little attention has been paid to the diseases of fishes, and to their parasites from the standpoint of the effect produced by them upon the host. Yet there can be no doubt that a knowledge of such diseases would be of great practical value. Any one who considers the proportions that fish epidemics may attain will hardly be inclined to question the utility of searching investigation in this direction. Thus, to take a single instance, in the epidemic of 1884 in Lake Mendota, Prof. Forbes[1] states that:

> It was estimated that fully 300 tons had died up to that time. On August 7 the Madison Transcript reported that 200 tons had been hauled away by the city authorities during the four weeks preceding and that the fishes were still dying.

Epidemics of similar extent have been reported in Europe.

The important results in the way of prevention of epidemics among domesticated animals and cultivated plants obtained as the result of scientific investigation afford some ground for the hope that similar

[1] Bull. U. S. Fish Com. for 1888 (1890), VIII, p. 482.

results may be obtained here. Obviously the first step in work of this kind is the collection of facts, especially those bearing upon the parasite, its nature, life-history, intermediate hosts, enemies, and its connection (whether causal or otherwise) with diseases or other morbid processes in its host. Such data are a necessary preliminary to preventive or curative measures.

The present paper is a contribution toward the object indicated. A few words now as to its scope. The attempt has been made to compress the entire literature (as far as possible, every known fact) into one article. Further, every form [1] which has been at any time definitely referred to the group is here included. Such collection of forms necessarily involved the exercise of some judgment as to specific identities and distinctions. As most of the known species are available only in the form of descriptions, usually very meager, and of drawings which, especially the older ones, represent only the most general features,[2] it is hardly reasonable to hope that any first attempt at compilation of the synonymy will prove satisfactory in all respects. Still in many cases the synonymy is fairly well established.

The main guide in the correlation of the described forms has been identity of host and seat. Of course it is not contended that this proves, but merely that it more or less strongly suggests, identity of parasite. The confirmatory test is naturally a comparison of figures and descriptions. This latter test will of course be preferred to the test by identity of seat as soon as we shall be in the possession of sufficiently accurate and detailed descriptions and figures, but in the present state of our knowledge the mere absence of difference between more or less incomplete descriptions and figures of two forms with different habitats, produces no conviction in my mind of the identity of the forms. In general it is only where a double correlation (of host and seat on the one side, and of descriptions and drawings on the other) has been possible, that different forms have been united. In other words, the presumption throughout has been in favor of distinctness. From this fact it may be expected that future investigation will tend to reduce somewhat the number of forms here recognized.

The nomenclature has been compared and revised, and for all recognizable species binomial names have been substituted for the clumsy circumlocutions "psorosperms of the pike," etc., formerly in use. It may perhaps be thought that in my preliminary paper and in the present

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[1] Although it has been my aim to include in this paper descriptions and figures of all forms ever definitely referred to the *Myxosporidia*, the species noted on pp. 135–137 have been omitted.

[2] It must be further noted that hardly one of the older writers regarded these forms from a taxonomic standpoint. Their principal desire was to work out the life-history and affinities of the group rather than of the individual species; and they seem to have observed the latter mainly for the light they shed upon the life-history of the group as a whole, contenting themselves with designating the different forms as "psorosperms of the pike," etc.

one, too many specific names have been introduced. In answer might be pleaded the difficulty, in a first attempt of this kind, of judging exactly how many species to recognize, and it is not impossible that future experience may require the suppression of a few of the names proposed. Regarding this contingency, however, as one of the incidents of an initial revision, the author will view with considerable equanimity the relegation to synonymy of such names as may prove to be redundant. Finally, as regards this branch of the subject, it should be stated that the main indication seemed to be the building up from the literature of a series of synonymic units which could be later, if necessary, welded into a more compact specific synonymy. This indication has been fulfilled, nearly all the units here constructed consisting merely of an original description and copies of the same by subsequent authors.

The plates appended to this paper include every published figure of every myxosporidian species (species Nos. 27 to 102, inclusive); further, every published figure of every species formerly regarded as myxosporidian but now rejected or queried (species Nos. 1 to 26, inclusive), excepting only some figures of *Psorospermia sciænæ-umbræ*, the figures of the species referred to on pp. 135–137, and the figures of *Lithocystis schneideri* in Schneider's *Tablettes Zoologiques*, which work was not accessible.

In the course of my studies I have been perplexed by the usual number of quotations without any or with only cryptographic references. In the hope of obviating this in the future, intelligible references are given for all statements made and, it is believed, for all important facts.

A number of new terms are introduced in this paper, as it is considered very desirable to have the definiteness and specialization of terms keep pace with the increasing detail of knowledge. They are defined on pp. 120–122. An exceedingly instructive instance of the confusion resulting from the application of the same name to two entirely different structures is afforded by the history of the filaments (see pp. 87–88). If such non-discrimination were to continue far, we should have to construct an elaborate synonymy for every structure as well as for every species.

The lack of a uniform (often, indeed, of any) system of arrangement of data forms, unfortunately, a marked feature in many papers. With very few exceptions the scheme given below has been adhered to throughout this paper. It may not prove to be the best possible, but if it serve to secure the adoption of some regular order (what particular one matters, perhaps, not a great deal) it will have fulfilled its object. The principles underlying it are:

(*a*) Describe all structures, etc., in the order of their occurrence in the life cycle, beginning with the adult; the process of formation of a structure to precede the description of that structure.

(*b*) Describe structures in order of position from without inward.

(*c*) Describe important and constant structures before unimportant and inconstant ones.

(*d*) Describe structure before function.

The principal exception is the change of place of the cyst, which for convenience is placed before the myxosporidium. Properly (were arrangement an end rather than a means) it should follow the myxosporidium. But the cyst occupies quite a subordinate (almost, so to speak, an accidental) position in the life cycle, and it sheds little light upon any of the structures either of the adult or of the spore. Further, to place it between the myxosporidium and the spore would make an awkward break in the continuity of the life-history.

The following is the order adopted, based upon the principles given:

I. Synonymy:
  a. Recognized binomial name, authority, date.
  b. Synonymy prior to recognized name, in parenthesis.
  c. Reference to proposition of recognized name, followed by subsequent synonymy.

II. Cyst:
  a. Formation.
  b. Structure.
    (1) Macroscopic (form, size, color, etc.).
    (2) Microscopic (*a*) structure and origin of membrane and (*b*) contents.

III. Myxosporidium:
  a. General characters (form, size, color, etc.).
  b. Ectoplasm.
  c. Endoplasm:
    (1) General description.
    (2) Nuclei.
    (3) "Granules" and "globules."
    (4) Vacuoles.
    (5) Inclusions, notably pigment.
  d. Pseudopodia.
  e. Amœboid movements.

IV. Spore formation:
  a. Formation and segmentation of pansporoblast.
  b. Development of sporoblast into spore (in same order as description of spore, below).

V. Spore:
  a. General description (form, size, tailed or not, etc.).
  b. Shell:
    (1) Physico-optico-chemical characters.
    (2) Valves, position and separability.
  c. Tail.
  d. Capsules:
    (1) Number, position, etc.
    (2) Filaments.
  e. Sporoplasm:
    (1) Form.
    (2) Nuclei.
    (3) Vacuole.
    (4) "Granules" and "globules."

VI. Exit of sporoplasm, and completion of life cycle with earlier stages of development of myxosporidium.

VII. Habitat; seat, season, frequency.

VIII. Pathological anatomy:
  a. Morbid structures (in order of formation):
    (1) Cell infection.
    (2) Tumors.
    (3) Ulcers (later stage of tumors).

IX. Effects and symptoms.

X. Epidemics:
  a. Fishes affected; territory covered; extent of ravages.
  b. Causes.
    (1) Predisposing or contributory:
      (*a*) Age, etc.
      (*b*) Pollution of streams.
    (2) Exciting: Mode of infection.

Further, were it not for the abundant evidence to the contrary, furnished by the literature, it would seem superfluous to urge that every report should contain, at least, the following data:

Host.—The place and date of collection, the water-temperature, the scientific name[1] of the host, together with the age (or size) of the latter,

[1] Upon this last point too much stress can not be laid. The habit of recording the host merely by the popular name (often local, always more or less ambiguous, and not infrequently designating a whole genus) is greatly to be deprecated, as identification is rendered difficult or impossible, especially for students of other times and countries.

the name of the person collecting, and particularly that of the person identifying it.

Microscopic technique.—Especially the fixation process and the stains found most useful should be mentioned.

Parasite.—Besides the indications contained in the above outline for arrangement, the gaps in the Tabular Key (pp. 138–165) offer an inviting field for future work. One other point should receive most careful attention, viz, a close comparison of the (at present probably unduly multiplied) forms habitant upon the same host, and especially those in the same organ of the same host. In this way a few years will suffice to condense the present synonymy to its proper dimensions. It may be added that even the dimensions of the spores—the most accurate of all data—are sometimes omitted.

Effects and epidemics.—Above all, attention should be directed to gathering accurate data as to the extent, the species of fishes affected and those exempt, the territory invaded, the season, as far as possible the relative potency as causative factors of temperature, water pollution, etc. The effects of all remedies tried, whether successful or not, should of course be recorded.

Reduction of measurements.—The older authors recorded their measurements in thousandths of a line.[1] I have reduced these to μ's. Owing to the number of inches (also, consequently, of lines) in use in Germany, the original measurements are quoted in parenthesis. In 1853 Robin[2] reduced the German measurements to decimals of a millimeter. He assumed $1'''$ = 2.25 mm. Bütschli[3] adopts the same equivalent for the "*Linie*" ($'''$). Wherever my results differ from Robin's I have noted his figures in parenthesis along with the original measurements.

The following are the calculations and the resulting equivalents adopted:

One Prussian foot = 1·0298 English feet.
One Prussian inch = 1·0298 English inches.
One m. = 39·371 English inches = 38·2317 Prussian inches.
One mm. = 0·0382317 Prussian inches = 0·45878 Prussian lines.
Thus 1 "*Linie*" = 2·18 mm. nearly instead of 2·25 mm.

Fortunately the discrepancies are slight. All spore-measurements are in μ's; cyst measurements in decimals of a millimeter.

As regards the translations, I am responsible for all, with the exception of Kolesnikoff's article the translation of which was made by Mr. Israeli, of the Surgeon-General's Library. Dr. Robert Stein, of

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[1] In the only case where I could find a direct comparison between Müller's "*Linie*" and the millimeter, viz, Müller's translation of Gluge's $\frac{2}{500}$ of a mm. for *Glugea anomala* (Gluge, Bull. Acad. Roy. Belg., 1838, v, p. 774; Müller, Müller's Archiv., 1841, p. 491), as 0·0020$'''$, Müller regards the former as equal to 2 mm.

[2] Hist. Nat. des Végét. Parasites.

[3] See *Chloromyxum mucronatum* (p. 264).

the U. S. Geological Survey, has, however, helped me in a number of points connected with this branch of the subject.

I am indebted to many friends for assistance. In particular, I wish to acknowledge my deep indebtedness to Dr. C. W. Stiles, of the Department of Agriculture, for numerous judicious suggestions and for encouragement and aid in very many ways, especially in the study of the nuclei. M. Thélohan very generously placed at my disposal notes on the synonymy of several species. The synonymy of the piscine hosts has been revised by Dr. Theodore Gill. Finally, I desire to thank the officials connected with the Library of the Surgeon-General, U. S. Army, for numerous courtesies extended me in the course of a protracted examination of the valuable collections under their charge.

As far as possible, this paper has been brought up to January 1, 1894. Several subsequent papers have also been included (see pp. 128–129).

GENERAL DESCRIPTION OF THE SUBCLASS MYXOSPORIDIA.

I.—NOMENCLATURE AND DEFINITION.

SUBKINGDOM PROTOZOA.

Class SPOROZOA Leuckart, 1879 (emendated).

The following is Leuckart's definition[1] verbatim, with the exception of the proposition of the *Gregarinida* as the type order, a proposition that is implied by Leuckart's language. The words inclosed in brackets should, as shown by subsequent observations, be omitted from the class definition.

Unicellular parasites [of stable body-form], destitute [of pseudopodia and] of ciliæ, covered with a smooth, more or less solid cuticle. At the anterior end not seldom a proboscidiform attachment-apparatus. Movements on the whole little striking, worm-like or feebly amœboid. Mode of life always parasitic; nutrition by endosmosis. Reproduction by more or less hard-shelled spores (pseudonavicellæ; psorosperms) formed in the interior of the protoplasm in variable but very considerable numbers,[2] either progressively or simultaneously (in the latter case at the termination of growth and after encystment). Germinal portion of spore consisting of falciform protoplasmic rods (*Gregarinida; Coccidia*) or a single protoplasmic mass (*Myxosporidia*); type order *Gregarinida*.

Subclass MYXOSPORIDIA Bütschli, 1881.

Zoolog. Jahres-Ber. f. d. J. 1880, I, p. 162; *ib.*, Bütschli, 1881, Ztschr. f. wiss. Zool., XXXV, pp. 630, 650; *ib.*, Bütschli, 1882, Bronn's Thier-Reich, I, p. 590; *ib.* of all subsequent authors; *Myxosporidæ* (Psorospermidæ J. Müller)[3] Zürn, 1882, Die thierischen Parasiten, Weimar, p. 816; *Myxospora*[4] (error) Mégnin, 1885, Compt. Rend. hebdom. Soc. Biol. Paris, II, p. 447; subclass *Myxosporidia*, Lankester, 1885, Encycl. Britan., 9 ed., XIX, p. 855; "Psorospermidæ J. Müller,"[3] Koch, 1887, Encyklop. d. gesammt. Thierheilkde u. Thierzucht, IV, p. 94.

THE SUBCLASSIC DESIGNATION.

Müller, in 1841, denominated the forms observed by him merely as "Psorospermien." Everything points to the conclusion that this name was used merely indefinitely as a group designation. He neither proposed it as a generic name nor did he anywhere latinize it. He

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[1] Die Parasiten des Menschen, 1879, 2 ed., p. 241.

[2] Compare *Bisporogenesis* in index.

[3] An error; Müller did not propose any such family. Zürn's definition is quoted to show the errors (italics):

"Order 4. *Myxosporidæ* (*Psorospermidæ*, J. Müller). Frequent in and on fishes and Amphibia. The *nucleus-less*, often granulated protoplasm, is surrounded tube-like by a cuticle. From the young protoplasm of these tubes, single or double contoured, fusiform, oval, or round spores originate *without previous encystment.* In the spore originate one *or several* germs, mostly resembling a nucleus-less, but somewhat granulated plasma-globule, *or representing a needle-shaped (stabförmige) body.* The spore membrane *often provided with 1 or 2 filaments*) bursts in order to free the *only very rarely motile* germs."

[4] "Psorospermies des poissons ou *Myxospora* de Bütschli."

used it in the same sense in the paper published by him and Retzius in 1842, and was followed in this use by Creplin, also in 1842. In 1843 his article of 1841 was reprinted in French in Rayer's Archives. In this the German "Psorospermien" is rendered by the French "psorospermies," both of them the exact equivalent of the general indefinite English plural *psorosperms.* If anything is needed to complete the evidence it is found in the fact that not one of these observers proposed a single binomial name. So it is certain that the term was used by Müller and his immediate successors as a general group term and not as a generic designation. And it was so used in 1845 by Dujardin, and in 1851 by Leydig, neither of whom employed a generic name. Further, they did not use any specific (binomial) names, all of their species, like those of previous authors, being designated as "psorospermies du brochet," "Psorospermien der Hecht," or by a similar title.

The first author to apply the binomial nomenclature to the "psorosperms" was Charles Robin. In his *Histoire Naturelle des Végétaux Parasites* (1853) were collected descriptions and figures of nearly all of the previously described forms. Robin there defines the "psorosperms" as a tribe of Diatoms, as follows:

> Tribus Psorospermeæ Ch. R.
>
> Phycoma ex cellulis organicis compositum; cellulæ albæ, fuscæ, lutescentes vel achromaticæ. Generatio ignota. (Piscium parasiticæ.)
>
> I form this group to receive a certain number of species of parasitic forms described first by J. Müller, and since carefully studied by him, Retzius, and myself.

From the foregoing it will be seen that to the subclassic (ordinal or tribal) name was appended an exceptionally clear definition. In the group thus defined Robin placed a single genus, *Psorospermia* Robin, which must, therefore, stand as the type genus of the group. His generic definition was: "*Characteres tribus.*" Robin failed to designate any particular species as the generic type. He reproduced descriptions and figures of 10 forms made known by other authors, under the customary headings of "psorosperms of the pike," etc. In addition to this, however, he inserted a description and figures of a single species of his own, which was the only one provided with a binomial name, or in other words the only species (in the nomenclatural sense) present. It is plain, therefore, that this species (*P. sciænæ-umbræ* Robin) must stand as the generic type.[1]

Curiously enough, however, of all the species collected by Robin this is almost the only one which can not be regarded as a myxosporidian. That it can not be so regarded is evident from a careful examination of his definition and figures. Unfortunate as it is that the name *Psorospermia* must henceforth be restricted to organisms having

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[1] In order to place the matter beyond doubt, I now propose to limit the genus *Psorospermia* Robin, as above indicated, viz: to forms of the type of *P. sciænæ-umbræ* Robin, which species I propose as the generic type. I further propose *Psorospermia* as the type genus of Robin's tribe *Psorospermeæ.*

no affinity with the "psorosperms," it is none the less inevitable that, as between the generic definition and the type species, the generic name must follow the fate of the type species.

Robin's name *Psorospermia* can not, therefore, be employed as the subclassic designation of, and for the same reason it can not be used as a generic name in, the *Myxosporidia*.

In this connection it may be noted that the name *Psorospermium* has obtained currency in the *Sporozoa*. Apparently I have not found the original use of the name, and can only give the following references. The forms are nonmyxosporidian (see also p. 135).

Psorospermium, Paulicki, 1872, Mag. f. d. gesammt. Thierheilkde, Berlin, XXXVIII, p. 6; *ib.*, Rivolta, 1878, Giorn. Anat. Fisiol. e Patol., Pisa, X, p. 233.

THE SUBCLASSIC DEFINITION.[1]

Sporozoa, whose adult stage is characterized by the presence of numerous nuclei originating by division; further by the power of amœboid movement,[2] and by the mode of spore formation, which takes place in definite transparent areas (pansporoblasts), and which is progressive, not being confined to the last stage of the life cycle;[3] whose spores exhibit always 2 and sometimes 3 axes of symmetry and possess a shell resistant to chemical reagents, 1 or more capsules (each inclosing a coiled filament capable of extrusion), and a single mass of sporoplasm; type order *Phænocystes*.

II.—MORPHOLOGY.

GENERAL DESCRIPTION OF STRUCTURE.

Omitting discussion of controverted questions and of peculiarities correlated with generic differences, the life-history and morphology of the subclass may be briefly outlined as follows:

In all the *Myxosporidia* two distinct stages are recognizable, viz, the myxosporidium (growth-reproduction or adult stage) and the spore. In addition a cyst may be present (see p. 77).

1. *The myxosporidium.*—At the time of its exit from the spore the myxosporidium possesses nuclei and sometimes a vacuole. It now[4]

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[1] Original. The first definition of the group was given by Lankester, as follows: "Sporozoa, in which the euglena-phase is a large multinucleate amœba-like organism. The cysts are imperfectly known, but appear to be simple. Some attain a diameter of two lines. The spores are highly characteristic, having each a thick coat which is usually provided with a bifurcate process or may have thread capsules (like nematocysts) in its substance. The spores contain a single nucleus and are not known to produce falciform young, but in one case have been seen to liberate an amœbula. The further development is unknown. The *Myxosporidia* are parasitic beneath the epidermis of the gills and fins, and in the gall bladder and urinary bladder of fishes, both fresh-water and marine."

[2] Except possibly *Thelohania*, in which the myxosporidium is unknown.

[3] Noted by Bütschli (Bronn's Thier-Reich, 1882, I, p. 595) in *Myxobolus mülleri* and *Myxidium lieberkühnii*.

[4] *Fide* Pfeiffer; cf. Korotneff; see pp. 187, 288, pl. 9, fig. 1, and pl. 46, fig. 1*b*.

enters upon an intracellular existence, penetrating into the interior of the red blood and other cells of the host, where, protected by the cell membrane, it grows by feeding on the cell contents. Finally, its continued growth produces distension, and ultimately rupture of the cell-membrane, and the myxosporidium becomes free. It now moves about amœboidly, grows larger, the nuclei become more numerous through karyokinesis, and spore formation begins. This last process is not confined to the last stages of the life cycle, but begins early and is progressive.

At this period the myxosporidium exhibits the following structure:

In outline it is vermiform, sacculated, roundish or not infrequently entirely irregular (see pls. 29, 37–39, 43–45). It usually possesses the power of amœboid movement and generally exhibits a distinct separation of ectoplasm and endoplasm (see pl. 39, figs. 1, 2, and pl. 44, fig. 1).

The ectoplasm (see pl. 16, fig. 4; pl. 39, fig. 1; and pl. 44, fig. 3) is very transparent, quite or nearly destitute of granules, sometimes more or less radiate-striate, and is often prolonged into pseudopodia which only involve the endoplasm when of very large size. The pseudopodia sometimes form a shaggy or bristly coat over the whole, or a part of the myxosporidium (see pl. 44, fig. 1*a*).

The endoplasm (see pl. 37, fig. 4; pl. 38, fig. 1, and pl. 39, fig. 1) is more or less coarsely granular and contains numerous nuclei, fat-globules, hæmatoidin crystals (pl. 44, fig. 5) and other pigment. The nuclei are derived from the primitive nuclei of the myxosporidium (the nuclei of the sporoplasm; see below). The hæmatoidin crystals are usually found within the fat-globules. The myxosporidium may contain other extraneous pigment, e. g., bile-, and perhaps a proper, pigment (see pp. 76, 277).

Spore formation: Each nucleus attracts to it a portion of the surrounding myxoplasm to form a pale, solid globule termed the pansporoblast (pl. 12, fig. 1 *a–c*, and pl. 47, fig. 1 *a*, *b*) which later segments into a number of sporoblasts (pl. 12, fig. 1 *h*, *i*, and pl. 47, fig. 1 *c*, *d*), each of which develops into a spore.

2. *Spore.*—This always contains three elements, shell, capsule with filament, and sporoplasm. The shell (see pl. 16, fig. 3, and pl. 28, fig. 1) is exceedingly transparent, very resistant to chemical reagents, and is frequently bivalve. The capsule (pl. 26, fig. 7, *cap.*) is a pyriform, hollow, elastic-walled body which always contains a single coiled thread (*filament*) capable of extrusion. The sporoplasm (pl. 26, fig. 7, *spo.*) is always a single mass of protoplasm. It contains nuclei (*n*), and sometimes a vacuole (fig. 7, *vac.*), which when present is always single. At maturity the shell splits when bivalve, or dissolves when univalve, thus setting free the sporoplasm (pl. 15, fig. 7 *b*), which, now become the myxosporidium, rebegins the life cycle.

DETAILED DESCRIPTION OF INDIVIDUAL STRUCTURES.

"PSOROSPERMS" THE SPORES.

The older writers seem to have tacitly admitted that their "psorosperms" represented the spore stage. Thus Lieberkühn[1] says that certain animals fix themselves to the skin of fishes and in reproduction fall apart into the "psorosperms." Balbiani,[2] however, regarded the "psorosperms" as an adult cryptogam. This view he subsequently virtually abandoned.[3] All the later authors, without exception, have regarded the myxosporidium as the adult.

THE MYXOSPORIDIUM.

This was first observed by Dujardin in 1845 (see p. 273). It occurs free or attached. Size 2 mm. or, more usually, much less, without constant or characteristic body-form, being cylindrical, ribbon-, or club-shaped, or more or less globular or irregularly amœboid, consisting of colorless or more or less yellowish protoplasm (pigment usually extraneous, see p. 76); usually, probably always, showing a more or less (frequently quite) distinct differentiation into ectoplasm and endoplasm. In the cyst-forming *Myxosporidia* (e. g., the branchicolous forms) the differentiation is also, at least in the older myxosporidia, very sharp.

ECTOPLASM.

Forming a very transparent granule-free or exceedingly finely granular zone, from which all of the elements characteristic of the endoplasm are absent.

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[1] Müller's Archiv., 1854, p. 357.

[2] Compt. Rend. Acad. Sci. Paris, 1863, LVII, p. 159.

[3] Journ. de Microgr., 1883, VII, pp. 198, 201, 276.

[4] Pfeiffer regards the large myxosporidia as composed by the fusion of many small ones. He thus explains progressive spore formation:

"With the view here expressed that the smallest psorosperm-tubes of the barbel are simple myxosporidia ('sporoblasts') similar to those of *Eimeria* in the schematic table, and to those of the *Microsporidia;* further, that the large tubes are a conglomerate of many different individual parasites which have run together accidentally in Gregarine fashion, and that their cyst nature originates through cicatricial incapsuling by the host, some things apparently do not entirely agree. Why are the large tubes empty in the middle? Where have the contents gone? (They can not be a consumed residual mass.) How are to be explained the appearances simulating nuclear division on the capsule wall in figs. 9 and 14? Does this last-mentioned fact compel us to admit after all a progressive endogenous division and a successive infection? We have above answered this in the negative; they must admit of definite solution when more comparative investigations (e. g., upon batrachians and birds) shall be at hand."

Subsequently (see p. 227) he explains the emptiness of the central portion by a supposition of spore-migration towards the periphery in search of better nutritive conditions.

A similar pressure-fusion occurs in "*Myxosporidium*" *bryozoides* (p. 188).

ENDOPLASM.

Much more coarsely and more or less yellowish granular, containing numerous nuclei, fat-globules, and sometimes one or more vacuoles; also pigment.

Nuclei.—First observed by Prof. Bütschli[1] in *Myxidium lieberkühnii*, where their nuclear nature was shown both by their structure and by their affinity for carmine; always very numerous, the smallest occurring only in the youngest forms, strewn irregularly through the endoplasm. As in a number of species the nuclei have been observed to originate by division, there is every reason to suppose that such origin obtains throughout the subclass[2], and that the myxosporidium nuclei are to be referred back to the nuclei of the sporoplasm.

"*Granules*" *and* "*globules.*"—Many of the structures loosely termed "granules" and "globules" by the older authors are really nuclei, and this should be borne in mind in reading their descriptions, which have sometimes been reproduced without change (see also pp. 209, 220).

According to Bütschli (see page 285), these bodies are of a fatty nature, as shown by their complete solubility in alcohol. According to several other authors, the hæmatoidin crystals are found within globules whose fatty nature was presumed from the same reaction. Thélohan, however (see below), while admitting the solvent action of alcohol upon certain chromatophorous globules observed by him in *Chloromyxum leydigii* and in *Myxidium lieberkühnii*, denies their fatty nature, as osmic acid is without action upon them.

Fat-globules.—Feebly glittering; size variable; always present except in very young individuals; especially frequent in *Myxidium lieberkühnii*.

Vacuoles.—Sometimes one or more; number, position, and presence inconstant; apparently always nonpulsating.

Pigment.—Although it has heretofore seemed probable[3] that all pigment occurring in the *Myxosporidia* was of extraneous origin, it would appear now, from Thélohan's recent observations, as though perhaps the presence of proper pigment must be admitted. This observer says:[2]

> In many myxosporidia which live in the free state in the natural cavities one finds the endoplasm riddled with strongly colored globules whose tint varies from golden yellow to brown. Very numerous in *Myxidium*, they give to the internal face of the pike's bladder a characteristic yellow tint; they also exist in *Chloromyxum leydigii* (Mingaz.). As these elements do not resist the action of alcohol or that of the essential oils, one finds no trace of them in sections; they are not fatty, as osmic acid is without action upon them.

Chloromyxum fluviatile also contains similar structures.

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[1] Ztschr. f. wiss. Zool., 1881, XXXV, pp. 632–633; Bronn's Thier-Reich, 1882, I, pp. 594–595. Bütschli (1882) was the first to suggest the generality in the *Myxosporidia* of the multinucleate condition. Lankester (see p. 73, foot note 1) took the same view.

[2] This is also Thélohan's opinion (Bull. Soc. philomat. Paris, 1892, IV, p. 169).

[3] As Bütschli remarked in 1881 (Ztschr. f. wiss. Zool., XXXV, pp. 642, 649). Cf. also *Pigment* in index.

The extraneous pigment consists of hæmatoidin crystals, whose origin, mode of occurrence, etc., are discussed elsewhere (p. 285).

Pseudopodia.[1]—Usually blunt, simple or lobed ectoplasmic processes, involving the endoplasm only when very large. In *Myxidium lieberkühnii* subpermanent bristle-like pseudopodia have also been observed (see p. 285).

Amœboid movements.—These have been seen in a number of species.[2] They are slow or active; sometimes absent, owing to the deleterious effect of so-called "indifferent" fluids.

THE CYST.

Encystment.[3]—This—or at least the tissue-imbedding which is so termed (see below)—is the usual preliminary to reproduction in *Myxobolus.* Reproduction takes place without it, however, exceptionally in *Myxobolus*, and constantly in those forms inhabiting the cavities of the hollow organs.[4]

MACROSCOPIC APPEARANCES.

The most striking feature of the myxosporidian cyst is the *invariable absence of pigmentation.* It is always of a cream-white color.[5] In size it varies within very wide limits, from a fraction of a millimeter to clusters of several centimeters in length. Shape also extremely variable, mostly spherical to fusiform. Usually it is easily detachable from its place in the tissues. The cyst contents are always milky or creamy, usually fluid, sometimes from deficiency of water, caseous, and consist of spores and more or less "granular matter."

MICROSCOPIC APPEARANCES.

Cyst membrane.—In harmony with his view of the nature of the contents of the *Glugea anomala* cyst, Gluge[6] regarded the cyst membrane as formed by the "solidification of an albuminous matter" of the host.

Concerning this structure in *Myxobolus mülleri*, Bütschli[7] remarks that it differs from the type of membrane usual among the unicellular organisms (particularly the Gregarines) in its plasmatic nature, being

[1] In Mlle. Leclercq's description of the *Myxosporidia* (Bull. Soc. Belg. de Microsc., 1890, XVI, p. 100) the erroneous statement is made that the *Myxosporidia* do not emit pseudopodia.

[2] Notably *Myxobolus ellipsoides* and *Myxidium lieberkühnii* (pp. 222, 286).

[3] From the view that the *Myxosporidia* undergo a true (zoological) reproduction-encystment, Bütschli (Bronn's Thier-Reich, 1882, I, pp. 592, 593) dissents.

[4] Cf. Lieberkühn, 1854, Bull. Acad. Roy. Belg., XXI, pt. 2, p. 23; Thélohan, 1890, Annal. de Microgr., II, pp. 197–198.

[5] Of course not all white (nonpigmented) cysts are myxosporidian. Some Trematodes occur in similar cysts, though they seem more usually to excite the deposition of pigment.

[6] Bull. Acad. Roy. Belg., 1838, V, p. 775.

[7] Ztschr. f. wiss. Zool., 1881, XXXV, pp. 632,633; Bronn's Thier-Reich, 1882, I, pp. 592, 593.

composed of clear, very finely granular protoplasm, containing many small nuclei which possess a distinct dark membrane and a somewhat irregular outline, and stain intensely with alum carmine. It is difficult to determine certainly whether this membrane is formed by the myxosporidium or by the host. Opposing the myxosporidian origin (which, however, is in no wise excluded) is the relatively greater size of the membrane nuclei compared with those of the endoplasm.

Balbiani's[1] views of cyst structure may be summed up thus:

Membrane of rather firm texture, very thick (sometimes 10 μ) without structure, showing small refringent granulations. In spite of Bütschli's assertion of the presence of carmine-staining nuclei, Balbiani could find nothing definite. He is disposed to regard the membrane as a production of the parasite rather than of the host.

Ludwig[2] believes the cyst membrane to be probably a production of the host.

Thélohan[3] could find no nuclei in the cyst membrane and believes their absence an argument of real value in favor of the derivation of the membrane from the (similarly nonnucleated) myxosporidian ectoplasm. Finally, he says, *Cystodiscus immersus* (which is free-floating) is surrounded by a clearly defined structureless membrane.

Perugia[4] has, it seems to me, recently made an important contribution to this subject. This observer has seen in *Myxobolus mugilis* a cyst which contained *three separate myxosporidia*. (See p. 213, pl. 14, fig. 5.) It is hard to resist the conclusion that, in this case at least, the host furnished the cyst membrane. But it is equally difficult to deny that in certain other forms, especially *Cystodiscus immersus*, which is free-floating in the bile, (1) that there is a membrane and (2) that such membrane is a product of the myxosporidium. Still other species (e. g., *Myxidium lieberkühnii*) show an ectoplasmic membrane. I suspect the explanation to be that the "cyst membrane" is really composed of two concentric membranes, one (the inner and constant one, whose degree of development and of condensation, however, probably varies greatly) being the ectoplasm of the myxosporidium and the other (the outer and inconstant one, being absent, for example, in the free-floating forms) being a product of the tissues of the host.

Finally Thélohan[5] has recently put forth essentially the same view, viz, that the so-called cyst membrane is not derived from but *is* merely the ectoplasm of the myxosporidium modified. His observations are as follows:

Those *Myxosporidia* which form well-defined cysts (*e. g.*, the branchicolous species) have the ectoplasm still distinct, but no pseudopodia are seen. Formerly he admitted the existence of a cyst membrane

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[1] Journ. de Microgr., 1883, VII, pp. 199, 200.
[2] Jahresber. d. rhein. Fisch.-Vereins Bonn, 1888, p. 31.
[3] Annal. de Microgr., 1890, II, pp. 203–205.
[4] Boll. Scientif., Pavia, 1891, XIII, pp. 23, 24.
[5] Bull. Soc. philomat. Paris, 1892, IV, pp. 168, 169.

formed by the parasite. Thélohan now believes a true membrane to be absent, the pseudo-membrane being merely the denser, most external layer of the ectoplasm, peculiarly modified (coagulated and contracted) under the action of the fixing and hardening reagents. It can then take on the aspect of a membrane, the resemblance being sometimes even further heightened by its exhibiting very definite striæ.

Sections of a barbel's intestine showed connective tissue spaces each inclosing a myxosporidium with an often very well differentiated external zone which presented a very distinct striation. Although at first regarding this as a confirmation, Thélohan, after a more thorough examination, varying the observation methods and studying a great number of sections of different myxosporidian species, became convinced that these pseudo-membranes are artificial productions, the result of a rougher action of the reagents on the more exposed external ectoplasmic layers, which action accentuates their differentiation and exaggerates their characters. In fact this membraniform layer can be seen to become continuous, without a line of demarcation, with the ectoplasm proper.

Further, a similar appearance was sometimes observed in sections of the pike's urinary bladder, where (the myxosporidia being free and motile) there can be no question of a cyst membrane. Moreover, the distinction is much more apparent in sections after the action of reagents (under which conditions the limit of the 2 layers is clearly indicated and marked by a continuous, often very pronounced, line) than in fresh preparations.

Thélohan[1] says that, as Bütschli remarks, the age of the cyst can be inferred from its size, the less advanced cysts being larger with a central zone containing the older spores and an outer one containing nuclei and spores in process of formation. The oldest cysts are small, contain no nuclei, and spore formation has ceased, only developed spores being present.

SPORE FORMATION

GENERIC RELATIONS.

This process exhibits differences which not only serve as ordinal characters, but which appear also to stand in some sort of relation to generic lines.

Thus in *Glugea* we have polysporogenetic pansporoblastic spore formation within a myxosporidium, the pansporoblast not subpersistent as a sporophorous vesicle.

In *Pleistophora* we have polysporogenetic pansporoblastic spore formation, no myxosporidium (completely transformed into pansporoblasts?), the pansporoblast subpersistent as a sporophorous vesicle.

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[1] Annal. de Micrógr., 1890, II, p. 204.

In *Thelohania* the myxosporidium appears to be absent (completely transformed into pansporoblasts?); the pansporoblast constantly produces 8 spores.

The process in *Cystodiscus* is imperfectly known (see p. 280).

Nothing is known of the process in *Sphæromyxa*.

The rule in *Myxobolus* appears to be pansporoblastic spore formation *with tripartite sporoblast segmentation*. Although at first sight *M. mülleri* appears to constitute an exception to the rule, I have endeavored elsewhere (p. 218) to show that this species really conforms to it.

Chloromyxum (as represented by *C. leydigii*; also *C. incisum*) throughout all its various habitats is characterized by monosporogenetic pansporoblastic spore formation. In *C. mucronatum*, however, Lieberkühn appears to have observed 2 spores in the pansporoblast.

Nothing is known of the process in *Sphærospora*.

In *Myxosoma* also nothing is known beyond the fact that the spores are developed within a myxosporidium.

Beyond the very striking peculiarity of bisporogenesis, nothing is known as to the process in *Ceratomyxa* (see p. 274).

Myxidium (*M. lieberkühnii*) appears to be characterized by pansporoblastic spore formation, *without sporoblast segmentation*. As, however, in *M. lieberkühnii* the developed capsule is a structure plainly separate from, and not continuous in substance with, the sporoplasm, its abstriction from the latter must occur at some period of the development. As this abstriction would differ from the *Myxobolus* segmentation mainly in the time of its occurrence, the real amount of difference between the 2 processes becomes problematical.[1]

HISTORY.

From the following (which, unfortunately, I have been unable to examine further) it seems to me probable that Leuckart recognized the pansporoblast as early as 1847. In speaking of the spores, he says:[2]

> Their formation takes place in an endogenous manner in the interior of special cells, as I have already shown in another place (Göttingische Gelehrte Anzeiger, 1847, p. 1032).

Leydig's description[3] is as follows:

A clear pale-contoured vesicle is first differentiated, in which a number

[1] Prof. Bütschli (Bronn's Thier-Reich, 1882, I, p. 600) takes, apparently with special reference to this species, the view that the capsules seem to lie not near, but *in* the sporoplasm, which appears to cover them with a delicate prolongation. This view is also, he remarks, to be expected from the developmental history. This, however, doubtless means only that the capsules are surrounded on all sides by the sporoplasm, not that they are continuous in substance therewith.

[2] Archiv. f. physiol. Heilkde, 1852, XI, p. 435.

[3] Muller's Archiv., 1851, p. 226. Leydig, it will be remembered, erroneously regarded this structure as a vesicle (*Tochterblase*). His observations were made upon *Chloromyxum leydigii* and *C. incisum*.

of granules originate. During the subsequent progress in development up to the ripe psorosperm, changes take place in the form of the vesicles, the character of the contour, and the contained corpuscles. The latter first elongate, one pole becomes sharpened, the whole corpuscle assumes the familiar clearness of outline, the granules diminish in number and form (perhaps through fusion or after previous solution) the 4 capsules. The contour of the sporoblast also becomes sharp.

Lieberkühn (see *Chloromyxum mucronatum*, p. 265) first noted the pansporoblast as a solid plasma-sphere, but he did not trace the connection of the solid sphere with Leydig's vesicles.

In 1880, Gabriel noted, in *Myxidium lieberkühnii* (see p. 287), that the vacuole stage of the pansporoblast is a subsequent and not the original condition. It is quite evident, however, that he did not understand the mode of pansporoblast formation.

In 1881, Bütschli[1] showed that the pansporoblast is primarily not a vacuole, but a plasma-sphere. The segmentation of this and the development of the resulting sporoblasts were also traced.

PROCESS.[2]

Formation and segmentation of the pansporoblast.—The first step in pansporoblast formation is the condensation around each of the numerous nuclei (of the endoplasm) of a small clear-contoured sphere of myxoplasm, which seems limited by a thin envelope resulting from a condensation of its peripheral layer, the whole constituting a pansporoblast. This subsequently shrinks slightly, so as to appear as a ball surrounded by a vacant space, and this latter in its turn by the membrane. The nucleus then divides (by karyokinesis) and redivides so that one very soon has a sphere (pansporoblast) with a dozen nuclei. The sphere then segments into two hemispheres (sporoblasts) which remain surrounded by the original pansporoblast membrane. Each sporoblast contains several nuclei (see below). The nuclei which do not enter into the formation of the two sporoblasts are rejected and are found in a small mass of protoplasm which remains (along with the two sporoblasts) within the original pansporoblast membrane.

In this connection it is well to quote from Kunstler and Pitres[3] the following erroneous description:

This envelope [the ectoplasm] would contain, according to Bütschli, small nuclei. The nuclei, in proportion as the cyst [membraned myxosporidium] enlarges, divide; *the protoplasm is condensed around them to form oval bodies, which Balbiani considers the spores; this author has indeed seen there the formation of four falciform corpuscles* [italics my own, for errors].

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[1] Ztschr. f. wiss. Zool., xxxv, pp. 645-646; Bronn's Thier-Reich, 1882, I, p. 596.

[2] Description based upon Thélohan's (Compt. Rend. Acad. Sci. Paris, 1890, CXI, p. 693). For the process in the *Cryptocystes*, see p. 201.

[3] Journ. de Microgr., 1884, VIII, p. 474.

Development of the sporoblasts into the spore.—As noted by Bütschli and Balbiani[1] in the 2-capsuled forms (*Myxobolus*), each sporoblast divides into 3 unequal uninucleated masses, 2 small and 1 large, destined to form respectively the 2 capsules[2] and the sporoplasm.

a. Development of the capsules.—Very soon there is produced in each of the two smaller masses, ordinarily in the neighborhood of the nucleus (see above) a small, rounded, clear vacuole, distinguishable from the surrounding protoplasm by the absence from all points of its wall, of granulation. Next a small protoplasmic button forms at some point of the wall and advances progressively into the vacuole, crowding its contents back against the sides, so that after a time it becomes a pyriform body surrounded by a clear layer (the vacuolic contents) and connected with the protoplasm by a pedicle. Little by little the pedicle becomes strangulated, the pyriform body thus finally becoming free. During this time it has acquired a membrane, and a filament is produced within it, evidently at the expense of its protoplasm, although Thélohan was unable to follow all the stages of the process. Around the capsule thus formed one finds the nucleus,[3] and débris of the protoplasmic globule which has given birth to the capsule. The nucleus remains most frequently attached to the capsule, but sometimes it becomes separated and is found engulfed in the sporoplasm. During development the capsules have no fixed direction, orientation taking place later.

b. Development of the sporoplasm.—The third mass becomes the sporoplasm. Very early 2 nuclei, generally near together, are seen. They persist to maturity. Thélohan was unable to determine whether these exist primitively in the sporoblasts (which would then contain 4 nuclei instead of 3, as Bütschli supposes) or whether they result from division.

c. Development of the finished spore.—The spores, until now rounded or oblong, very soon assume their definite and characteristic shape and acquire an envelope. The tail is folded against one side of the spore, becoming straight only after the rupture of the pansporoblast membrane, which latter persists a rather long time.

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[1] Bütschli for *M. mülleri;* Balbiani for *M. ellipsoides* (see pp. 218, 223).

[2] Not rarely, especially in *Myxobolus ellipsoides,* 3 to 8 capsules are found. The constant association with each of a nucleus shows that their formation takes place in the usual manner. In this case the [pan]sporoblast without doubt incloses an abnormal number of nuclei. Sometimes it even seems probable that a single spore is formed instead of 2 (Thélohan). [It would be exceedingly interesting to ascertain whether in these cases the number of rejected nuclei is correspondingly less. Unfortunately, at present nothing is known on this point.]

[3] Thélohan here remarks that in a preceding work (Compt. Rend. Acad. Sci. Paris, 1889, CIX, pp. 920–1, and Annal. de Microgr., 1890, II, p. 210) he considered these nuclei as belonging to the sporoplasm and attributed to them a different origin, an error which a study of the development has rectified.

THE SPORE.

The myxosporidian spore always consists of at least 3 structures, viz: a shell, one or more capsules with filament, and the single mass of sporoplasm. In *Myxobolus* (p. 207) there is also sometimes present a fourth structure—the tail.

Pfeiffer[1] regards the myxosporidian spore as the equivalent of the individual falciform germs (*sporozoites*) of the *Coccidia.*

The Shell.

This was noticed by even the earliest observers, who commented upon its most prominent features, viz: its extreme transparency and resistance to the strongest chemical reagents. Creplin[2] was the first to observe the separation of the valves after prolonged immersion in water. It is extremely probable that the shell substance is the same throughout the whole group, as we find the constant shell characters to be the micro-chemical ones, variation appearing to be rather structural than chemical. This substance is thin, very transparent, insoluble in the strongest acids and alkalies in the cold, certainly in some, and probably in most species destroyed by (soluble in?) concentrated sulphuric acid at its boiling temperature;[3] usually with little affinity for staining reagents. The shell possesses a minute pore (or pores) for the exit of the spiral filaments.

Two types of shell are (provisionally at least) to be distinguished. These are the bivalve shell, and a type in which no bivalve structure has been detected.

The first type comprises 2 subtypes, viz: (*a*) plane of junction of valves coincident with the longitudinal plane; characteristic of *Myxobolus;* and (*b*) plane of junction of the valves perpendicular to the longitudinal plane; characteristic of the *Cystodiscidæ* and the *Chloromyxidæ.*

The second type is found in the *Glugeidæ* and in *Myxidium lieberkühnii.*

Tail.—Confined within and described under the genus *Myxobolus* (p. 207).

Capsules and Filaments.

MORPHOLOGY.

Capsule.—Always pyriform, consisting of a thick, elastic, brilliant, ordinarily opaque wall encompassing a central cavity; wall drawn out

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[1] Die Protozoen als Krankheitserreger, 1891, 2 ed., p. 8.

[2] Wiegmann's Archiv. f. Naturgesch., 1842, I, p. 63.

[3] Balbiani asserts (Journ. de Microgr., 1883, VII, p. 202) that boiling sulphuric acid does not affect the shell. This Bütschli (Ztschr. f. wiss. Zool., 1881, XXXV, p. 634) denies, stating that strong heating with sulphuric acid destroys entirely the shell substance. My own experience with several species tallies exactly with that of Bütschli.

anteriorly into a duct which pierces the shell near its anterior extremity, affording exit for the filament. Wall usually taking (sometimes retaining, sometimes yielding up upon washing out) stains, especially the nuclear. Thélohan[1] considers the substance composing the capsular wall identical with that forming the shell, as both stain in the same way with safranin. From this view I must dissent, as in my experience not only the optical character, but also all the prominent staining reactions, differ. In particular the capsules are *uniformly opaque*, the filaments never being visible through them, even in glycerin, while the shell is transparent in the highest possible degree. Further, in *Myxobolus macrurus* (other species were not tried) bismarck brown and fuchsin each stain the capsule without even tinting the shell.

Two reagents render the capsular wall transparent, thus permitting the filament to be seen coiled *in situ*. The first is iodine water (solution with potassium iodide). This reagent also causes extrusion of the filaments, sometimes even in alcoholic specimens (pp. 85, 120). The second is strong ammonia water. I have never seen it produce extrusion of the filament.

Bütschli[2] and Balbiani[3] have observed that when the filament is extruded there is ("as in the thread cells proper", Bütschli) a very marked diminution in the volume of the capsule, from which Bütschli infers that such extrusion is produced by the pressure of the stretched elastic capsular wall.

This may be the cause of filament-extrusion, but might it not equally well be interpreted as the result of such extrusion or, more properly, as a co-result with the latter of a general increase of intrasporal pressure? However this may be, it seems very probable that the filament-extrusion which takes place under the influence of such energetic dehydrants as sulphuric acid, glycerin, etc., is merely a physical effect, the result of the intense intrasporal endosmotic pressure. Thus in several species (among others, *Myxobolus transovalis*) sulphuric acid produces a pronounced swelling of the spore, extrusion (even in alcoholic specimens) of the filaments, and finally the expulsion of the capsules bodily, under an evidently great pressure. It can not, however, be denied that the action of iodine water is not thus explicable.

Filament.—Exceedingly tenuous, attached at its proximal extremity to the capsular wall, free at its distal extremity; usually coiled into a spiral; in this condition entirely inclosed within the capsule cavity. Capable of uncoiling and of extrusion (*via* the capsular duct) as a semiuncoiled or a fully uncoiled (nearly or quite straight) thread whose length may be many times that of the spore. That the semiuncoiled condition is merely an intermediate stage between the fully coiled and the fully uncoiled condition, and is not a specific character, is shown

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[1] Annal. de Microgr., 1890, II, p. 207.

[2] Ztschr. f. wiss. Zool., 1881, XXXV, p. 636.

[3] Journ. de Microgr., 1883, VII, p. 204.

by the occurrence of both in the same species under the influence of sulphuric acid. The other reagents which tend to produce filament-extrusion are caustic alkalies, hydrochloric and nitric acids, ether, glycerin, boiling water, mechanical pressure (e. g., the rolling of a mass of spores in an insufficiency of fluid, under the cover-glass), etc. As noted by Bütschli,[1] the extrusion in the latter case is apt to be more or less abnormal.

Concerning filament-extrusion in preserved material, Thélohan[2] says:

> After the action of alcohol upon the spores the filament remains in the capsule and it becomes impossible to make it go out.

While not usual, extrusion does sometimes occur with alcoholic specimens, a certain (rather small) proportion of the spores emitting their filaments under the action both of sulphuric acid and of iodine water. In my experience the filaments appear usually not to have much affinity for stains; the capsule where stained, always shows a markedly lighter center. Kolesnikoff, however, found them to stain in *Myxobolus kolesnikovi.*

HOMOLOGY AND FUNCTION.

The capsules were first observed by Müller (see p. 241), who considered them the embryos.

In 1852 Leuckart[3] regarded these structures as fat globules. He says:

> Also, they [the spores] contain some plain granules of a fatty quality, which are distinguished through their constant location in one or both poles.

In 1863 Balbiani[4] discovered the filament and its capability of extrusion. Regarding the spore as an adult cryptogam, he assigned to the filament the role of an antherozoid.

In 1875 Schneider[5] remarked that—

> As regards a resemblance between the falciform corpuscles and the polar organs of the psorosperms of fishes, it is impossible for me to find it. * * * The falciform corpuscles are not such sacks occupied by a slender filament rolled into a spiral.

Commenting upon Balbiani's views, Leuckart says:[6]

> The signification of the elements is unknown, but it may be safely admitted that Balbiani's view, which sees therein an antherozoid, is without foundation. Perhaps it is to be regarded as an attachment apparatus.

He further remarks that a comparison of the capsules with the falciform corpuscles is excluded by Lieberkühn's and Balbiani's observations of the exit and amœboid movement of the sporoplasm.

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[1] Ztschr. f. wiss. Zool., 1881, XXXV, p. 635; see *Myxobolus mülleri*, p. 219.

[2] Annal. de Microgr., 1890, II, p. 207.

[3] Archiv. f. physiol. Heilkde, XI, pp. 434–5.

[4] Compt. Rend. Acad. Sci. Paris, LVII, p. 159. This discovery has since been confirmed by numerous observers.

[5] Archiv. de Zool. Exper., Paris, IV, pp. 548–9. I have not seen a distinctly asserted comparison between the capsules and the falciform corpuscles to which this could refer, but such a comparison is implied by Leuckart's parallelism of *Myxidium* (?) *sp.* 102 (Archiv. f. physiol. Heilkde, 1852, XI, fig. 21 *b*) with the spore from the testicle of *Lumbricus.*

[6] Die Parasiten des Menschen, 1879, 2 ed., p. 247.

Upon the same subject Prof. Bütschli[1] remarks that:

Balbiani's view that they [the filaments] represent male fertilizing elements comparable to the antherozoids of the cryptogams, may be entirely rejected, as, apart from the general improbability of this view (which, moreover, is not further supported by actual observations), there are, at present known, no vegetable spermatozoon-like organisms whose structure permits of comparison with these nematocystoid polar corpuscles.

Prof. Bütschli[2] regards the capsule as comparable to the nematocysts of the Cœlenterates. This view is, he says, supported by its development, the filament being originally in the extruded condition and only subsequently becoming retracted and coiled.[3] Further Bütschli remarks that:

One might suspect that the capsular filaments serve for the attachment of the spores to other fishes or to the food of the same.

Taking the two together, I interpret Prof. Bütschli's meaning to be that morphologically they are nematocysts, but that here they function differently.

Replying to the preceding criticisms of his theory, Balbiani[4] says:

This last observer [Bütschli] compares with reason these filaments to the urticating organs or trichocysts of the Cœlenterates. But, knowing the signification of urticating organs, I admit that I do not well understand in what way these organs can serve psorosperms which are completely immovable and do not nourish themselves, for one knows that the trichocysts have for their object only the paralysis of prey in order to render its capture more easy.

And further, among other repetitions of his theory, he says:

We have, in effect, here, all the phenomena of sexual union (*rapprochement*); first, the embrace (*rapprochement*) of two individuals; then the presence of a female element, the sarcodic globule, becoming free at that moment; and, finally, filaments which I have compared to antherozoids. In a word, the process recalls involuntarily to the observer a cryptogamic sexual generation. But these interpretations, although emitted with reserve, have drawn upon me on the part of Leuckart and Bütschli a severe criticism. These authors prefer to compare them to urticant organs. One can respond by asking them what would here be the physiological signification of urticant organs, which are offensive or defensive weapons. What would be, in these organisms, their rôle and utility? At all events the phenomena in question deserve to be studied anew. I was then as much, if not more, in the right to consider them as antherozoids, than Leuckart and Bütschli to make of them urticant organs. We had, I believe, equal reasons, the German observer and I, to sustain our interpretation.

Curiously enough Balbiani shows no indication of abandoning his antherozoid theory (on the contrary it is further elaborated by the designation of the sporoplasm as the "female element"), notwithstanding

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[1] Ztschr. f. wiss. Zool., 1881, XXXV, p. 638; Bronn's Thier-Reich, 1882, I, p. 603.

[2] Bronn's Thier-Reich, 1882, I, pp. 599, 600.

[3] Bütschli's own observations for the *Myxosporidia*. The same very probable for *Hydra* (Jickeli, Morphol. Jahrb., VIII, p. 373). Without assigning any reason, Lutz doubts Bütschli's observation (Centralbl. f. Bakt. u. Parasitenkde, 1889, V, p. 87).

[4] Journ. de Microgr., 1883, VII, pp. 204, 277, 278.

the fact that at the same time he *practically abandons*[1] *his view of the adult nature of the "psorosperm."*

Kunstler and Pitres[2] think that the capsules "appear to be true nematocysts."

Ludwig[3] accepts the Leuckart-Bütschli attachment theory, regarding the filaments as probably organs of attachment. He says that though little is known as to the conditions under which filament-extrusion naturally occurs, spores kept long in water extrude their filaments, and adds:

Probably the filaments serve for the attachment of the spores, which have reached the water through the opened tumors of the fish, to any living or dead substances whatever.

Thélohan[4] comments upon Prof. Bütschli's view as follows:

Bütschli, after having severely criticised that idea [Balbiani's antherozoid theory], compares them to urticant organs. At the outset, as Balbiani observes, one can not see what could here be the rôle and the utility of urticating organs. Further, the filament of the polar capsules resembles but little those of the true nematocysts; after their exit they present most often a sinuous aspect, sometimes neatly spiral, which is far from recalling the appearance of the urticant filaments which shoot out abruptly from their capsules and present themselves under the form of rigid bayonets.

Mingazzini[5] takes a totally different view from other authors and one which it is impossible to reconcile with the present evidence. In the following passage, besides other errors, *the* (*capsular*) *filaments are confounded with certain shell-processes* (*ribbonettes*) described by Balbiani in *Myxobolus ellipsoides*, and further Bütschli's view (given above) of the function of the filament is curiously distorted:

Many observers have noted (in treating the myxosporidian spore with various reagents) the exit from the polar bodies of a very long filament, which normally is coiled within the polar body. As to the signification of this filament various opinions have been emitted. *Balbiani thinks that it can serve as the organ of dispersal of the spore, functioning at the maturity of the latter in a similar manner to the elaters of the Elaterium spore.* Bütschli expresses the opinion that they can have the signification of urticant filaments.[6] But Balbiani has further observed that *in the mature spore these filaments are unwound and stand each around either the membrane of its own spore or around that of a neighboring spore,* and supposes that in the last case the filaments have the signification of copulating organs. Again, however, Bütschli, not entirely satisfied with his first interpretation, has thought that the function of urticant capsules for a spore which has a membrane resistant to acids and alkalies, is a kind of luxury, and that the filaments could serve to attach the spore to other fishes *or to feed it* [italics my own for errors].

From an analysis of the opinions it appears that none of them is entirely satisfactory, while, in my opinion, from what I have seen of the gregarinoid forms, it may be assumed that the polar bodies are nothing else than the embryos of the *Myxosporidia,* homologous with the falciform bodies of the gregarine and coccidian spores, on which view the filament of the polar body would be nothing else than the tail of the gregarinoid form which remains inclosed in the polar body while

[1] Journ. de Microgr., 1883, VII, pp. 198, 201, 276.

[2] Journ. de Microgr., 1884, VIII, p. 474.

[3] Jahresber. d. rhein. Fisch.-Vereins Bonn, 1888, p. 33.

[4] Annal. de Microgr., 1890, II, pp. 207–208.

[5] Boll. Soc. Nat. Napoli, 1890, IV, p. 163.

[6] See above (p. 86).

the mass of internal protoplasm would represent the residual nucleus (*nucleo di reliquat*) of the spore. The homology is demonstrated with all the greater probability, inasmuch as, as in the gregarine and coccidian spores, the number of the falciform bodies is constant with the species, so also in the *Myxosporidia* the number of the polar bodies is constant in the different species, and the residual nucleus would serve to feed them within the spore and perhaps to determine their exit at maturity. There would thus be explained what was seen by Balbiani, viz, the exit of the polar bodies at maturity without having recurrence to the forced interpretation of fecundation (which would not be constant) or to the unsatisfactory interpretations of Bütschli. We can thus see in the spore of the *Myxosporidia* all the parts that are encountered in that of the typical *Sporozoa* (the Gregarines and *Coccidia*), and in this way more easily discover the zoologic link which connects these groups with the *Myxosporidia*.

Perugia[1] accepts the Leuckart-Bütschli theory that the filaments are organs of fixation. He compares them to the long filaments of the eggs of parasitic Trematodes. This writer has, however, followed Mingazzini's error, and confounded the ribbonettes (described by Balbiani in *Myxobolus ellipsoides*, p. 223) with the capsular filaments.[2] It is necessary to direct special attention to this error or we shall soon find an elaborate table of structural synonymy a necessity. He says:

Balbiani compares them to organs of dissemination such as the elaters of the Equiseti. Having afterward observed that sometimes this filament is coiled around another spore he saw in them an organ of copulation. *Thélohan asserts that he has observed that many spores are destitute of such a filament and evinces an inclination to regard the filamentous organs as accidental productions(!)* [Italics my own for errors.]

Pfeiffer[3] regards the filaments as organs of movement or attachment, saying:

Probably this organ is no thread-cell, but serves for progression or attachment.

He[4] asserts that these structures also occur with the falciform germs of Miescher's tubes, and says that the spores of the *Myxosporidia* and *Sarcosporidia* are, according to his representation, not at all so widely different from one another. Further, in the description of fig. V, he says:

A well-developed falciform corpuscle; to the right the large colorable nucleus; to the left a noncolorable indefinite body with a beak-like process at the left pole (thread-cell?).

Thus, in spite of the unqualified statement in the text, there appears to be no certainty as to the nature of the structure in question. Turning to the figure, all that can be said is that it is entirely too indefinite to sustain the weight of the assertion of its capsular nature, against which view the verdict of "not proven" must be placed.

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[1] Boll. Scientif., Pavia, 1890, XII, p. 137.

[2] Thélohan has recently pointed out Perugia's error (Bull. Soc. philomat. Paris, 1892, IV, p. 167).

[3] Die Protozoen als Krankheitserreger, 1 ed., 1890, p. 47; 2 ed., 1891, pp. 17, 132.

[4] *Ibid.*, 1 ed., pp. 47 (and footnote), 99, plate, fig. V; 2 ed., p. 133. It will be noted that Pfeiffer says nothing of, nor do his figures show, any extruded filaments. Nothing short of this could be accepted to prove the capsular nature of the body in buestion. See also pl. 7, fig. 5.

Remarks.—Balbiani, Thélohan, and Mingazzini appear to assume, as the basis for their criticism of Prof. Bütschli's view, that a structure morphologically a nematocyst must necessarily be urticant in function, in other words that the terms nematocyst and urticant organ are synonymous. This assumption is, to say the least, very dubious.

Concerning the homologies of the organs in question it is impossible to see how, as suggested by Mingazzini, they are to be brought into comparison with the falciform bodies of the gregarine and coccidian spores, inasmuch as (as noted by Schneider; see p. 85) the falciform bodies are not in any respects structurally similar to the myxosporidian capsules, and further it would seem (as implied in Leuckart's view above given) that the homology should lie between the protoplasmic structure in the one spore, and the protoplasmic structure in the other, whereas Mingazzini's parallel is between the protoplasm in the one and a structure which shows no evidence of such composition in the other, being apparently destitute of such characteristic protoplasmic structures as nuclei, vacuole, etc.

I can not, however, feel much greater confidence in their homology with the cœlenterate nematocyst. I can only interpret homology to mean such correspondence in development and structure as would (upon the evolution theory) imply descent from a common ancestor, and conversely no homology seems possible except in cases where (upon the same theory) one would be willing to admit such common origin.

In the present case, while the myxosporidian capsule shows a marked *histologic* resemblance to the cœlenterate nematocyst, it presents one very important difference, viz, that it appears and functions at an entirely different period of the life-history, i. e., it characterizes the spore and disappears before the adult stage is reached. Add to this the point cited by M. Thélohan (p. 87), and their (probable) utter uselessness to the myxosporidian spore as offensive or defensive weapons, and the parallel is by no means close enough to justify their assimilation to the nematocysts. The fact that the myxosporidian filament agrees (how closely?) with that of *Hydra* in having the filament first extruded and only subsequently retracted-coiled, does not seem sufficient to prove the morphological equivalence of the structures, as it might be possible that this mode of formation is the only one capable of producing the necessary elastic tension. Further,[1] "nematocysts" are known in some mollusks. All these facts render it very probable that these "nematocysts" have been independently evolved in the different groups. It may, however, well be a question to what extent of detail all of these "nematocysts" correspond.

As regards the function of the capsules and filaments, the only intelligible suggestion that has yet been made appears to be the view of Leuckart and Bütschli, which sees in them an apparatus for attachment. I can see no basis in the facts for Balbiani's antherozoid theory,

[1] Lankester, E. Ray, 1878, Encycl. Britan., 9 ed., VI, p. 108.

and no evidence in favor of Mingazzini's supposition that the capsules represent the embryos, the filaments functioning as flagellæ.[1]

On the contrary everything that we know about the *Myxosporidia* favors the view that the embryo is *not* the capsule but the sporoplasm, the presence in it of nuclei, of a vacuole, and of amœboid movements being quite conclusive. The most probable supposition in relation to the capsules is that they are accessory and temporary structures whose function is to secure attachment and perhaps a certain amount of motion, for the fulfillment of both of which objects they seem very well adapted. And it may be noted in passing that nematocystoid bodies are known which function for attachment, as well as those which function for stinging, etc.[2]

Before discussing the mode of action of the filaments, a few words may advantageously be devoted to the relative functions of the spore and myxosporidium stages.

(1) *Dispersal is absolutely necessary to the species:* This dispersal can take place only by the actual separation of myxosporidian individuals from one host and their migration to another, unless we adopt one of two very improbable suppositions, viz, either that they attach themselves to the eggs of the host and await their development or that they develop in an intermediate host which feeds upon the fish.[3]

(2) *The spore is the means by which such dispersal is effected:*[4] Thus Lieberkühn[5] saw some cysts "lost" and others opened, their contents escaping into the water. Also Ludwig and Railliet (p. 228) have observed the rupture of cysts *in situ* with escape of their contents. Thélohan[6] has seen the same occur with *Glugea anomala;* and in *Myxobolus ellipsoides* he saw cysts shell out entire and burst.[7]

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[1] Mingazzini's description given above implies very strongly this idea as to the function of the filaments, nevertheless he does not distinctly so state. Compare here Lieberkühn's statement (Bull. Acad. Roy. Belg., 1854, XXI, pt. 2, p. 21) that the capsules, when extruded with the sporoplasm from the spore, show not the slightest trace of movement.

[2] In the body epithelium of the Ctenophora we find peculiar adhesive cells with uneven and sticky surfaces. Their bases are prolonged into spirally coiled contractile filaments.—(Arnold Lang's Text Book of Comparative Anatomy, London, 1891, pt. 1, p. 82.)

[3] The latter mode of change of host, though improbable, is not inconceivable. Still, everything seems to point toward the view that the whole life cycle from the attached spore in one generation to the liberated spore in the next, takes place in the same host.

[4] The only place where this view is distinctly stated is the following (Mlle. Leclercq, 1890, Bull. Soc. Belg. de Microsc., XVI, p. 101):

"On account of the presence of organs compared to nematocysts, *but which seem rather elaters,* one can believe that the spore is the disseminating form of the parasite, and that it can lead for some time a free life in the water." [Italics my own for errors.] Here we again see the unfortunate results of the dual signification of the term "filament."

[5] Müller's Archiv., 1854, p. 356.

[6] Compt. Rend. hebdom. Soc. Biol. Paris, 1892, IV, pp. 82–4.

[7] Annal. de Microgr., 1890, II, pp. 203–4. The observation was upon a spore habitant on the tench (*Myxobolus ellipsoides?*).

Finally that, in at least one species, dispersal could hardly take place by the myxosporidium is shown by Bütschli's observation[1] that in *Myxidium lieberkühnii* that structure dies rapidly when removed from its natural habitat (the urine of the pike) to even "indifferent fluids."

(3) *The myxosporidium, on the other hand, is the post-embryonic, comparatively stationary, growth-reproduction stage:* There is little reason to suppose that there is ever any migration from one host to another during this stage. The evidence all points to the conclusion that after (and probably soon after) its attachment to the host, the valves of the spore separate, freeing the sporoplasm, which thenceforward is known as the myxosporidium. Thus Lieberkühn, Balbiani, Pfeiffer, and Perugia have all seen the sporoplasm leave the spore and exhibit amœboid movements.

Now, if this view as to their relative functions in the life-cycle be correct, the capsular filaments may conceivably serve in several ways. First, they may serve as a flagelliform swimming apparatus, a view that I think quite improbable, dispersal being more probably effected by currents, etc. Second, they may (and this is probably their most important function) serve for attachment.[2]

Further, if it be conceded that, after attachment, motion is necessary to the spore, the filaments might easily subserve such function either by a maximum extrusion, fixation of the tip, and a subsequent coiling-retraction (similar to that of the *Vorticella* stem), the spore in this case progressing "anterior" end foremost, or by a minimum extrusion followed by fixation of the tip and progressive uncoiling-protrusion, the spore in this case being pushed "posterior" end foremost. In *Glugea anomala*, which has but one filament, 50μ long, motion could hardly be effected in the latter way. But such motion is easily conceivable with the 2-capsuled (*Myxobolus*, etc.) spores; and if it were admissible to suppose that the final lodgment preliminary to reproduction is ever effected by the spore and not by the myxosporidium, the latter being liberated and growing *in situ* (a view which, however, the present evidence tends to negative), this backward motion would be the best possible for inserting the spore under a scale, especially for those species provided with a tail, which latter structure would form an efficient guide to such insertion. I incline, however, to the view that *the* function of the filament is attachment, and that the motion necessary for the attainment of a place for reproduction-encystment is effected by the liberated myxosporidium.

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[1] Ztschr. f. wiss. Zool., 1881, XXXV, p. 639.

[2] Perfectly consonant with this view is the observation of Bütschli (Ztschr. f. wiss. Zool., 1881, XXXV, p. 635) that the filaments are extruded in spores which are preserved a long time in water. For we thus see the floating spores ready for instant attachment to any object with which they may come into contact. A possible cause for such extrusion might perhaps be found in osmotic pressure (preponderant endosmosis from the surrounding water) from within. At any rate, it is difficult for me to attribute the rupture of the shelled-out cyst observed by M. Thélohan (see p. 221) to any other cause.

Sporoplasm

This was noted (but apparently regarded as a third capsule) by Müller,[1] and it appears in several of his figures. Subsequently Lieberkühn[2] observed its exit from the spore and its amœboid movements. He also notes its visibility within the spore.[3] These observations have been confirmed by Balbiani[4] and later by others (see pp. 263, 287).

The sporoplasm is extremely transparent, more or less granular, and contains nuclei (1 or more), sometimes a vacuole, and, at any rate in the genus *Myxobolus*, a variable number of brightly refringent granules.

Nuclei.—These were first demonstrated by Thélohan.[5] Their number is variable in the same spore, according to the stage of development. In *Myxobolus ellipsoides*, Thélohan demonstrated their origin by continuous division from a primitive single one. He further says[6] that all species studied by him (with the possible exception of the *Glugea* species, in which the small size of the spore prevented accurate determination) have shown 2 nuclei. This accords with my own observations.

Granules ("refringent globules," etc.).—These have been noticed in several *Myxobolus* species. They are described under that genus (see p. 209).

Vacuole.—This structure is of two types: (1) The noniodine-staining (*aniodinophile*) vacuole. This is known only in, and forms a marked characteristic of, the *Cryptocystes.* It is situated in the large extremity of the ovoid or pyriform spores and is unaffected by iodine. This structure was first observed, but not at that time recognized as a vacuole, by Thélohan.[7] Subsequently he recognized its true nature.[8] (2) The iodine-staining (*iodinophile*) vacuole. This is known only in, and forms a marked characteristic of, the *Myxobolidæ.* It is stained by iodine dark brown against a light yellow-brown ground. This reaction is best obtained with a dilute solution (aqueous, with potassium iodide). Further details are given under *Myxobolus* (p. 208).

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[1] Müller's Archiv., 1841, p. 484, pl. 16, fig. 3 *i, k;* cf. fig. 5.

[2] Müller's Archiv., 1854, pp. 353–4, pl. 14, figs. 7, 8.

[3] Bull. Acad. Roy. Belg., 1854, XXI, pt. 2, p. 21.

[4] Compt. Rend. Acad. Sci. Paris, 1863, LVII, p. 160.

[5] Compt. Rend. Acad. Sci. Paris, 1889, CIX, pp. 920–21. For Perugia's confirmation, see *Myxobolus? merlucii* (p. 242). For Bütschli's "nucleus", see p. 219.

[6] Compt. Rend. Acad. Sci. Paris, 1892, CXV, p. 1092.

[7] Annal. de Micrygr., 1890, II, p. 211, pl. 1, fig. 17*a*, *b*.

[8] Relative to the homology of the vacuole, Thélohan says:

"Is there any connection between the central vesicle and the rest of segmentation of the other *Sporozoa?* A certain fact is that the aspect of the plasmic mass of the spores of the *Myxosporidia* with that vesicle refractory to staining, and the nuclei disseminated in the protoplasm, recalls in a striking manner certain phases of development of the spores of the Gregarines."

EXIT OF THE SPOROPLASM.

This, the last phenomenon of the spore stage, was first observed by Lieberkühn,[1] who described the process as seen in *Myxobolus sp.* 65. He also figured it as occurring in *M. sp.* 44. Gabriel[2] also describes (but in a somewhat different way, and possibly erroneously) the freeing of the sporoplasm in *Myxidium lieberkühnii*. It was also observed by Balbiani[3] in *Myxobolus ellipsoides*, and recently it has been confirmed by Pfeiffer[4] and by Perugia.[5]

Bütschli,[6] however, entertains some doubt as to the supposed simplicity of the life-history based upon these observations. His objections are chiefly that this view leaves no function for the capsules to perform. As indicated above, this exit appears only to take place at a (for the capsules) *post-functional* period.

III.—ZOOLOGICAL POSITION.

Gluge[7] regarded the spores of *Glugea anomala* as crystals modified by an unknown cause. He says:

> It is known from the researches of M. Ehrenberg that the silvery color of fishes is produced by a great number of corpuscles of a crystalline structure and a form cylindrical and a little recurved. It appears to me extremely probable, from all that precedes, that the corpuscles contained in the cysts are only the crystals of the normal state, but changed by an unknown cause.

Müller[8] regarded the *Myxosporidia* as agreeing neither with the spermatozoa nor with the germs of developing animals, nor with the tailed *Entozoa* or *Cercariæ*, and as deviating equally in structure from the known fungi parasitic upon animals; finally, through their form, structure, development, specific distinctions, and absence of motion, they deviate from all known normal and pathological cell formations. This observer[9] bestowed upon these anomalous forms the name of "psorosperms,"[10] recalling both the cutaneous "eruption" produced by them and the resemblance of the tailed spores to spermatozoa.

The credit of first suggesting a definite zoölogical position for the subclass is due to Creplin.[11] It will be seen that he was the originator of what may be called the "gregarine theory."

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[1] Muller's Archiv., 1854, p. 354; Bull. Acad. Roy. Belg., 1854, XXI, pt. 2, p. 21.

[2] Jahres-Ber. schles. Ges. vaterl. Cultur f. d. J. 1879, LVII, p. 192.

[3] Compt. Rend. Acad. Sci. Paris, 1863, LVII, p. 160.

[4] Die Protozoen als Krankheitserreger, 1890, 1 ed., p. 47; 2 ed., 1891, p. 133.

[5] Boll. Scientif., Pavia, 1891, XIII, p. 23.

[6] Ztschr. f. wiss. Zool., 1881, XXXV, pp. 637–8; Bronn's Thier-Reich, 1882, I, p. 595.

[7] Bull. Acad. Roy. Belg., 1838, V, p. 776.

[8] Müller's Archiv., 1841, pp. 487, 488.

[9] Mlle Leclercq (Bull. Soc. Belg. de Microsc., 1890, XVI, p. 100) erroneously attributes the name to Gluge.

[10] Derivation furnished by Balbiani (Journ. de Microgr., 1883, VII, p. 145) as follows: ψωρα, mange; σπερμα, seed.

[11] Wiegm. Archiv. f. Naturgesch., 1842, I, pp. 65, 66.

Creplin says:

Nothing even remotely similar has ever been seen by me in the many kinds of small cysts which I have frequently found in the invertebrate animals and have examined for Helminths. Since, however, I have seen v. Siebold's fine Contributions to the Natural History of the Invertebrate Animals (Danzig, 1839) I believe I have found something analogous to them in the organisms discovered by v. Siebold in cysts in the small intestine of *Sciara nitidicollis*, which he terms *Navicellæ*. See ff. 63 and the accompanying figures on Tab. III. * * * Although some features may appear to indicate a vegetable nature, the cyst bears distinctive marks of its animal nature. Cyst formation precedes spore formation, the spores perhaps originating from the granules seen in the cyst fluid, or perhaps by free formation within that fluid, or by production from the cyst-wall.

Dujardin[1] also suggested the correlation of the "psorosperms" with the Gregarines in the following:

Perhaps it is necessary to range with these productions those that one frequently observes in the testicles of *Lumbrici*.

In 1851 Leydig[2] developed the gregarine theory at some length. In brief, his reasons were as follows:

On him they made the impression of gregarine-like bodies and he knew no weighty reason against this view. They consist of roundish vesicles or vermiform tubes with a delicate membrane, and semi-fluid contents with granule masses. Frequently they appear as if a special membrane had not yet been separated from the contents, in which case the gregarinoid bodies have in contour somewhat the appearance of segmentation spheres. The fact that they only show granules does not contraindicate their gregarine nature, nor does the absence of motion, as slight motions might have been present, and further in some Gregarines motion cannot always be detected. Further, all who have studied the Gregarines unite in regarding the spores (*Navicellenbehälter*) as proceeding from the Gregarine. But any one who has compared the pseudonavicellæ and the psorosperms will certainly admit the conclusion that the navicellæ, Müller's psorosperms, and the forms discovered by him in the diseased air bladder of *Gadus callarias* form one series, the different members of which are related as the genera of a family.

Further Leydig, having, as he believed, demonstrated the Gregarines to be life-stages of *Filaria*-like nematodes,[3] says (pp. 232–233) that the *Myxosporidia* of the plagiostomes can perhaps also be brought into unison with these views, by similar connection with the round *Filaria*-like nematode which he found in the blood of several plagiostomes and in the parenchyma of various abdominal viscera (especially in the spleen-pulp) and rarely in the blood of the umbilical cord of embryos of *Mustelus lævis*.

Leuckart,[4] in 1852, accepting Leydig's view that the Gregarines were developmental stages of nematodes, regarded the "psorosperms" as forming similar developmental stages, this view being based upon

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[1] Hist. Nat. des Helminthes, 1845, p. 645.

[2] Müller's Archiv., pp. 226–228.

[3] According to Mingazzini (Boll. Soc. Nat. Napoli, 1890, IV, p. 162, footnote 2) these filarioid forms are referable to *Trypanosoma*.

[4] Arch. f. physiol. Heilkde, XI, pp. 434–6.

the great similarity between the spores and the pseudonavicellæ. He says:

For the further fate of our psorosperms it is not without interest to observe that they frequently occur free in the bile passages, while on the contrary they are no longer to be found in the intestinal canal, in which they, however, incontestably arrive. May they not here develop directly into those round worms which we not rarely encounter in the intestinal canal of these fishes.

Charles Robin was the first to assert their vegetable nature. In his *Histoire Naturelle des Végétaux Parasites* (Paris, 1853, pp. 291–2, 321), he collected descriptions and figures of nearly all the previously described species, placing them (as a special tribe, the *Psorospermeæ*) under the Diatoms. He says:

Several facts have convinced me of the vegetable nature of these bodies. These are the entirely peculiar aspect of the species[1] that I have had under observation; the definite rupture of the coriaceous cells of which they are composed; the presence upon some of special opercles; their contents partly homogeneous, partly formed of drops of oil in suspension in a clear liquid; the solubility of the walls, which often occurs in concentrated sulphuric acid in the manner of cellulose (although they are not colored by iodine). Like Müller and Retzius * * * I believe that these vegetables approximate by their form and general structure to the Diatoms, among other forms to *Navicula* and *Melosira*, etc., although they differ in the absence of silica in the walls. * * * Like the *Diatoms* they can live either free or reunited into colonies. * * * Although it is probable that the species described below will one day form at least two genera, * * * I shall unite them provisionally [under one genus.]

Lieberkühn[2] in his first paper expressed the opinion that the "psorosperms" could not be, as Leydig supposed, Gregarines, inasmuch as they possessed no nucleus. In his second paper[3] he again rejects Leydig's view in so far as the innominate form (*Gen. incert. sp.* 12) found by him under the skin of *Gasterosteus aculeatus* is concerned, saying that:

This mode of origin [the process of spore formation] is so peculiar that we certainly can not reckon such formations among the Gregarines. Their size, absence of structure, occurrence in water, the importance for reproduction of the granules, and the observed young stages, all give rise to opinions but not to certain knowledge.

Further, it is doubtful, he says, whether any Gregarine lives in water, whereas in all probability the psorosperm animal does, and attaches itself to the skin merely for reproduction. That the "psorosperms" are not amœbæ is indicated by his failure, on careful investigation, to find any of them capable of taking up foreign bodies into their substance. Also, he was never able to find an amœba which had just attached itself to the skin preliminary to reproduction. He concludes by saying that his researches on the parasites of fresh-water sponges promise to throw light on this subject, as he has there found large psorospermiform bodies consisting of small and large globular

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[1] *Psorospermia sciænæ-umbræ* Robin (see p. 166).

[2] Müller's Archiv., 1854, p. 5.

[3] *Ibid.*, pp. 357–367.

heaps, amœbiform corpuscles of the same size with precisely similar granules, which corpuscles protruded processes of various form, and finally much larger formations, containing, simultaneously, both fine granules and psorospermiform structures which, moreover, showed movements similar to those of the amœbæ.

Myxidium lieberkühnii is, however, referred to the Gregarines. The presence of a membrane is not regarded as a character indispensable to the definition of a Gregarine, inasmuch as in the earthworm there exist forms possessing all the other characters of true Gregarines (viz, a similar nucleus, the same form and size of granules, the same albuminoid substance, and the same manner of movement), and also other forms showing a plain but proportionately smaller nucleus, no demonstrable membrane, and none or only extremely fine granules. These forms possess amœboid movements, without, however, having the ability to take up into their substance foreign bodies or coloring matters. These characters permit of their classification under no other group than the Gregarines. Whether they represent young stages of these or special species is immaterial. This much, however, is clear: the nondemonstration of a structureless membrane does not exclude them from the Gregarines. The same may be said of the failure of demonstration of a nucleus, as either it may exist in spite of such failure, or it may be destroyed by the manipulation preliminary to examination, or it may be present at some other period of the life-history. Further, the opinion has been several times expressed that nonnucleated Gregarines exist. May they not rather be amœbæ? From these organisms they are delimited by their inability to take up into their substance undissolved solid particles.

In 1863 Balbiani [1] expressed a decided opinion in favor of their cryptogamic nature and, regarding the spore as the adult organism, assigned to the filaments the function of antherozoids, a view which he supplemented in 1883 by the designation of the sporoplasm as a "female element."[2] He further considered the "elastic ribbons" of *Myxobolus ellipsoides* comparable to the elaters of the *Equisetum* spore and supposed that, in addition to effecting valve separation, they serve to maintain the contact of two individuals during what he considered a state of conjugation. These views he reaffirmed in 1866.[3]

In 1875 Schneider [4] placed himself on record in opposition to the current theory of the close relationship between the *Myxosporidia* and the Gregarines, saying that:

One knows that, under the name of *Psorosperms*, there have been united (rather by reason of taxonomic necessities than by the coördination of positive data and sufficiently precise elements) four things, (Gregarines, *Myxosporidia*, *Sarcosporidia*

[1] Compt. Rend. Acad. Sci. Paris, LVII, pp. 157–161.

[2] Journ. de Micrŏgr., VII, p. 278.

[3] Journ. Anat. et Physiol., III, pp. 600–602.

[4] Archiv. de Zool. Expér., Paris, IV, pp. 548, 561, and Notes et Revue, pp. XL, XLI.

and *Coccidia*), which it is necessary, at least until further information is obtained, to regard as distinct.

He further says that he fails to see any homology between the myxosporidian capsule and the falciform bodies of the gregarine spore.

Giard (see p. 170) suggests that the relation of the "psorosperms" to the Gregarines may be parasitic and not genetic; *Lithocystis schneideri* is regarded as a vegetable.

In 1879 Leuckart[1] recorded his opinion against the gregarine nature of the *Myxosporidia*, remarking that:

It appears, however, scarcely permissible at present to unite these psorosperm-sacs with the Gregarines, not merely because they lack the shell-wall which surrounds the gregarine spore (*Pseudonavicellen-Behälter*) but still more because the formation of the psorosperms begins at a time when the organism is still more or less removed from its maximum size, and such formation progresses thence during the whole of the subsequent existence. What is divided with the Gregarines into two successive phases falls with the psorosperm-sacs into one.

In several papers[2] Gabriel refers the "psorosperms" to the Myxomycetes. In his myxosporidian paper[3] (upon *Myxidium lieberkühnii*) he says that—

The *Myxosporidia* can not be Gregarines, as they lack (1) the definite typical form, (2) the differentiated membrane, (3) the nucleus, and (4) the monosporogenetic centers. Further, they possess the following nongregarine characters: (5) the manifold peculiar protoplasmic movements, (6) the "thread-drawing" substance, (7) yellow pigment, (8) vacuoles, (9) polysporogenetic centers. The importance of characters 1 to 4 demands the separation of the *Myxosporidia* from the gregarine phylum. Further, while Lieberkühn's opinion that a membrane is not essential to a Gregarine might be admitted, the essentiality of a nucleus is less easily waived, and the fact remains that no Gregarine is known which simultaneously lacks both of these structures. Little satisfactory when considered alone, characters 5 to 9 confirm the myxomycetoid affinities of the *Myxosporidia*, as they are analogous to many exclusively myxomycetoid characters. Moreover, in Lieberkühn's time many subsequently discovered myxosporidioid, myxomycetous, and mycetozoan characters were still unknown.

Too much stress should not be laid upon the absence of pigment in gregarine species, although it is not concealed that the presence of pigment (yellow, brownish yellow, dark brown, blackish brown) is highly characteristic of the Myxomycetes.

The *Myxosporidia* are, therefore, to be annexed (not subordinated) to the Myxomycetes. The fact that they do not display typical myxomycete characters must not, however, be ignored. Though nearly allied to the same phylum, they are phylogenetically of more recent date and represent a small, sharply defined group, intermediate between the Myxomycetes and the Gregarines, originating by progressive adaptation to restricted and new life conditions.

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[1] Die Parasiten des Menschen, 2 ed., p. 245.

[2] Tagebl. d. 51 Versamml. d. deutsch. Naturf. u. Aerzte, 1878, pp. 51, 52; Tagebl. d. 53 Versamml. etc., 1880, pp. 82, 83; extracts, criticism, etc., Zool. Anzeiger, 1880, III, p. 572; Zoolog. Jahresber., 1880, I, p. 161; Journ. Roy. Micr. Soc. London, 1882, II, pp. 358, 359.

[3] Jahresber. schles. Ges. vaterl. Cultur f. d. J. 1879, LVII, pp. 188–195.

In 1881, as the result of an extended study of both *Myxosporidia* and Gregarines, Bütschli[1] expressed his opinion substantially as follows:

That the relation between the *Myxosporidia* and the Gregarines is no very intimate one is shown both by the structure of the myxosporidium and by that of the spore, and also by the mode of spore formation. In the last two respects the *Myxosporidia* can be compared with the Gregarines only in the most general way. There are, indeed, some observations (e. g., the dubious one of Claparède's on *Monocystis capitata* Leuck., and that of Gabriel on a Gregarine of *Julus*, the latter, however, too incomplete to serve as a basis for theoretic conclusions) which render a nonencysted (perhaps also an endogenous) spore formation in certain Gregarines not improbable. The possession in common of bivalve and tailed spore shells is an unimportant similarity. Above all, we have every right to regard the capsules as a character especially indicative of the *Myxosporidia*, and of these no gregarine spore has so far shown a trace, the two bodies found by Schneider in the *Adelea* spore being scarcely to be paralleled with them.

These conditions [the capsules] of the myxosporidian spore speak just as strongly against a close connection between the *Myxosporidia* and the Myxomycetes, as the spores of the latter possess no structures comparable to the myxosporidian capsule. The pigment found in a few *Myxosporidia* (*Myxidium lieberkühnii*, etc.) is not to be compared to that of the Myxomycetes, as it is not of myxosporidian but of extraneous origin. Naturally, the Myxomycetes, especially in the simplest forms, show in their partly peculiar endogenous spore formation a certain similarity to the *Myxosporidia*, but such a similarity also exists between the Myxomycetes and certain *Rhizopoda*. Among the latter the *Myxosporidia* seem to possess some special relation with the interesting *Pelomyxa*, inasmuch as the latter possesses a great number of small nuclei, and in addition it is probable that it produces endogenously chlamydospores, which, however, show no trace of capsules. Further, in the determination of the systematic position of the *Myxosporidia* stress should be laid upon the capsules. From everything that we know they are comparable only to the thread cells, which latter are exclusively animal structures which recent investigations have shown to be present in the *Protozoa*. I do not conceal that this criterion, like the other barriers which have again and again been raised between the animal and vegetable kingdoms, may be erected only to be overturned through more penetrating research.

In 1890 Pfeiffer[2] unites into his family "*Sporidien*" the *Myxosporidia*, *Microsporidia*, and *Sarcosporidia*. He says:

As a transition to more dangerous parasites are next to be made known the *Sarcosporidia*, of which Miescher's tubes in the transversely striped muscles of the warm-blooded animals are already known to physicians, but which are also found exactly similar, only with differently shaped spores, e. g., in the flesh of the barbel.

Spore formation has, he says, no constancy, transitions being found towards more highly developed forms and also toward the lower members of the *Sporozoa*. Thus in the tench fully developed forms are found only upon the branchiæ and in the air-bladder. In the gall bladder and the cysts on the splenic artery, spore types are found which form, step by step, transitions to the simple pseudonavicellæ of the Gregarines and to the structureless ovoids of the microsporidian cysts of *Bombyx*, *Daphnia*, etc., and to the condition observed in coccidian

[1] Ztschr. f. wiss. Zool., XXXV, pp. 648–650; also Bronn's Thier-Reich, 1882, I, pp. 601–603.

[2] Die Protozoen als Krankheitserreger, 1 ed., pp. 25–27, 42, 48, 74.

infection of epithelium. The typical myxosporidian spore-form is accordingly not of such preëminent importance. Further:

> Whether the differentiation of the *Sporidia*, heretofore principally based upon the structure of the spore, will permit itself to be maintained is a matter for zoologists. The following investigations show too often how little stress is to be laid upon this mark alone, and what variations occur through adaptation.

Compared with the Gregarines, the *Myxosporidia* show their lower position by the lack of constant body form.

In the second edition of the same work (1891, pp. 7, 8, 10) he reduces his family *Sporidia* to the rank of a subfamily of the family *Coccidia*. He regards the "psorosperm" as a resting spore, and says it may be the equivalent of the individual falciform germs of the *Sarcosporidia*. The capsules, he says, also occur in the sarcosporidian spore (see p. 88).

The following is, I think, a fair summary of the evidence:

The *Myxosporidia* differ from the remaining *Sporozoa* in the multinucleate amœbiform adult, the pansporoblastic spore formation, and especially in the capsulate spores, which never contain falciform germs. At the same time the consensus, and I believe the evidence, favors their retention in the *Sporozoa*, of which they form a rather aberrant subclass.

As regards the relation of the *Myxosporidia* to the Myxomycetes, is there any evidence that the myxosporidium is a plasmode? In the diagnosis of the myxomycete plasmode the following are the most important points:

(*a*) Actual observation of plasmode formation by fusion of individuals. Now, not only has this never been seen[1] in the *Myxosporidia*, but the multiple nuclei of the myxosporidium are known in several cases to (and in all probability always do) originate by the division of the primitive single one.

(*b*) The presence of various shades of red, brown, or black pigment. This has never been seen in the *Myxosporidia*. All pigment there found appears to be of extraneous origin.[2]

Add to this the differences in the methods of spore formation (and particularly the fact that spore formation in the *Myxosporidia* does not terminate the life cycle) and the further fact that, as Bütschli remarks, no known myxomycete spore has any structure comparable to the

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[1] Of course it may hereafter be found, but it will be time enough to approximate the two groups when it is found.

Even if its existence were demonstrated (and, from sarcosporidian analogy, Pfeiffer regards it only as probable), the process described by Pfeiffer (Die Protozoen als Krankheitserreger, 1 ed., 1890, p. 34; 2 ed., 1891, p. 108; see also p. 227) in the muscles of the barbel could not possibly bear this construction, as the myxosporidium fusion here described is not zoologic, but secondary to common incapsulation, and is rather comparable to fusion of abscesses and ovarian cysts, where the adjacent walls disappear from pressure-atrophy, or otherwise.

This fusion process under pressure has also recently been observed by Korotneff (see p. 188).

[2] This statement must perhaps now be qualified; see pp. 77, 277.

myxosporidian capsule, and the evidence against the myxomycete theory becomes very strong.

IV. DISTRIBUTION.

From the practical standpoint there is no more important branch of the subject than the conditions under which the growth of the parasite takes place. Closely related to these conditions is its distribution as regards host and organ, space and season.

ZOOLOGICAL DISTRIBUTION.

The following table includes all the doubtful and true *Myxosporidia* (species 7 to 102) arranged zoologically by hosts. This arrangement reveals a few correlations between the taxonomic relations of the host and those of the parasite.

Distribution zoologically by hosts.

Host.	Seat.							Genus.										Stage known.			Species.	Species No.
	Muscles.	External surface.	Solid organs.	Branchial cavity.	Air bladder.	Gall and urinary bladders, bile ducts, and urinary tubules.	Miscellaneous.	Genus incert.	Glugea.	Pleistophora.	Thelohania.	Myxobolus.	Chloromyxum.	Ceratomyxa.	Cystodiscus.	Sphæromyxa.	Myxidium.	Cyst.	Myxosporidium.	Spore.		
Polyzoa:																						
Alcyonella fungosa							perivisceral cavity	×											×	×	bryozoides *	26
Vermes:																						
Nais proboscidea												×								×	sp. incert	40
Crustacea:																						
Palæmon rectirostris	interfibrillar.										×									×	octospora	31
Palæmon serratus	do										×									×	do	31
Palæmonetes varians	×										×									×	macrocystis	33
Crangon vulgaris	×										×									×	giardi	32
Astacus fluviatilis	×										×									×	contejeani	30
Insecta:																						
Tortrix viridana							body cavity								×			×		×	diploxys	98
Pisces:																						
Squalus acanthias						gall bladder							×						×	×	leydigii	94
Galeorhinus galeus						do								×					×	×	sphærulosa	87
Galeus mustelus						do							×						×	×	leydigii	94
Do						do								×					×	×	sphærulosa	87
Scylliorhinus stellaris						do							×						×	×	leydigii	94
Scylliorhinus canicula						do							×						×	×	do	94
Pristiurus melanostomus						do							×						×	×	do	94
Squatina squatina						do							×						×	×	do	94
Raja batis						do							×						×	×	incisum	93
Do						bile ducts											×			×	sp. incert	102
Raja clavata						gall bladder							×						×	×	leydigii	94
Torpedo torpedo						do							×						×	×	do	94
Torpedo marmorata						do							×						×	×	do	94
Dasyatis sp.						do							×						×	×	do	94
Dasyatis pastinica						do								×					×	×	agilis	85
Cephaleutherus aquila						do							×						×	×	leydigii	94
Leptocephalus conger						do		×											×		congri *	11
Erimyzon sucetta oblongus		head										×						×		×	oblongus	54
Do				branchiæ								×						×		×	globosus	62
Cyprinus carpio												×								×	cf. oviformis	43
Do				branchiæ								×								×	oviformis	42

* "*Myxosporidium*" (name not in good standing; see p. 206).

Distribution zoologically by hosts—Continued.

Host.	Seat.							Genus.										Stage known			Species.	Species No.
	Muscles.	External surface.	Solid organs.	Branchial cavity.	Air bladder.	Gall and urinary bladders, bile ducts, and urinary tubules.	Miscellaneous.	Genus incert.	Glugea.	Pleistophora.	Thelohania.	Myxobolus.	Chloromyxum.	Ceratomyxa.	Cystodiscus.	Sphæromyxa.	Myxidium.	Cyst.	Myxosporidium.	Spore.		
Pisces—Continued.																						
Carassius carassius							body cavity.					×								×	sp. incert	56
Labeo niloticus												×								×	unicapsulatus	34
Barbus barbus	×		liver, spleen, kidney, ovary.				heart-cavity; intestinal wall.					×						×	×	×	sp. incert	51
Do				branchiæ								×						×	×	×	mülleri	46
Gobio gobio		fins		do								×								×	oviformis	42
Do			kidney				body cavity.					×						×		×	sp. incert	65
Hybognathus nuchalis		head										×						×		×	macrurus	75
Leuciscus rutilus				opercle, pseudobranchiæ.								×						×		×	cycloides	58
Do							heart	×												×	sp. incert	19
Do				pseudobranchiæ.									×							×	dujardini*	92
Do		sides of body.										×								×	sp. incert	67
Leuciscus cephalus								×											×	×	sp. incert	14
Do						gall bladder.							×						×	×	fluviatile	95
Do					×			×												×	sp. incert	15
Do		fins		branchiæ								×						×	×	×	mülleri	46
Leuciscus grislagine												×								×	sp. incert	50
Leuciscus rutilus or erythrophthalmus.												×								×	do	59
Leuciscus erythrophthalmus.												×								×	do	52
Do		subsquamous.						×												×	do	21
Do				branchiæ									×						×	×	dujardini*	92
Phoxinus phoxinus			kidney, ovary.									×								×	mülleri	46

Do			"accidentally" in kidney.										×							×	elegans *	83
Do		head										×						×		×	sp. incert	53
Phoxinus funduloides		subsquamous.										×								×	transovalis	63
Notropis megalops		subcutaneous.						×										×		×	sp. incert	13
Tinca tinca			spleen	branchiæ		?gall bladder.						×								×	piriformis	35
Do			spleen, kidney.	?do								×								×	brachycystis	37
Do			liver	branchiæ	×	?gall bladder.	intestine					×						×	×	×	ellipsoides	49
Do				do								×								×	bicostatus	48
Do		cornea										×						×		×	sp. incert	38
Do		scales						×													do	20
Chondrostoma nasus	tongue roots.							×										×		×	do	18
Abramis brama				branchiæ				×										×	×		do	7
Do				do								×								×	do	44
Do				do								×								×	do	45
Alburnus alburnus												×								×	obesus	57
Do				branchiæ								×								×	oviformis	42
Misgurnus fossilis			kidney									×								×	piriformis	35
Rhamdia sebæ				lining membrane.								×								×	linearis	78
Pimelodus clarias												×								×	inequalis	36
Synodontis schal		head										×						×		×	strongylurus	73
Pseudoplatystoma fasciatum.				branchial lamellæ.								×								×	linearis	78
Do				branchial arches.								×								×	sp. incert	47
Ameiurus melas		dorsal fin										×						×		×	cf. linearis	77
Coregonus fera	intermuscular tissue.											×						×		×	zschokkei	68
Do	interstitial muscular connective tissue.											×						×		×	kolesnikovi	81
Do	×											×						×	×	×	sp. incert	82
Do				branchial arches.								×						×		×	do	76
Do				do								×						×		×	spheralis	60
Lucius lucius				do								×						×		×	sp. incert	41
Do			ovary									×								×	cf. creplini	69
Do	orbit						eye					×						×		×	schizurus	79

* *Sphærospora.*

Distribution zoologically by hosts—Concluded.

Host.	Seat.							Genus.										Stage known			Species.	Species No.
	Muscles.	External surface.	Solid organs.	Branchial cavity.	Air bladder.	Gall and urinary bladders, bile ducts, and urinary tubules.	Miscellaneous.	Genus incert.	Glugea.	Pleistophora.	Thelohania.	Myxobolus.	Chloromyxum.	Ceratomyxa.	Cystodiscus.	Sphæromyxa.	Myxidium.	Cyst.	Myxosporidium.	Spore.		
Pisces—Concluded.																						
Lucius lucius				branchiæ								×								×	psorospermicus	80
Do						urinary bladder.											×		×	×	lieberkühnii	100
Cyprinodon variegatus		subcutaneous.										×								×	lintoni	75
Aphredoderus sayanus	×											×						×		×	monurus	74
Gasterosteus aculeatus		do																×		×	sp. incert	12
Do								×												×	do	22
Do				branchial "copules"				×										×			do	24
Do		subcutaneous.							×									×	×	×	anomala	28
Do			renal tubules; ovary.										×							×	elegans*	88
Do			do									×								×	brevis	70
Do			do									×								×	medius	71
Pygosteus pungitius			do										×							×	elegans*	88
Do			do									×							•	×	brevis	70
Do			do									×								×	medius	71
Do		subcutaneous.							×									×		×	anomala	28
Syngnathus aequoreus						gall bladder											×		×	×	incurvatum	101
Siphostoma acus						do											×		×	×	do	101
Mugil capito				branchiæ								×						×		×	mugilis	39
Mugil auratus				do								×						×		×	do	39
Scomber scombrus	×											×								×	sp. incert	25
Perca fluviatilis		skin; scales.										×						×		×	sp. incert	66
Do				branchiæ															×		do	8
Do				do								×								×	psorospermicus	80
Stizostedion lucioperca				do				×										×		×	sp. incert	23
Do		head; fins		opercle branchiæ.								×						×		×	sp. incert	61
Acerina cernua												×								×	creplini	72

Do												×								×	perlatum	90
Crenilabrus melops												×						×	×	×	mülleri	46
Cottus scorpio	interfibrillar.									×									×	×	typicalis	29
Gobius fluviatilis							body cavity.	×												×	sp. incert	16
Aphya alba		subcutaneous.							×									×		×	anomala	28
Callionymus lyra	intrafibrillar.								×										×	×	destruens	27
Do						gall bladder											×		×	×	incurvatum	101
Blennius pholis						do											×		×	×	do	101
Lota lota						do		×											×		sp. incert	9
Do				branchiæ				×											×		do	10
Do			ovary										×						×	×	do	91
Do			kidney									×								×	diplurus	83
Do			do			urinary bladder.													×	×	mucronatum	96
Onus tricirratus						gall bladder											×		×	×	incurvatum	101
Do						do													×	×	arcuata	84
Do						do													×	×	balbianii	99
Onus maculatus						do													×	×	do	99
Merlucius merlucius						do						×							×	×	merlucii	64
Lophius piscatorius						do								×					×	×	appendiculata	86
Batrachia:																						
Bufo agua						do									×				×	×	immersus	97
Bufo lentiginosus						renal tubules; bladder.														×	ohlmacheri	89
Cystignathus ocellatus						gall bladder									×				×	×	immersus	97
Reptilia:																						
"Crocodile"							intestinal mucosa and muscularis.	×												×	sp. incert	17

* *Sphærospora.*

ORGANAL DISTRIBUTION.

ORGANAL DISTRIBUTION OF THE GENERA AND SPECIES.

Perugia[1] remarks that there is a marked difference in seat between the *Myxosporidia* of marine and those of fresh-water fishes. In marine fishes they occur principally in the gall bladder, while in fresh-water fishes their organal range is much wider. The finding of cysts on the branchiæ of the marine genus *Mugil* (see p. 213) rather corroborates than contradicts this view, inasmuch as these fishes ascend rivers for a long distance, and those which yielded the myxosporidian cysts also yielded a Trematode of a genus peculiar to fresh-water fishes, viz, *Tetraonchus vanbenedenii* Par. & Per.

The organal distribution of the *Myxosporidia* is very extended. The following points are of special interest, and comprise the principal anomalies of distribution not covered by the tables below.

Nervous system.—No species have ever been reported.

Testicle.—No species have ever been reported, a fact which,[2] considering their frequency in the ovary, is very surprising (cf. the presence of "*Myxosporidium*" *bryozoides* on the spermatoblasts of *Alcyonella fungosa*; see p. 187).

Superficial tract.—General similarity of conditions, histologic structure, and fauna justify the fusion of the general surface, skin, scales, the branchiæ, the eye, and the air bladder into one tract. The characteristics of this tract are principally the predominance of connective tissue, and (?) a relatively larger supply of oxygen (see p. 224).

Air bladder: Only two species are known from this seat. Both of these occur in *Cyprinidæ*, in which the bladder communicates freely with the intestine, and hence presumably contains oxygen. This fact, the histologic similarity, and the fauna suggest very strongly the propriety of including the air bladder in the external tract. The species are *Gen. incert. sp.* 15 and *Myxobolus ellipsoides*.

Intestinal canal.—They would appear to be very rare here. I am not aware that any species has ever been reported from the lumen, the nearest approach to it being one (*Myxidium? sp.* 102) from the bile-ducts. And yet such a species as the last must almost certainly find its way into the intestine; probably, however, as separated, single spores, very difficult to find. In addition, *Myxobolus ellipsoides* and *M. sp.* 51 (the latter from the wall), and finally *Gen. incert. sp.* 17 (which, however, may or may not be myxosporidian) occur on, or in the intestine.[3]

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[1] Boll. Scientif., Pavia, 1890, XII, p. 139.

[2] As remarked by Thélohan (Annal. de Microgr., 1890, II, p. 197).

[3] The fact that *M. ellipsoides* and *M. sp.* 51 are, of all the *Myxosporidia*, the species having the widest organal distribution, should not be lost sight of in considering their presence in unusual seats.

Liver (exclusive of gall bladder and ducts). But two species are known here, and these are the two which have the widest organal range, viz: *Myxobolus ellipsoides* and *Myxobolus sp.* 51.

Kidney.—In only a few instances has any distinction been made between the stroma of the kidney and the tubules. It seems, however, not improbable that, as regards organal distribution, a distinction should be made, and the tubules be regarded as a part of the hollow fluid-filled urinary tract, the stroma forming a solid connective tissue seat. The following occur here:

"Kidney": *M. piriformis, M. brachycystis, M. mülleri, Myxobolus sp.* 51, *M. ? sp.* 65, *M. diplurus.*

Renal tubules: *Myxobolus brevis, M. medius, Chloromyxum* (*S.*) *elegans, C.* (*S.*) *ohlmacheri.*

Spleen.—This organ has furnished: *Myxobolus piriformis, M. brachycystis, M. Ellipsoides, M. sp.* 51.

Ovary.—From this are known: *Myxobolus mülleri, M. sp.* 51, *M. brevis* (2 hosts), *M. medius* (2 hosts), *M. cf. creplini, Chloromyxum* (*S.*) *elegans* (2 hosts), *C. sp.* 91.

Excretory tract.—For purposes of organal distribution, the gall and urinary bladders should be considered together, as they present practically identical environmental conditions, both being internal (which means a uniform temperature) and both being fluid-filled. To these cavities may perhaps be added, as exhibiting similar conditions, the bile-ducts and the renal tubules.

If, now, we consider this tract as a whole, we find that its rich and peculiar fauna stands in strong contrast to the species inhabiting the remaining organs. For we find absolutely confined to it the following: The *Chloromyxidæ* except only *Chloromyxum dujardini*, the *Cystodiscidæ*, except the insecticolous *Cystodiscus ? ? diploxys*, and the *Myxidiidæ*. Besides these, only the following species occur in this tract:

(*a*) In the gall bladder: *Genus incert. sp. 9*, "*Myxosporidium*" *congri*,[1] *Myxobolus ? merlucii.*[2]

(*b*) In the renal tubules: *Myxobolus brevis, Myxobolus medius.*

In the following table all the species—47 in number—whose generic references are fairly certain and whose seats are known, are compared as regards their organal distribution. The unit adopted is the occurrence of 1 myxosporidian species in 1 organ of 1 host. The number of such "occurrences" is shown for each species by the Roman, and for each genus by the Arabic numerals.

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[1] Spore unknown (genus? See pp. 110, 182).

[2] Generic reference, in the almost entire absence of a description, by no means certain.

Organal distribution.

Muscles.	Superficial tract. Body surface, skin, scales, fins, subcutaneous tissue, cornea, eye.	Superficial tract. Branchial cavity (lining membrane of), branchial lamellæ, pseudo branchiæ.	Air bladder.	Intestine.	Liver (except gall bladder and ducts).	Spleen.	Ovary.	Kidney (except renal tubules).	Excretory tract. Renal tubules.	Excretory tract. Gall bladder.	Excretory tract. Urinary bladder.	Excretory tract. Bile ducts.	Genera and species.	Species No.
1	3	......	...	...	......	...	...	......	...	...	...	...	Glugea:	
I	......	......	...	...	......	...	...	......	...	...	...	...	destruens	27
...	III	......	...	...	......	...	...	......	...	...	...	...	anomala	28
1	......	......	...	...	......	...	...	......	...	...	...	...	Pleistophora:	
I	......	......	...	...	......	...	...	......	...	...	...	...	typicalis	29
5	......	......	...	...	......	...	...	......	...	...	...	...	Thelohania:	
I	......	......	...	...	......	...	...	......	...	...	...	...	contejeani	30
II	......	......	...	...	......	...	...	......	...	...	...	...	octospora	31
I	......	......	...	...	......	...	...	......	...	...	...	...	giardi	32
I	......	......	...	...	......	...	...	......	...	...	...	...	macrocystis	33
...	......	......	...	...	......	...	...	......	...	...	...	...		
3	10	14	1	1	2	2	7	4*	4	...	...	...	Myxobolus:	
I	......	......	...	...	......	...	...	......	...	...	...	...	kolesnikovi	81
I	......	......	...	...	......	...	...	......	...	...	...	...	sp. incert	82
I	......	......	...	...	I	I	I	I*	...	...	...	...	sp. incert	51
...	I	......	...	...	......	...	...	......	...	...	...	...	oblongus	54
...	I	......	...	...	......	...	...	......	...	...	...	...	lintoni	55
...	I	......	...	...	......	...	...	......	...	...	...	...	transovalis	63
...	I	......	...	...	......	...	...	......	...	...	...	...	strongylurus	73
...	I	......	...	...	......	...	...	......	...	...	...	...	monurus	74
...	I	......	...	...	......	...	...	......	...	...	...	...	macrurus	75
...	I	......	...	...	......	...	...	......	...	...	...	...	cf. linearis	77
...	I	......	...	...	......	...	...	......	...	...	...	...	schizurus	79
...	I	III	...	...	......	...	...	......	...	...	...	...	oviformis	42
...	I	II	...	...	......	...	I	I*	...	...	...	...	mülleri	46
...	......	I	...	...	......	...	...	......	...	...	...	...	sp. incert	76
...	......	I	...	...	......	...	...	......	...	...	...	...	globosus	62
...	......	I	...	...	......	...	...	......	...	...	...	...	sp. incert	45
...	......	II	...	...	......	...	...	......	...	...	...	...	linearis	78
...	......	II	...	...	......	...	...	......	...	...	...	...	psorospermicus	80
...	......	I	I	I	I	...	...	......	...	...	...	...	ellipsoides	49
...	......	I	...	...	......	I	...	I*	...	...	...	...	piriformis	35
...	......	......	...	...	......	...	I	......	...	...	...	...	cf. creplini	69
...	......	......	...	...	......	...	II	......	II	...	...	...	brevis	70
...	......	......	...	...	......	...	II	......	II	...	...	...	medius	71
...	......	......	...	...	......	...	...	I*	...	...	...	...	diplurus	83
3	10	14	1	1	2	2	7	4*	4	...	...	...	Total "occurrences" of vacuolate species.	
...	......	2	...	...	......	...	2	1*	3	13	1	...	Chloromyxum:	
...	......	II	...	...	......	...	...	......	...	...	...	...	(S.) dujardini	92
...	......	......	...	...	......	...	II	I*	II	...	...	...	(S.) elegans	88
...	......	......	...	...	......	...	...	......	I	...	...	...	(S.) ohlmacheri	89
...	......	......	...	...	......	...	...	......	...	I	...	...	incisum	93
...	......	......	...	...	......	...	...	......	...	XI	...	...	leydigii	94
...	......	......	...	...	......	...	...	......	...	I	...	...	fluviatile	95
...	......	......	...	...	......	...	...	......	...	...	I	...	mucronatum	96
...	......	......	...	...	......	...	...	......	...	5	...	...	Ceratomyxa:	
...	......	......	...	...	......	...	...	......	...	I	...	...	arcuata	84
...	......	......	...	...	......	...	...	......	...	I	...	...	agilis	85
...	......	......	...	...	......	...	...	......	...	I	...	...	appendiculata	86
...	......	......	...	...	......	...	...	......	...	II	...	...	sphærulosa	87
...	......	......	...	...	......	...	...	......	...	2	...	...	Cystodiscus:	
...	......	......	...	...	......	...	...	......	...	II	...	...	immersus	97
...	......	......	...	...	......	...	...	......	...	2	...	...	Sphæromyxa:	
...	......	......	...	...	......	...	...	......	...	II	...	...	balbianii	99
...	......	......	...	...	......	...	...	......	...	5	1	1	Myxidium:	
...	......	......	...	...	......	...	...	......	...	V	...	...	incurvatum	101
...	......	......	...	...	......	...	...	......	...	...	I	...	lieberkühnii	100
...	......	......	...	...	......	...	...	......	...	...	...	I†	sp. incert	102
...	......	2	...	...	......	...	2	1*	3	27	2	1	Total "occurrences" of nonvacuolate species.	

* "Kidney." As no distinction has been made between the kidney stroma and the tubules, these 4 cases are, as regards the present discussion, indeterminate.

† As regards the present question, it matters not whether eventually this species proves to be a *Myxidium* or to belong to some other of the genera with capsules in two separated groups, as all of these genera are nonvacuolate.

These data may be summarized as follows:[1]

Species.*	Species of Phænocystes compared.	
	Non-vacuolate.	Vacuolate.
Confined to excretory tract	14	0
Common to both tracts	1	2
Limited to nonexcretory tracts	1	22

"Occurrences."	Number of "occurrences."	
	Non-vacuolate species.	Vacuolate.
Total*	37	44
In excretory tract	33	4
In nonexcretory tract	4	40

* Omitting the dubious "kidney" species and occurrences, and the somewhat questionable occurrence of *Myxobolus ellipsoides* in the gall bladder.

ORGANAL DISTRIBUTION OF THE VACUOLE.

From an examination of the above table it will be seen that the range of the genus *Myxobolus* throughout the organs is a wide one, *but that it is almost strictly complementary to that of the Chloromyxidæ, Cystodiscidæ, and Myxidiidæ.*

The real significance of these peculiarities of organal distribution lies, however, not so much in the peculiarities of generic-organal distribution, interesting as these are, as in the fact that *these limits of the distribution of the genera in the organs almost exactly coincide with the limits of the presence of the iodinophile vacuole in the subclass,* nearly all of the nonvacuolate *Phænocystes* being confined to the excretory tract, while nearly all the vacuolate *Phænocystes* are absent from this tract.

Two questions immediately suggest themselves:

1. Is it possible that the function of the vacuole is here even remotely shadowed? The constancy of the vacuole in the spore and the inconstancy of vacuoles (? genetically related) in the myxosporidium would seem to indicate that it functions during the spore stage. One supposition which suggests itself is that in some way it might subserve oxygenation, but it is more probable that it serves as a food reservoir for the sporoplasm (cf. Thélohan's comparison of its micro-chemical reactions with those of glycogen; p. 208). Unfortunately the origin of the structure and the phenomena of its disappearance after the exit of the sporoplasm have not been worked out.

[1] If the dubious occurrence of *Myxobolus ellipsoides* in the gall bladder be excluded as not proven. In any case the exceptionally wide organal range of this species should be considered in estimating the value of its occurrence in unusual seats.

2. Are the present generic references of some species correct and are their structural characters accurately determined? While at present the force of analogy is not so absolutely overwhelming as to justify a positive assertion, I strongly suspect that species of genera now indeterminate will ultimately tend to range themselves in accordance with the lines indicated: i. e., that species inhabiting gall bladders (Perugia's "*Myxosporidium*" *congri*, for example) will be found to be referable to nonvacuolate genera.

GEOGRAPHICAL AND SEASONAL DISTRIBUTION.

Out of 76 species of hosts and 96 forms of *Myxosporidia* (true and doubtful; species 7 to 102) localities are known for only 27 species of hosts and 19 forms of *Myxosporidia*, and many of the localities are so vague that they amount to little. In the hope that future descriptions will supplement this glaring deficiency, a table is given showing all the localities and dates of collection heretofore reported.

The condition of the data as regards season is even worse than that referring to locality. Even an approximate date of collection is known in only about 25 per cent of the forms, and yet of all classes of data this is certainly one of the most important. Many of the statements are general in the extreme (e. g., "summer"), and in not a single instance has the temperature of the water been recorded.

Geographical and seasonal distribution.

Locality.	Date.	Host.	Species.	Species No.
Asia:				
Irtisch	May, June	Perca fluviatilis	Myxobolus sp. incert	66
Europe:				
Russia—				
Don	First of winter, May, June.	Stizostedion lucioperca	Myxobolus sp. incert	61
Germany—				
Near Kiel*		Gasterosteus aculeatus	Gen. incert. sp	22
Exact locality?		Carassius carassius	Myxobolus sp. incert	56
Weser		Lucius lucius	Myxidium lieberkühnii	100
Elbe		do	do	100
Rhine		do	do	100
Do		Barbus barbus	Myxobolus sp. incert	51
Saar		do	do	51
Do		Lucius lucius	Myxidium lieberkühnii	100
Mosel		Barbus barbus	Myxobolus sp. incert	51
German rivers	May, June	Stizostedion lucioperca	Myxobolus sp. incert	61
Do	do	Leuciscus rutilus	Chloromyxum dujardini	92
Do	May, June; May 8, 1835; Jan. 31, 1839.	do	Myxobolus cycloides	58
Do	May, June	Perca fluviatilis	Myxobolus sp. incert	66
France:				
Roscoff	Mar. 15 to Nov. 15 ad max.; July 15 to Aug. 31.	Palæmon serratus	Thelohania octospora	31
Do		Onus tricirratus	Sphæromyxa balbianii	99
Do	August, 1892	do	Ceratomyxa arcuata	84
		do	Myxidium incurvatum	101
		Onus maculatus	Sphæromyxa balbianii	99
		Crenilabrus melops	Myxobolus mülleri	46
		Blennius pholis	Myxidium incurvatum	101

* The mention of this locality affords the only chance of an inferential correlation of this form with some one of the others known to live on the same fish.

Geographical and seasonal distribution—Continued.

Locality.	Date.	Host.	Species.	Species No.
Europe—Continued.				
France—Continued.				
Roscoff	Aug. and Sept., 1892.	Lophius piscatorius	Ceratomyxa appendiculata.	86
		Syngnathus æquoreus	Myxidium incurvatum	101
Concarneau	Mar. 15 to Nov. 15; ad max. July 15 to Aug. 31.	Palæmon serratus	Thelohania octospora	31
	Sept., 1892	Dasyatis pastinica	Ceratomyxa agilis	85
		Blennius pholis	Myxidium incurvatum	101
Le Croisic	Mar. 15 to Nov. 15; ad max. July 15 to Aug. 31.	Palæmon rectirostris	Thelohania octospora	31
	Aug. and Sept., 1892.	Lophius piscatorius	Ceratomyxa appendiculata.	86
Seule River		Phoxinus phoxinus	Myxobolus sp. incert	53
Marne River		Barbus barbus	do	51
Department of Doubs.		Astacus fluviatilis	Thelohania contejeani	30
Valéry-au-Caux	Aug., 1891	Galeorhinus galeus	Ceratomyxa sphærulosa	87
	Aug., 1891	Galeus mustelus	do	87
Vilaine, at Rennes		Leuciscus erythrophthalmus.	Chloromyxum dujardini	92
Boulogne		Crangon vulgaris	Thelohania giardi	32
Italy:				
Mincio, near Verona		Palæmonetes varians	Thelohania macrocystis	33
Mediterranean Sea (? near Cagliari, Island of Sardinia; See Müller's Archiv., 1851, p. 223).		Scylliorhinus canicula	Chloromyxum leydigii	94
		Squalus acanthias	do	94
		Squatina squatina	do	94
		Torpedo torpedo	do	94
Europe (unknown localities).	Aug., 1890	Leptocephalus conger	Gen. incert. ("Myxosporidium") congri.	11
	April, May	Coregonus fera	Myxobolus zschokkei	68
	Beginning of February, 1892	Lucius lucius	Myxobolus cf. creplini	69
	May, June	do	Myxobolus schizurus	79
	March 14, 1837	Acerina cernua	Myxobolus creplini	72
	Aug. 13, 1890	Merlucius merlucius	Myxobolus merlucii	64
Africa:				
Nile		Labeo niloticus	Myxobolus unicapsulatus	34
		Synodontis schal	Myxobolus strongylurus	73
North America:				
Massachusetts: Atlantic, at Woods Holl.	Aug. 20, 1889; Aug. 1, 1892.	Cyprinodon variegatus	Myxobolus lintoni	55
New Jersey: Near Woodbury.		Aphredoderus sayanus	Myxobolus monurus	74
Virginia: Four-mile Run (tributary Potomac River), near Carlins.	June 29, 1892	Phoxinus funduloides	Myxobolus transovalis	63
North Carolina: Kinston.		Erimyzon sucetta oblongus.	Myxobolus oblongus	54
Do		do	Myxobolus globosus	62
South Carolina: Columbia.	March 21, 1880	do	do	62
Mississippi: Tributaries Fox River.		do	do	62
Do		do	Myxobolus oblongus	54
Texas: Neches River, 14 miles east of Palestine.	Nov. 24, 1891	Hybognathus nuchalis	Myxobolus macrurus	75
Iowa: Storm Lake	Aug. 23, 1890	Ameiurus melas	Myxobolus cf. linearis	77
Illinois: Sycamore, De Kalb County.	Sept., 1892; July, 1893.	Bufo lentiginosus	Chloromyxum ohlmacheri	89
Ohio: Black River, Lorain County, 6 m. above Lake Erie.	Sept. 1, 1890; Oct. 5, 1891.	Notropis megalops	Genus incert. sp	13
South America:				
Guiana		Pimelodus clarias	Myxobolus inequalis	36
Surinam		do	do	36
South American rivers.		Rhamdia sebæ	Myxobolus linearis	78
Do		Pseudoplatystoma fasciatum.	do	78
Brazil (1 locality)		Bufo agua	Cystodiscus immersus	97
(2 localities)		Cystignathus ocellatus	do	97

V.—CLASSIFICATION OF THE MYXOSPORIDIA.[1]

Although several times previously authors had proposed generic names (apparently merely because the forms looked quite different, and, if we may judge from the absence of even a single generic definition to support any of the generic names, probably without any clear idea of the direction of generic lines) the first serious attempt at classification of the subclass was made by Thélohan.[2] The following is Thélohan's primary classification:

Myxosporidians.

Spores..	Pyriform; capsule 1, at pointed extremity; vacuole 1, aniodinophile, at large extremity.			I. *Glugeidians.*
	Form variable....	No vacuole; capsules 2 or 4.	Capsules 2..	II. *Myxidians.*
			Capsules 4..	III. *Chloromyxans.*
		Vacuole 1, iodinophile.	Capsules 1–2.	IV. *Myxobolans.*

The 3 principles laid down by him as a basis for classification may be thus summarized:

1. The habitat furnishes no sound basis for specific distinctions.

Here the following judicious criticism by Thélohan may be quoted:

Beyond the difference of their habitat, Perugia mentions no other characters which enable him to distinguish specifically the organisms that he has observed. But the habitat can not serve as a criterion, for, in addition to its being a fact entirely removed from the morphologic, histologic, and developmental characters of the parasite, it frequently happens that the same form lives at the expense of very different hosts, and, besides, a myxosporidian habitually parasitic on one particular host can accidentally invade a different species.

The conditions under which the parasite is encountered can not better be taken as a distinctive character, for the same species can present itself under very different states; for example, under the form of small, well-circumscribed tumors, or an irregular infiltration of the tissues.

There is little to add to this, except the hope that it may succeed in directing future investigations toward the parasite rather than the host.

2. The myxosporidium affords no taxonomic criteria.

The myxosporidium exhibits characters that are too nearly identical and too little contrasted to serve as bases for specific determinations. It is, however, possible and advantageous to take account of it, especially in the forms living free in the internal cavities, in which forms its differentiations are much more marked.

3. The spores alone (at least in the present state of our knowledge) offer characters suitable to serve as a basis for classification.

By noting the differences of form and size of these elements, the number of their

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[1] The classification given below has already been published as a preliminary note in the Bulletin of the Commission for 1891 (XI, pp. 408–412). The present discussion contains everything there given with some amplifications.

[2] Bull. Soc. philomat. Paris, 1892, IV, pp. 165–178.

polar capsules, by taking account of the presence or absence of a vacuole in the plasma, of their number in the [pan]sporoblasts, one can, I believe, succeed in obtaining elements sufficient for an attempt of this kind.

And further:

I do not pretend to give a final classification of these organisms; I have wished only to furnish a means, a provisional means, for assigning to the species that may be discovered, a place in accord with their affinities; and above all I have wished, if not to terminate, at least to diminish the confusion which results from the arbitrary and vague manner in which all species have been designated; a confusion which I have only too often had occasion to recognize since I have studied these parasites, and which I believe adds a serious obstacle to the progress of our knowledge in their direction.

Upon the above extracts no criticism is needed. As far as they go they express exactly the conclusions at which I had independently arrived.

In any case, there can be no question as to the propriety of drawing a trenchant line between the "Glugeidians" of Thélohan, and the remaining *Myxosporidia.* This primary division (foreshadowed as early as 1890 by Thélohan)[1] can not, however, rest upon so comparatively unimportant a character as the outline of the spore. I have regarded it as of ordinal value, defining the two orders thus:

I. *Cryptocystes. Myxosporidia* in which the pansporoblast produces many (at the fewest 8) spores; the last minute, without distinct symmetry, with a single capsule; type (and only) family, *Glugeidæ.*

Etymology: κρυπτός, concealed; κύστις, capsule.

II. *Phænocystes. Myxosporidia* in which the pansporoblast produces few (at the most 2) spores;[2] the last relatively large, with distinct symmetry and 2 or more capsules;[3] type family, *Myxobolidæ.*

Etymology: φαίνω, I appear; κύστις, capsule.

Thélohan subdivides the *Phænocystes*[4] thus:

No vacuole; 2 or 4 capsules.....	2 capsules.	II. *Myxidians.*
	4 capsules.	III. *Chloromyxans.*
1 iodinophile vacuole; 1 or 2 capsules.	....	IV. *Myxobolans.*

While the structure of the sporoplasm is of the utmost importance and the presence or absence, and the micro-chemical reactions of the vacuole are undoubtedly its most important taxonomic features, to obtain

[1] He says (Annal. de Micrógr. II, p. 205):

"It is necessary to distinguish in the *Myxosporidia* two types of spores; the one of small size, always ovoid, and deprived of polar capsules; these Gluge discovered in the stickleback. The others, with which the authors have principally occupied themselves, are distinguished by their more considerable size, the different forms which they present, and by the presence of capsules."

[2] Three asserted in one species by Leydig (Müller's Archiv., 1851, p. 229).

[3] Except *Myxobolus unicapsulatus* and *M. piriformis.* This qualification is omitted by Braun (Centralbl. f. Bakt. u. Parasitenkde, 1884, XVI, p. 86).

[4] For the classification of the *Cryptocystes,* see p. 190.

a satisfactory classification of the order it will be necessary to utilize additional characters, in particular those connected with spore topography and spore symmetry. This brings us to a consideration of the

SYMMETRY OF THE MYXOSPORIDIAN SPORE.

Considering the importance of the presence or absence of symmetry throughout the animal kingdom, it is strange that no attention has heretofore been paid to this feature of the myxosporidian spore. These bodies exhibit four varieties of symmetry, viz:

1. *Absence or obscurity of symmetry.*—This is found in the *Cryptocystes*. Antero-posterior symmetry is certainly absent; bilateral and supero-inferior symmetry (or asymmetry) obscure.

2. *Bilateral symmetry* (symmetry around the vertical plane). Present in all genera of *Phænocystes* except *Ceratomyxa*,[1] which is asymmetric as regards the position of the sporoplasm.

3. *Supero-inferior symmetry* (dorso-ventral symmetry; symmetry around the longitudinal plane).—This is the rule in the *Phænocystes*, but as no attention has been directed to the detection of asymmetry, it may be that it is present in a few species. It certainly forms a striking feature of *Myxobolus macrurus*, in which the differentiation of a dorso-ventral axis is perfectly plain. Further, the supero-median cornu extends farther forward than the inferior median cornu in several (all examined by me) *Myxobolus* species, furnishing another indication of this differentiation and a clue to the homology of the superior and inferior surfaces in different spores (see pp. 122, 235).

4. *Antero-posterior symmetry* (symmetry around the transverse plane). This type appears to be characteristic of, and confined to, the genus *Cystodiscus*, in which antero-posterior symmetry is equally present, whether we regard the extremities of the spores as (anterior and posterior) ends or as (right and left) wings.

The importance, for classification, of a study of spore symmetry is soon seen. Employing the knowledge thus obtained for the purpose of orienting the spore, we find that the characters of greatest taxonomic value are:

1. *Spore topography.*—Thus in *Myxidium lieberkühnii* the presence of bilateral and the absence of antero-posterior symmetry show that the two pointed extremities of this spore, heretofore, like all other pointed extremities, loosely termed "ends," do not correspond to anterior and posterior, but to right and left. On the other hand the "ends" in *Cystodiscus* appear to represent ends *sens. strict.*, i. e., to correspond to anterior and posterior.

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[1] With the further exception of two *Myxobolus* species (*M. unicapsulatus* with only 1 capsule, and *M. inequalis* with 2 unequal capsules), which, on account of reduction of characters, have suffered a corresponding loss of the perfect symmetry characteristic of the genus. To make the exception absolutely complete, *M. strongylurus* may be added (see p. 249).

2. *Position and grouping of the capsules.*—Compared to these all-important characters, the mere *number* of the capsules is of minor importance. For, not only does the same genus frequently show 1 or 2, 2 or 4, but the number may even vary in the same species, as (apart from the entirely anomalous case of *Myxobolus ellipsoides*, where "accessory" capsules may develop) *Myxidium lieberkühnii* shows sometimes 2 and sometimes 4 capsules.[1] But what is never varied in the same genus is the *topographic relation* of the capsules. Thus in *Myxobolus*, while in number they may be either 2 or 1, they are never arranged otherwise than in one group, or placed otherwise than at the anterior end, and similarly in all the other genera. In *Myxidium* the capsules are 2 or 4, but whether 2 or 4, they are always in two groups at the right and left extremities of the spore. Also in *Cystodiscus* they are 2 or 4, but always in two groups, which, however, are probably anterior and posterior in position (see p. 278).

In the following table I have plotted out the principal characters and indicated their relations to generic lines.

Comparison of generic characters in the Phænocystes.

[×=present; 0=absent; ( )=less usual; —=condition not known.]

	Symmetry.		Capsules.				Shell.				
					In two groups.			Inclination of plane of junction of valves to longitudinal plane.			
	Antero-posterior.	Bilateral; perfect.	Number.	In one group (at the anterior end).	At the (anterior and posterior) ends.	In the (right and left) wings.	Bivalve.	0°.	90°.	Vacuole.	Tail.
Myxobolus Bütschli *sens. strict*	0	×	2 (or 1)	×	...	...	×	×	...	×	0
Henneguya Thélohan	0	×	2	×	...	...	×	×	...	×	×
Chloromyxum Mingazzini	0	×	4	×	...	...	×	—	× ?	0	0
Myxosoma Thélohan	0	×	2	×	...	...	(*)	—	—	0	0
Sphærospora Thélohan	0	×	2	×	...	...	×	—	× †	0	0
Ceratomyxa Thélohan	0	‡	2	×	...	...	×	...	×	0	0
Cystodiscus Lutz	×	×	2 (or 4)	...	×	...	×	...	×	—	0
Sphæromyxa Thélohan	...	...	2	...	(?)	...	×	...	...	0	...
Myxidium Bütschli	0	×	2 (or 4)	...	...	×	0	...	...	0	0

* From analogy and general similarity of appearance, this genus can hardly be other than bivalve.
† *C. (S.) ohlmacheri.*
‡ Imperfect. Shell and capsules symmetrical; sporoplasm unilateral.

From this table we may conclude that—

1. *Henneguya* agrees with *Myxobolus* in every respect but one, the presence of a tail. (See also p. 206.)

2. Thélohan's groups, "*Myxidiées*" and "*Chloromyxées*," must undergo reärrangement (see table below); for clearly *Chloromyxum*, *Myxosoma*, and *Sphærospora* form a compact group, with which *Myxidium* has no character of consequence in common except the absence of a vacuole.

[1] Balbiani, 1883, Journ. de Microgr., VII, p. 274, fig. 64*g*.

3. *Sphærospora* and *Myxosoma* do not differ at all in the characters given (the distinction between these unispecific genera resting solely upon the outline of the spore), and the two taken together present only a single character in contrast to *Chloromyxum*, viz, the *number* of the capsules. They may therefore be fused as a subgenus of *Chloromyxum*.

4. *Ceratomyxa* agrees sufficiently closely with *Chloromyxum* to permit its reference to the *Chloromyxidæ*.

5. *Cystodiscus* is certainly entitled to separate family rank. To it may be provisionally approximated *Sphæromxya*, it having the capsules in two groups and a bivalve shell. (Compare carefully p. 278.)

6. *Myxidium* must form the type of a separate family, the entirely different position and grouping of the capsules forbidding its reference to the *Chloromyxidæ*.

The following table shows the relations of Thélohan's classification to the one now proposed:

THÉLOHAN'S CLASSIFICATION.

No vacuole, 2 or 4 capsules.	2 capsules: Myxidians. Spores	Fusiform, 1 capsule at each extremity. *Myxidium.*
		Elongated; shell formed of two hollow-cone valves soldered along their bases. *Ceratomyxa.*
		Flattened-ovoid, more or less elongate. *Myxosoma.*
		Spherical. *Sphærospora.*
	4 capsules: Chloromyxans	*Chloromyxum.*
1 iodinophile vacuole; 1 or 2 capsules.	Myxobolans. Spore-shell	Destitute of a tail; capsules 1 or 2. *Myxobolus.*
		With a tail; capsules 2. *Henneguya.*

PROPOSED CLASSIFICATION.

Genus.	Family.	Characters.
Myxidium	*Myxidiidæ*	Bilateral but not antero-posterior symmetry; capsules in two groups right and left; no bivalve shell; no vacuole.
Ceratomyxa	*Chloromyxidæ*	Bilateral but not antero-posterior symmetry; capsules in one group (at the anterior end); a bivalve shell, with the valve-junction plane perpendicular to the longitudinal plane; no vacuole.
Chloromyxum, et subgen. *Sphærospora* (including *Myxosoma*).		
Myxobolus	*Myxobolidæ*	Bilateral but not antero-posterior symmetry; capsules in one group (at the anterior end); a bivalve shell with the valve-junction plane parallel to the longitudinal plane; an iodinophile vacuole.
Henneguya		
Cystodiscus	*Cystodiscidæ*	Bilateral and antero-posterior symmetry; capsules in two groups, anterior and posterior; a bivalve shell with the valve-junction plane perpendicular to the longitudinal plane; condition of sporoplasm unknown.
? *Sphæromyxa*		

SPECIFIC CHARACTERS.

Spore-form: This is a somewhat variable character, e. g., elliptic spores, varying in breadth; nevertheless, considerable dependence may usually be placed upon it.

Tail: I have elsewhere (p. 207) indicated my belief that the presence of a tail is a good specific character. The length of the tail relative to that of the body (caudal index) will also prove useful.

Ridge index: As the width of the ridge bears a very constant ratio to the whole width of the surface of which the ridge forms a part, this ratio is a good specific character, especially as it often differs markedly in different species.

Capsular index: This is a character of great constancy, and hence of much taxonomic value.

Nuclei: The presence or absence of the pericornual nuclei has proved constant in several species examined by me (see p. 210). The position of the remaining nuclei is inconstant.

VI.—PATHOLOGY.

Pfeiffer says[1] that myxosporidian infection is characterized by the rapid disappearance of the nuclei of the infected cells, the infection of the red blood corpuscles, and the attacking of all the elemental tissues of the host, with the possible exception of those of the nervous system; further, through the early spore formation which is unconnected with any external evidence of maturity. And, further, considering how the blood parasites of *Emys*, *Lacerta*, birds, and of malarially diseased cattle and men, employ the blood-corpuscle membranes as protective coverings for their naked bodies; also, that the youngest myxosporidia, just out of the spore shell, attack the red blood corpuscles; and, further, that the *Myxosporidia* spare no organ or elemental cells (the nervous system possibly excepted), the destructiveness of this group of parasites must be recognized to be very great; and, further, that the parasite withdraws directly or indirectly a large quantity of blood from the host, is shown by the hæmatoidin crystals found in all myxosporidia. Finally, a cachexia, comparable with the cancerous cachexia of the warm-blooded animals, is produced.

By a reference to p. 187 it will be seen that Korotneff observed in the polyzoan, *Alcyonella fungosa*, substantially the same process that Pfeiffer records in *Lucius lucius*, viz, an intracellular development during the earlier myxosporidium stages.

Mode of infection.—Leydig[2] remarked that an organism like *Gen. incert. sp.* 4. could pass with the blood current into the various organs, effect a lodgment, become encysted, and give rise to the "psorosperms."

[1] Die Protozoen als Krankheitserreger, 1890, 1 ed., pp. 48–49; 2 ed., 1891, p. 135.

[2] Müller's Archiv, 1851, p. 229.

Lieberkühn[1] believed that such amœboid organisms attach themselves to the skin for the purpose of reproduction. Ludwig[2] thinks that the greater frequency of occurrence on the gills indicates a greater ease of infection through this channel than *via* the alimentary canal. Also he says:

> The lymph channels of the connective tissue appear to represent the principal paths through which the parasite spreads itself further through the body.

He, however, fails to give any actual evidence in favor of this view. Pfeiffer[3] says:

> The common occurrence of the *Myxosporidia* in all organs presupposes a distribution *via* the circulation, a mode demonstrated by the infection of the red blood corpuscles.[4]

Effects.—Upon this Balbiani[5] has the following:

> Unlike the Gregarines and the *Coccidia*, the psorosperms spread themselves through almost all the organs, the deep as well as the superficial, the skin, spleen, kidney, air bladder, and even the heart and ovary. They are also found in the cells of the urinary tubules, and in the young Graafian follicles, which they transform into a pocket filled with psorosperms. As at the same time they increase with great rapidity, it results that animals thus infested present grave diseases and may even die. Certain morbid states of fish ought without doubt to be attributed to the *Myxosporidia*. Such is the case of that Merluche[5] observed by J. Müller and which was remarkable for an extraordinary emaciation. I have myself often seen roach, tench, and other fishes reduced by these parasites to a cachectic state characterized by a decoloration of the tissues, destruction of the red blood globules, and augmentation of the white globules; a veritable leucocythæmia. It is not, then, surprising that this disease can cause great ravages among fishes, above all in the young, which are most often affected. Nevertheless this cause is not usually noted as among those which destroy fishes. This is easily explained; when the disease reigns attempts are first made to explain it by macroscopic causes and ordinarily it is the worms which are accused. This was the case in the epidemic of the tench in the étangs of Dombes; it was the Ligules which interfered with digestion and the fishes died of inanition. Microscopic causes are not the ones most frequently suspected. I believe that more frequent search would reveal microscopic lesions capable of explaining the mortalities of young fish, particularly those living in marshes and in aquaria.

Upon this point M. Thélohan[5] remarks that these parasites are generally well borne, but that sometimes the tumors may cause death by pressure effects, e. g., he saw a cyst in *Gasterosteus aculeatus* produce fatal pressure upon the heart.

The principal extensive epidemics have been those involving the barbels and the crayfishes (see pp. 197, 231).

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[1] Müller's Archiv., 1854, p. 357 (see also p. 185).

[2] Jahresber. d. rhein. Fisch.-Vereins, 1888, pp. 33–4.

[3] Die Protozoen als Krankheitserreger, 1890, 1 ed., p. 48.

[4] For the latter see p. 288.

[5] Journ. de Microgr., Paris, 1883, VII, pp. 280–281.

[6] I have elsewhere noted this error (p. 172). The fish in question is *Gadus morrhua* and not *Merlucius merlucius*.

[7] Annal. de Microgr, 1890, II, p. 203.

VII.—MICROSCOPIC TECHNIQUE.

The older observers used no reagents beyond acetic acid, potassium hydrate, etc. Bütschli[1] was the first to use a staining reagent. He believed that alum carmine stained nuclei in the ectoplasm. The first observer to employ modern technique was Henneguy.[2] Subsequently Thélohan[3] employed similar technique, and Pfeiffer[4] devotes some space to the technique of protozoan investigation. Finally Henneguy and Thélohan[5] give a few additional remarks upon this subject.

The following is a summary of the methods recommended: Fixing and hardening preferably by chromic or osmic acid or both (Perenyi's or Flemming's liquids[6]) or corrosive sublimate solution. Washing out, dehydration, paraffining, sectioning as usual. Affixing to the slide by Mayer's albumen. Where alcohol-fixed material is the only kind available, much may be gotten out of it in the way of study of the spore.

Dissociation (1 per cent osmic acid solution; Ripart and Petit's liquid) shows certain facts better than the section method.

Sections are necessary to determine the seat, and, above all, to follow the different stages of development.

Culture in the blood (overhanging drop method) is recommended by Pfeiffer for the study of development.

Stains:[7] For alcoholic specimens, carmine; above all other forms hydrochloric acid alcohol carmine is very reliable. For chrom-osmium (and may be tried on alcoholic) specimens, especially gentian violet, double stain with the violet by eosin. Safranin, by Henneguy's method,[8] evinces an electivity valuable in the study of development where we have to do with the most complex phenomena of cellular life under circumstances in which the small size of the elements renders observation extremely difficult. The sections must be decolorized in clove oil for a very long time. Small stellate-grouped masses of crystals, which are often precipitated and whose presence is very annoying in the subsequent study of the section, may be easily removed by successive alternate washings of the latter in chloroform and bergamot oil.

Valve separation: Most certainly effected by sulphuric acid (cold, concentrated).

Vacuole: Best shown by very dilute iodine water (with potassium iodide).

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[1] Ztschr. f. wiss. Zool., 1881. XXXV, p. 632.

[2] Mém. publiées Soc. philomat. Paris l'Occas. Centen. Fondation, 1888, p. 165.

[3] Annal. de Microgr., 1890, II, p. 196.

[4] Die Protozoen als Krankheitserreger, 1891, 2 ed., pp. 19–24.

[5] Annal. de Microgr., 1892, IV, pp. 620–621.

[6] Also Kleinenberg's liquid (Henneguy, 1888).

[7] Henneguy (1888) also used picrocarmine.

[8] Journ. Anat. et Physiol., Paris, 1891, XXVII, pp. 398–400.

Filament extrusion: Most certainly produced in the fresh state by strong sulphuric acid, iodine water, glycerin, nitric, hydrochloric, acetic, formic acids, alkaline hydrates, boiling water, ether, etc., especially the first two. In alcoholic specimens, also, occasional spores extrude their filaments under the action of sulphuric acid or iodine.

VIII.—DEFINITIONS.

Anterior (and posterior): There can be no question that the longitudinal diameter is the antero-posterior axis of the body. The discrimination of anterior from posterior is, however, in the absence of cephalization, impossible. I have followed custom in calling the sharper, capsular end "anterior," and the opposite rounded end "posterior."

Capsules: The pyriform, hollow, filament-containing bodies characteristic of the myxosporidian spore ("twinned vesicles" of Balbiani; "polar capsules" of Bütschli). "Capsule" is preferred to "vesicle" on account of greater definiteness, and to "polar capsule," as the situation implied by the latter is not constant.

Cornua: The pointed anteriorly projecting extremities of the sporoplasm. They are infero-, and supero-lateral, and infero-, and superomedian. (See also *Surface, superior*, p. 122.)

Diameter, longitudinal: The line formed by the intersection of the longitudinal and vertical planes.

Diameter, transverse: The line formed by the intersection of the transverse and longitudinal planes.

Diameter, vertical: The line formed by the intersection of the vertical and transverse planes.

Ducts: The ducts into which the capsule is drawn out anteriorly and which serve for the exit of the filaments.

Ends (of the spore): The median (anterior and posterior) extremities in contradistinction to the wings.

Filaments: The filaments which lie coiled within the capsules. The "capsular filaments," "spiral filaments," and "coiled filaments" of the authors. *Not* to be confounded with the ribbonettes.

Host: In the usual sense; see also *Seat.*

Myxoplasm: The protoplasm of the myxosporidium.

Myxosporidium: The amœboid adult stage; *Mutterblase*, Leydig.

Pansporoblast: see *Sporoblast.*

Pericystic space: The space apparently empty (presumably fluid-filled) surrounding the capsules.

Plane, longitudinal:[1] Horizontal and percapsular, passing through both capsules and the sporoplasm, and dividing the spore into a superior and an inferior portion.

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[1] For brevity and clearness these planes are defined as if rectangularly arranged about the center of the *Myxobolus* spore, the latter being supposed to be viewed "on the flat."

Plane, transverse:[1] Vertical and (usually) post-capsular in position, dividing (roughly) the spore into a capsular (anterior) and a sporoplasmic (posterior) portion.

Plane, vertical: Longitudinal and intercapsular, passing between the capsules and through the ends of the spore and the median cornua of the sporoplasm, and dividing the spore into a right and a left half.

Posterior: See *Anterior*.

Protocysts: The two smaller segments of the *Myxobolus* sporoblast, which ultimately form the capsules.

Protosporoplasm: The larger segment of the *Myxobolus* sporoblast, which ultimately forms the sporoplasm.

Ribbon: The shell processes described by Balbiani in *Myxobolus ellipsoides* (see pp. 223).

Ribbonettes: The terminal subdivision of the ribbons, termed "filaments" and confounded with the capsular filaments by some writers (see pp. 87, 88, 263).

Ridge: The ridge or "welt" which extends around the circumference, and marks the line of junction of each valve.

Ridge index: The ratio of the width of the ridge to the total width of the surface on which the ridge is situated.

Seat: This term invariably denotes the organ or part of the body in which the myxosporidian is located (see also *Host*).

Sporoblast (and pansporoblast): This term was first used (in the *Myxosporidia*) by Bütschli[2] for the transparent spherical globule formed by the condensation around one of the nuclei, of a portion of the surrounding myxoplasm. The spherical globule so formed subsequently segments into two hemispheres (see p. 81), each of which gives rise to a spore. Now, Balbiani,[3] and Thélohan,[4] and Henneguy and Thélohan,[5] apply the term sporoblast to the two hemispheres. Further, Pfeiffer[6] uses the term sporoblast as a synonym for the *whole sporing myxosporidium*. This latter use of the word should, I think, be unhesitatingly rejected as having no warrant in analogy. By the advice of Dr. C. W. Stiles (who has specially studied the equivalence of this and several other terms[7]), I have followed the lead of Balbiani and Thélohan in restricting the term *sporoblast* to the segments (the two hemispheres above mentioned) formed by the division of the primitive sphere. For the latter (the sporoblast of Bütschli) the term *pansporoblast* is here used.

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[1] Equatorial plane of Lutz, 1889, Centralbl. f. Bakt. u. Parasitenkde, v, p. 86.

[2] Bronn's Thier-Reich, 1882, I, p. 596. He says: "Since the spores originate from the plasma globules, we may conveniently term them *sporoblasts*." Compare also an exceedingly obscure sentence in Bütschli's next paragraph.

[3] Journ. de Microgr., Paris, 1883, VII, p. 275.

[4] Compt. Rend. Acad. Sci. Paris, 1890, CXI, p. 693.

[5] Annal. de Microgr., Paris, 1892, IV, p. 634.

[6] Die Protozoen als Krankheitserreger, 1890, 1 ed., pp. 32, 34, *et al.*

[7] Notes on Parasites; Journ. Compar. Med. & Veter. Archives, New York, 1892, XIII, pp. 321–324.

Sporocyst (rejected): Synonym for spore. Employed by Pfeiffer.[1]

Sporoplasm: The "posterior mass," "plasmic mass," etc., of the spore. This term is used as the equivalent of the phrase "protoplasm of the spore."

Surface, inferior: That upon which the inferior valve (*q. v.*) and the infero-median cornu are situated (see also next).

Surface, superior: That upon which the superior valve (*q. v.*) and the supero-median cornu are situated.

These are, respectively, the equivalent of dorsal and ventral, or of ventral and dorsal. In the absence of hæmal and nervous systems and of an alimentary tract, the proper correlation of these surfaces with the corresponding ones in extra-myxosporidian organisms seems impossible. *Inter se*, however, the superior surfaces may be correlated by a greater convexity of the superior valve, but probably most frequently by the *further projection forward of the supero-median cornu*, which may (?) even reach the extreme anterior end of the shell cavity.

Valve: Each shell half.

Valve, inferior: The less convex valve; see also next.

Valve, superior: The more convex valve. The differentiation is probably possible in only a few cases. The supero-median cornu will probably form a better guide to the discrimination of the superior and inferior surfaces

View, longitudinal, transverse, or vertical; view along the line of the corresponding diameter (*q. v.*).

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[1] Die Protozoen als Krankheitserreger, 1891, 2 ed., pp. 7, 8.

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[1] Pfeiffer, in his bibliography of the *Myxosporidia* (Ztschr. f. Hygien., 1888, IV, p. 436), erroneously includes with the word "Myxosporidia" the following: Blanchard, Bull. Soc. Zool. France, 1885, X, p. 291. The citation is an error and Blanchard's only paper in the volume (pp. 244–276) is sarcosporidian.

[2] According to Pfeiffer (Ztschr. f. Hygien., 1888, IV, p. 436) these 3 articles are the same. They are here given separately on account of the different titles shown by the Royal Society's Catalogue.

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[Article erroneously headed *Ballisan* in the Gazette Médicale, but correct in the index. The two articles are nearly, though not quite, indentical.]

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1867. BALBIANI, G. XXIII.
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1874. CLAPARÈDE. XXV.
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1875. WITTMACK, Dr. L. XXVI.
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1879. LEUCKART, R. **XXIX.**
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1880. RYDER, Prof. JOHN A. **XXX.**
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1882. BÜTSCHLI, O. **XXXIV.**
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1883. BALBIANI, G. **XXXV.**
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1884. BALBIANI, G. **XXXVI.**
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[Erroneously attributed to Davaine, in Leuckart's Parasites of Man, 2 ed., 1886, p. 191.]

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[An almost *verbatim* reprint of preceding; no figure.]

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1886. KOLESNIKOFF, N. F. **XLII.**
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[Practically identical with preceding.]

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[Unimportant; psorospermosis of carp found labeled "multiple sarcoma."]

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[1] Misquoted by Pfeiffer (1890, *infra*, p. 49) as "Bacteriologisches Centralblatt, 1890."

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1890. LECLERCQ, Mlle. **LXI.**

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[1] In the second edition (1891, *infra*, p. 7) Pfeiffer says the plate is rendered obsolete by the subsequent discovery of the swarm-spores.

[2] Misquoted "d'Agricult." (Pfeiffer, 1891, *infra*, p. 105.)

[3] Date of distribution *fide* records of U. S. Fish Commission.

Bibliographic reference No.

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On the classification of the Myxosporidia; Bull. U. S. Fish Com. for 1891 (July 15, 1893), XI, pp. 407-420; review, Braun, Centralbl. f. Bakt. u. Parasitenkunde, Jan. 16, 1894, XV, pp. 86-8.

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Sur les affinités réciproques des Myxosporidies; Compt. Rend. Acad. Sci. Paris, Feb. 19, 1894, CXVIII, pp. 428–430 (abstract, p. 275.)

b. The literature by authors.

Author.	Date.	Bibliographic reference number.	Author.	Date.	Bibliographic reference number.
Balbiani	1863	XXI.	Leydig	1851	XII.
Do	1866	XXII.	Lieberkühn	1854	XVI.
Do	1867	XXIII.	Do	1854	XVII.
Do	1883	XXXV.	Do	1854	XVIII.
Do	1884	XXXVI.	Do	1855	XIX.
Bessels	1867	XXIV.	Linton	1891	LXX.
Borne	1886	XLVII.	Do	1891	LXXI.
Braun	1893	LXXXIV.	Ludwig	1888	LIV.
Bütschli	1881	XXXII.	Lutz	1889	LV.
Do	1881	XXXIII.	Mégnin	1885	XXXIX.
Do	1882	XXXIV.	Do	1885	XL.
Claparède	1874	XXV.	Mingazzini	1890	LXV.
Creplin	1842	VI.	Moniez	1887	XLIX.
Dujardin	1845	X.	Müller	1841	III.
Engler & Prantl	1892	LXXIX.	Do	1841	IV.
Gabriel	1880	XXXI.	Do	1841	V.
Garbini	1891	LXIX.	Do	1843	VIII.
Gluge	1838	I.	Ohlmacher	1893	LXXXVI.
Do	1841	II.	Perrier	1893	LXXXIII.
Gurley	1893	LXXXVII.	Perugia	1890–91	LXVII.
Heckel & Kner	1858	XX.	Pfeiffer	1887	L.
Henneguy (see also Henneguy & Thélohan; Thélohan & Henneguy)	1888	LII.	Do	1888	LI.
			Do	1890	LXII.
			Do	1890	LXIII.
Do	1889	LVI.	Do	1891	LXXII.
Henneguy & Thélohan	1892	LXXVIII.	Do	1893	LXXXVIII.
Do	1892	LXXXII.	Prantl (see Engler & Prantl)		
Kner (see Heckel & Kner).			Railliet	1886	XLIII.
Koch	1887	XLVIII.	Do	1886	XLVI.
Kolesnikoff	1886	XLII.	Do	1890	LXIV.
Korotneff	1892	LXXIV.	Do	1893	XCI.
Kruse	1892	LXXVI.	Rayer	1843	VII.
Ladague	1884	XXXVII.	Do	1843	IX.
Lankester	1885	XLI.	Remak	1852	XIII.
Leclercq	1890	LXI.	Robin	1853	XV.
Leuckart	1852	XIV.	Ryder	1880	XXX.
Do	1847	(See p. —).	Schneider	1875	XXVII.
Do	1879	XXIX.	Sibley	1890	LX.
Do	1886	XLIV.	Solger	1877	XXVIII.
Leunis	1886	XLV.	Sticker	1892	LXXXIX.
Leydig	1851	XI.			

b. The literature by authors—Concluded.

Author.	Date.	Bibliographic reference number.	Author.	Date.	Bibliographic reference number.
Thélohan (see also Henneguy & Thélohan; Thélohan & Henneguy)	1889	LVII.	Thélohan (see also Henneguy & Thélohan; Thélohan & Henneguy)	1893	LXXXV.
Do	1890	LVIII.	Do	1894	XCII.
Do	1890	LIX.	Thélohan & Henneguy	1892	LXXVII.
Do	1890	LXVI.	Volkszeitung	1888	LIII.
Do	1891	LXVIII.	Weltner	1892	LXXV.
Do	1892	LXXIII.	Whinery	1893	XC.
Do	1892	LXXX.	Wittmack	1875	XXVI.
Do	1892	LXXXII.	Zschokke	1884	XXXVIII.

TABLE SHOWING THE DERIVATION AND EQUIVALENCE OF ALL FIGURES IN THIS PAPER REPRODUCED FROM PREVIOUS AUTHORS.

The following table shows the equivalence of all figures in the literature, including those of species formerly considered myxosporidian but now rejected. Figures to the right are copied from those farther to the left on the same horizontal line, and those copied in this paper are, in all cases, taken directly from the original. Further, wherever several series of letters or figures (indicated, for economy of space, as "*a–m*" "1–16, etc.) occur on the same horizontal line, the individual members of such series correspond *always and rigidly* each to each, that is, *a* to *a*, *b* to *b*, 1 to 1, 2 to 2, or 7 to 10, 8 to 11, etc., as the case may be. To save space all intermediate columns not required on any particular page are omitted from that page. Such omitted columns will of course appear on some other page, and their relative positions in the full series of illustrated articles represented in this table, are indicated by the bibliographic reference number (Roman numerals). Plate numbers (heavy type) are inserted only where absolutely necessary to prevent ambiguity.

After much study of the literature certain figures can not now be placed with any certainty. They are those to which no species number corresponds in the table. It will be seen that they are principally some of Pfeiffer's and Balbiani's and are mainly to be distributed between the two probably very distinct but at present not very clearly delimited species habitant on the tench, *Myxobolus piriformis* and *M. ellipsoides*. On the plates I have thought it best to reproduce the groups of figures entire and to leave to the future the apportionment of the individual figures, and will only add that in the synonymy of *M. piriformis* and *M. ellipsoides* I have ventured on a taxonomic guess, the dubious figures being separated from those definitely placed by a period or a parenthesis.

Table of equivalence of figures.

Gluge, 1838, I.	Gluge, 1841, II.	Valentin, 1841.	Müller, 1841, III.	Müller & Retzius, 1842.	Creplin, 1842, VI.	Rayer, 1843, VII.	Müller, 1843, VIII.	Dujardin, 1845, X.	Leydig, 1851, XII.	Remak, 1852, XIII.	Leuckart, 1852, XIV.	Robin, 1853, XV.	Gurley, 1894.	Species No.
I*a*	I*a*	...	...	...	...		...	...	...	...	...	...	**10**,1*a*	28
b	*b*	...	...	...	...	11	...	...	...	...	...	...	*b*	28
II*a-b*	II*a–b*	...	...	...	...		...	...	...	...	...	...	*c,d*	28
c	*c*	...	...	...	...	12	...	...	...	...	...	...	*e*	28
d–e	*d–e*	...	...	...	...	...	...	...	...	...	...	...	*f,g*	28
f	...	...	...	...	...	...	...	...	...	...	...	...	*h*	28
...	...	16*a–m*	...	...	...	...	...	...	...	...	...	...	4,1*a–m*	4
...	...	...	1*a–b*	...	...	...	1*a–b*	...	...	...	...	14,2*a–b*	36,1*a–b*	79
...	...	...	*c*	...	...	...	*c*	...	...	...	...	...	*c*	79
...	...	...	*d*	...	...	...	*d*	...	...	...	...	3	*d*	79
...	...	...	2*a–b*	...	...	...	2*a–b*	...	...	...	...	4*a–b*	31,5*a–b*	73
...	...	...	3*a–b*	...	...	...	3*a–b*	...	...	...	...	5*a–b*	25,6*a–b*	61
...	...	...	*c*	...	...	...	*c*	...	...	...	...	6*c*, *d*	*c*	61
...	...	...	*d*	...	...	...	*d*	...	...	...	...	*e*	*d*	61
...	...	...	*e*	...	...	...	*e*	...	...	...	...	*f*	*e*	61
...	...	...	*f*	...	...	...	*f*	...	...	...	...	*l*	*f*	61
...	...	...	*g–k*	...	...	...	*g–k*	...	...	...	...	*g–k*	*g–k*	61
...	...	...	*l*	...	...	...	*l*	...	...	...	...	...	*l*	61
...	...	...	4*a*	...	...	...	4*a*	...	...	...	...	...	28,5*a*	58
...	...	...	*b–c*	...	...	...	*b–c*	...	...	...	...	6*b–c*	40,4*b–c*	92
...	...	...	*d–g*	...	...	...	*d–g*	...	...	...	...	*d–g*	28,5*d–g*	58
...	...	...	5*a–d*	...	...	...	5*a–d*	...	...	...	...	7*a–d*	13,1*a–d*	34
...	...	...	6*a–b*	...	...	...	6*a–b*	...	...	...	...	8*a–b*	2*a–b*	36
...	...	...	7	...	...	...	7	...	...	...	...	9	26,3	54
...	...	...	8	...	...	...	8	...	...	...	...	...	4	54
...	...	...	9*a–b*	...	...	...	9*a–b*	...	...	...	...	10*a–b*	5*a–b*	54
...	...	...	10	...	...	...	10	...	...	...	...	11	36,2	78
...	...	...	...	1	...	14	...	...	...	...	...	*a–l*	2,3*a–l*	3
												...	*m–p*	3
...	...	...	...	...	1A–E	...	...	...	...	...	...	...	32,1*a–e*	72
...	...	...	...	...	...	13	...	...	...	...	...	...	26,2	53
...	...	...	...	...	...	...	...	12N_1	...	...	...	...	40,5	92
...	...	...	...	...	...	...	...	N_2	...	...	...	...	6	92
...	...	...	...	...	...	...	...	...	1*a–e*	...	...	...	38,1*a–e*	94
...	...	...	...	...	...	...	...	...	2*a*	...	...	...	2*a*	94
...	...	...	...	...	...	...	...	...	3*a–e*	...	...	...	39,1*a–e*	94
...	...	...	...	...	...	...	...	...	4*a–f*	...	...	...	37,1*a–f*	93
...	...	...	...	...	...	...	...	...	*g*	...	21*b*	...	47,8	102
...	...	...	...	...	...	...	...	...	5*a–b*	...	...	...	39,2*a–b*	94
...	...	...	...	...	...	...	...	...	...	5	...	...	14,1	37
...	...	...	...	...	...	...	...	...	...	7*a–c*	...	...	2*a–c*	37
...	...	...	...	...	...	...	...	...	...	8	...	...	3	37
...	...	...	...	...	...	...	...	...	...	9B	...	...	26,1	52
...	...	...	...	...	...	...	...	...	...	...	*c*	...	22,4*a*	50
...	...	...	...	...	...	...	...	...	...	...	*d*	...	*b*	50
...	...	...	...	...	...	...	...	...	...	...	*e*	...	32,2	72
...	...	...	...	...	...	...	...	...	...	...	22	...	39,3	94
...	...	...	...	...	...	...	...	...	...	...	...	14	1,1*a*	1
...	...	...	...	...	...	...	...	...	...	...	...	15	*b*	1
...	...	...	...	...	...	...	...	...	...	...	...	**15** 1	...	1
...	...	...	...	...	...	...	...	...	...	...	...	2	...	1
...	...	...	...	...	...	...	...	...	...	...	...	3	...	1
...	...	...	...	...	...	...	...	...	...	...	...	4	...	1
...	...	...	...	...	...	...	...	...	...	...	...	5*a–b*	...	1
...	...	...	...	...	...	...	...	...	...	...	...	6	1,2	1
...	...	...	...	...	...	...	...	...	...	...	...	7	3	1
...	...	...	...	...	...	...	...	...	...	...	...	8	4	1

Table of equivalence of figures—Continued.

Lieberkühn, 1854, XVI.	Lieberkühn, 1855, XIX.	Balbiani, 1867, XXIII.	Leuckart, 1879, XXIX.	Ryder, 1880, XXX.	Bütschli, 1881, XXXIII.	Bütschli, 1882, XXXIV.	Zschokke, 1884, XXXVIII.	Lankester, 1885, XLI.	Leuckart, 1886, XLIV.	Leunis, 1886, XLV.	Koch, 1887, XLVIII.	Engler & Prantl, 1892, LXXIX.	Gurley, 1894.	Species No.
21–27													**14,** *4a–g*	38
28													**7,** *4a*	13
1													**43,** *1a*	100
2			98						98		668, 1		*1b*	100
3													**46,** 3	100
4													**47,** 2	100
5						17							**39,** *5a*	96
6			*99a*						99A		668, 3		*b*	96
7						*18b*					668, 2		**15,** *7b*	44
8			*99b*			*18c*			99B				*c*	44
9–12													**7,** *4b–e*	13
	10–12												**15,** 2–4	41
	1												5	41
	6–8												*6a–c*	41
		10											**42,** 11	98
		11											12	98
		12a–c											*13a–c*	98
				1A–C									**32,** *3a–c*	74
				2B–D									*4b–d*	74
					1								**17,** *1a*	46
					2	*6b*		40					*b*	46
					3								*c*	46
					4								2	46
					5	7							**16,** *3a*	46
					6	8							*b*	46
					7								**17,** 5	46
					8								*4a*	46
					9								*b*	46
					10								*c*	46
					11								*d*	46
					12								6	46
					13								3	46
					14	*10a*							**16,** *6a*	46
					15	9		41					*b*	46
					16								*c*	46
					17								*d*	46
					18	*10b*							*e*	46
					19								**17,** *7a*	46
					20								*b*	46
					21								**16,** 5	46
					22	*6a*							1	46
					23					1, 118			4	46
					24								2	46
					25								**44,** *1a*	100
					26								*b*	100
					27								2	100
					28								3	100
					29								**43,** 3	100
					30								4	100
					31								**44,** 4	100
					32	15						22E	**47,** 3	100
					33								5	100
					34a–d								**44,** *5a–d*	100
					35	*14a*						22B	**47,** *1a*	100
					36	*b*							*b*	100
					37	*c*						22C	*c*	100
					38	*d*						22D	*d*	100
					39								*e*	100
					40								*f*	100
						5							**40,** 7	92
						11							**15,** 1	41
						12		34					**43,** 5	100
						13							2	100
						16a		43					**34,** *1a*	80
						b							*b*	80
						c		44					*c*	80
						18a							**15,** *7a*	44
						19							**19,** 1	48
						20							**6,** 1	9
						21		42					**36,** 4	83
						22							**40,** 3	91
						23a–b							**14,** *7a–b*	40
						24							**6,** 2	10
							16						**31,** *1a–e*	68

Table of equivalence of figures—Continued.

Balbiani, 1883, XXXV.	Balbiani, 1884, XXXVI.	Mégnin, 1885, XXXIX.	Kolesnikoff, 1886, XLII.	Railliet, 1886, XLVI.	Borne, 1886, XLVII.	Pfeiffer, 1887, L.	Pfeiffer, 1888, LI.	Henneguy, 1888, LII.	Ludwig, 1888, LIV.	Lutz, 1889, LV.	Henneguy, 1889, LVI.	Thélohan, 1890, LVIII.	Pfeiffer, 1890, LXII.	Pfeiffer, 1890, LXIII.	Pfeiffer, 1891, LXXII.	Gurley, 1894.	Species No.
40*a-h*	36*a-h*			72*a-h*							2*a-h*					**21,** 1*a–h*	49
41*a-d*	37*a-d*															**34,** 3*a–d*	80
42*a-d*	38*a-d*															4*a–d*	80
43*a-b*	39*a-b*															**28,** 7*a–b*	57
44*a-b*	40*a-b*															**40,** 2*a–b*	90
45*a-c*	41*a-c*															**39,** 6*a–c*	96
61*a-e*	42*a-e*															**21,** 2*a–e*	49
62*a-c*	43*a-c*						15*a*									**20,** 1*a–c*	49
63*a-c*	44*a-c*															2*a–c*	49
64*a-d*	45*a-d*															**46,** 2*a–d*	100
64*e-g*	45*e-g*															**47,** 4*a–c*	100
65*a-c*	46*a-c*															**20,** 3*a–c*	49
66*a-f*	47*a-f*															**13,** 4*a–f*	(*)
	9															**19,** 4	49
	1															**18,** 1 }	{ 35
	2															2 }	{ 49
	3A															**13,** 3A	(*)
	B															B	(*)
	C															C	(*)
		A														**25,** 1*a*	51
		A′-A‴														a_1–a_3	51
		B-H														*b–h*	51
			1													**35,** 1	81
			2													2–6	81
			3													7	81
					215											**29,** 8*a–b*	67
						2*e*										**22,** 1	(*)
						f										2	(*)
						g										3	(*)
							15*b*									**21,** 4	(*)
							c									5	49
								A–D								**10,** 6*a–d*	31
									1–3							**25,** 2*a–c*	51
										1						**42,** 1	97
										2						2	97
										3						3	97
										4						4	97
										5						5	97
										6						6	97
										7						7	97
										8						8	97
										9						9	97
										10						10	97
												1	}			**31,** 2	{ 71 { 88
												2				**19,** 5	49
												3				6	49
												4				**10,** 2	28
												5				**34,** 2*a*	80
												6				*b*	80
												7				*c*	80
												8				**14,** 8*a*	42
												9				*b*	42
												10				*c*	42
												11				*d*	42
												12				**20,** 4*a*	49
												13				*b*	49
												14				*c*	49
												15				*d*	49
												16				*e*	49
												17*a-i*				**10,** 3*a–i*	28
												18				**31,** 4	71
													A1		43*a*	**7,** 5	(†)
													A2		43*b*	**25,** 3	51
													C1-8			**24,** 1*a–h*	51
														10A–E	45A–E	**24,** 2*a–e*	51
														12A–B	52A–B	**46,** 1*a–b*	100
														13A–C	53A–C	**45,** 3*a–c*	100
														14A–B	54A–B	**19,** 7, 8	49
														15A–H	55A–H	**45,** 1*a–h*	100
														16	56	**21,** 3	(*)
															57	**23,** 2*a–d*	51
														I		**45,** 2 I	100
														II*a–b*		II*a–b*	100
														III*a–b*		III*a–b*	100
														IV		**25,** 4	51
														V*a–c*		5*a–c*	51

* See pp. 211, 294. † Sarcosporidian falciform body from the sheep.

Table of equivalence of figures—Continued.

Perugia, 1891, LXVII.	Garbini, 1891, LXIX.	Linton, 1891, LXX.	Linton, 1891, LXXI.	Korotneff, 1892, LXXIV.	Weltner, 1892, LXXV.	Thélohan, 1892, LXXX.	Cuénot, 1892 (see p. 171).	Henneguy & Thélohan, 1892, LXXXI.	Schewiakoff, 1893 (see p. 176).	Ohlmacher, 1893, LXXXVI.	Pfeiffer, 1893, LXXXVIII.	Stiles, 1893 (see p. 175).	Whinery, 1893, XC.	Gurley, 1894.	Species No.
1-6														**37**, 2-7	94
7-8														**14**, 5-6	39
9-11														**29**, 2-7	64
15-29														**6**, 3-8	11
	a													**12**, 3 *a*	33
	b													*b*	33
	c													*c*	33
	d													*d*	33
	e													*e*	33
		1-16												**27**, 1-16	55
			1											**7**, 1	12
			2*a*											2*a*	12
			a'											*a'*	12
			b											*b*	12
			b'											*b'*	12
			c											*c*	12
			3											3	12
				1										**8**, 1	26
				2										2	26
				3										3	26
				4										4	26
				5										**9**, 1*a*	26
				6										1*b*	26
				7										1*c*	26
				8										1*d*	26
				9										1*e*	26
				10										2	26
				11										3	26
				12										4	26
					1-16									**30**, 1*a*-*q*	69
						1								**41**, 4	87
						2								**39**, 4	95
							1							**2**, 1	2
							2*a*							2*a*	2
							b							*b*	2
								1						**11**, 1	31
								2						2	31
								3						3	31
								4						4	31
								5						5*a*	31
								6						*b*	31
								7						*c*	31
								8						*d*	31
								9						**12**, 1	32
								10-20						2*a*-*l*	32
								21						*m*	32
								22						*n*	32
								23						*o*	32
								24						*p*	32
								25*a* *b*						*q*, *r*	32
								26						**10**, 4	30
								27*a*-*b*						5*a*, *b*	30
									17-23					**4**, 2-8	6
									24-32					**5**, 1-9	6
									33*a*-*l*					10*a*-*l*	6
									34*a*-*b*					11*a*-*b*	6
										1				**40**, 8	89
										2				**41**, 1*a*	89
										3				2	89
										4*a*				1*b*	89
										b				*c*	89
										c				*d*	89
											13			**22**, 5	51
											14			6	51
											15			**23**, 1	51
											16			**25**, 6	51
												1		**3**, 1	5
												2		2	5
												3		3	5
												4		4	5
												5*a*		5*a*	5
												b		*b*	5
													1	**41**, 3	89

DESCRIPTION OF GENERA AND SPECIES.

Tabular Key.

The following tabular key includes all the species, which can by any reasonable possibility be construed as myxosporidian, with their principal characters plotted out. The order of arrangement is a trifle more artificial than that found in the text.

Descriptions of the following species are omitted, as I believe there is no rational chance of their being *Myxosporidia:*

Psorospermium hæckelii Hilgendorff, 1883.

(Parasite of *Astacus fluviatilis*, Häckel, 1855, *De telis quibusdam Astaci fluviatilis*, Inaug. Dissert. Friedr. Wilhelm. Univ. Berlin, p. 42, pl. 2, fig. 25A–C; *ib.* Häckel, 1857, Ueber d. Gewebe d. Flusskrebses, Müller's Archiv., pp. 561–2, pl. 19, fig. 25A–C; *ib.*, Grobben, 1878, Beiträge z. Kenntn. d. männl. Geschlechtsorg. d. Dekapoden; not seen.

Psorospermium hæckelii, Bericht d. Gesellsch. Naturf. Freunde Berlin, pp. 179–181 (not seen); *ib.*, Zacharias, 1888, Ueber *Psorospermium häckelii*, Zoolog. Anzeiger, XI, pp. 49–51 (abstr. Journ. Roy. Micr. Soc. London, 1888, VIII, p. 240); *ib.*, Wierzejski, Kleine Beiträge z. Kenntn. d. *Psorospermium häckelii*, Zoolog. Anzeiger, XI, pp. 230–231 (abstr. Jour. Roy. Micr. Soc. London, 1888, VIII, p. 598).

This form and the next have never been definitely referred to the *Myxosporidia*, but Prof. Linton's bibliography of the "*Psorospermiæ*"[1] includes the articles containing them. They have no connection with the *Myxosporidia*.

Psorospermium lucernariæ Vallentin, 1888.

Zoolog. Anzeiger, XI, pp. 622–623; abstr. Journ. Roy. Micr. Soc. London, 1889, pp. 75–76.

See note on preceding.

Pfeiffer[2] states that *Myxosporidia* were found by Leuckart and Lieberkühn in the gall bladder and the kidneys of toads. Now, the assertion, in so far as it concerns Leuckart, is, I suspect, an error. It was probably copied from Lutz,[3] who says:

> The *Myxosporidia* are, as it is known, entirely parasitic, and in the large majority of cases live upon fishes. The only one of the authors accessible to me who mentions their occurrence in the *Amphibia* is Leuckart, who found them frequently in the urinary bladder of frogs, and also mentions the occurrence of a species described by Lieberkühn in the kidney.

I have been unable to find any such observation of Leuckart's, and correspondence with both him and Dr. Lutz failed to elicit a reference or a substantiation of the statement; so that "Leuckart" is here probably an error for Lieberkühn. Furthermore, there is absolutely nothing to indicate the myxosporidian nature of the forms described by

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[1] Bull. U. S. Fish Com. for 1889, IX, p. 102.

[2] Virchow. Archiv. f. pathol. Anat. u. Physiol., Berlin, CXXII, p. 557; Die Protozoen als Krankheitserreger, 1891, 2 ed., p. 134; recently copied by Ohlmacher, Journ. Amer. Med. Assoc., 1893, XX, p. 562.

[3] Centralbl. f. Bakt. u. Parasitenkde, 1889, V, p. 84.

Lieberkühn.[1] On the contrary, both his descriptions and figures (which show spores, apparently of two different species, containing falciform corpuscles) justify the opposite conclusion. And Lankester[2] distinctly affirms its coccidian nature.

Possibly, Pfeiffer[3] says, a form reported by Kunstler and Pitres[4] from a pleural exudate of man is perhaps referable here. But from their descriptions and figure it is hard to see how by any possibility it could belong to the *Myxosporidia*. The smallest spores are 18 μ "long" and the largest 100 μ. In such large spores it is inconceivable that the capsules could be missed, and Kunstler and Pitres appear to regard it as coccidian.

Further, Pfeiffer says:

> Also relations exist with a form found in chickens by Arloing and Tripier.

The following data will suffice for its rejection:

Arloing and Tripier[5] tell us that they found oval bodies with granular contents, a clear central nucleus, and a sort of "button" at each extremity of the longer diameter. These bodies measure 500 to 550 μ (400 to 450 μ, excluding the "buttons") in length, and 200 to 220 μ in breadth. Balbiani, from an examination of hardened specimens, reserved his opinion, but rather believed them to be "psorosperms." In spite of and after this, the authors tell us that they identified these oval bodies by finding *identical bodies in the oviduct of a worm* found imbedded in the same situation (œsophageal mucosa); in other words, they are the ova of a worm. It is hardly necessary to go further than their dimensions to exclude them from the possibility of being myxosporidian spores. It might, however, be added, that Balbiani would certainly have noted in his *Leçons sur les Sporozoaires* (1884) such an unprecedented anomaly as the occurrence of a myxosporidian in a bird.

I cannot, perhaps, better place the following remarks made by M. Armand in the way of discussion of Arloing and Tripier's paper. M. Armand, in concert with Balbiani, undertook, in 1873, the inoculations of "psorosperms" both in warm and in cold blooded animals. The attempt succeeded, and several pieces showing the proliferation and modifications of these bodies transported into organisms very different from their normal habitat were obtained, and preserved in the collection of the Laboratory of General Physiology of the Jardin des Plantes. As the subsequent myxosporidian literature is silent upon this point, it is probably safe to presume either that in this case "psorosperms" did not mean *Myxosporidia*, or, if it did, that the myxosporidian branch of the work proved barren of results.

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[1] Müller's Archiv., 1854, pp. 1–5, pl. I, figs. 1–19.

[2] Encyclop. Britan., 9 ed., XIX, 1885, p. 855.

[3] Die Protozoen als Krankheitserreger, 1 ed., 1890, p. 49; 2 ed., 1891, p. 135.

[4] Sur une psorospermie trouvée dans une humeur pleuritique; Journ. de Micr219gr., 1884, VIII, pp. 469–474, 520–526, pl. 11, figs. 1–15; pl. 12, figs. 1–3.

[5] Lésions organiques de nature parasitaire chez le poulet; Compt. Rend. Assoc. franç. l'Avanc. Sci., 1874, 2d (Lyons) Sess., pp. 810–814.

Parasite of *Sygnathus*, Pfeiffer, 1891, Die Protozoen als Krankheitserreger, 2 ed., p. 111, figs. 46–49:

From a perusal of the description and an examination of the figures I can find no evidence of myxosporidian affinities, and have therefore excluded this form. While this paper is passing through the press, I have, however, observed Pfeiffer's paper,[1] in which, in the portion devoted to the *Myxosporidia*, he says:

Of the *Syngnathus* from the North Sea, which the author was able to investigate two years ago in Helder (Holland), the relative conditions have been thoroughly pictured by the author in another place.

Finally, a comparison with the following may perhaps not be inadvisable:

Csokor, Gregarinosis d. Forellen, Oesterreich. Ztschr. f. wiss. Veterinärkde, Wien, 1888, II, pp. 56–58.

The author says the forms observed were undoubtedly referable to the "oviform and globular Coccidia (Gregarines)." From the general tenor of his description I suspect they were not *Myxosporidia*, and in any case there is at present no evidence to warrant their admission into the subclass.

Hardly any explanation of the table is necessary. The grouping and position of the capsules (and the correlated orientation of the spore) is made the leading character. Next come the other generic characters (bivalve condition of shell, presence or absence of vacuole, etc.).

One of the most important uses of this table is to direct attention to the gaps in our knowledge. Thus it will serve a useful purpose in showing readily where work is most needed.

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[1] Centralbl. f. Bakt. u. Parasitenkde, 1893, XIV, p. 124.

Tabular key.

Species No.	Genera.	Spore.											
		Capsules.					Shell.		Vacuole.		Symmetry.		
		1 only.		2 or more in—									
					2 separated groups.								
		Obscure; spore minute.	Conspicuous; spore relatively large.	1 group (at anterior end).	At each (anterior and posterior) end.	In each (right and left) wing.	Bivalve.	Inclination of valve-junction plane to longitudinal.	Aniodinophile.	Iodinophile.	Antero posterior.	Bilateral.	Supero inferior.
1	Psorospermia (non-myxosporidian).	....	....	.....	.....	.....	Operculate	.....	....	....	Obscure or absent.		
2	Lithocystis (non-myxosporidian).	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
3	Genus incert. (non-myxosporidian).	....	....	.....	.....	.....	Valves in contact at middle, diverging towards their ends.	.....	....	....	Apparently symmetrical in all directions.		
4	......do	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
5	Balbiania	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
6	Genus incert. (non-myxosporidian).	....	....	.....	.....	.....	Apparently 0.	.....	Apparently none.		.....	.....	....
7	Genus incert. (probably myxosporidian; spores unknown).	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
8	......do	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
9	......do	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
10	......do	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
11	......do	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
12	......do	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....
13	Genus incert. (aberrant *Myxosporidia?*).	....	....	.....	.....	.....	.....	.....	....	....	.....	.....	....

Tabular key.

Spore.										Index.					
Tail.				Outline on vertical view.	Dimensions.										
	Present.														
	Single.														
Absent.	Undivided.	More or less bifurcate.	Double from base.		Length in μ.	Breadth in μ.	Thickness in μ.	Length of capsules in μ.	Presence of filament; length in μ.	Capsular.	Caudal.	Ridge; presence and index.	Presence of cornua of sporoplasm recognized.	Nuclei *ad plurimum*.	Species No.
......	......	......	......	Ovoid, ovoid-elongate, rarely spherical.	27	18	17	......	......	......	......	......	......	......	1
......	......	......	......	Ovoid, distally truncate, proximally rounded.	Macrospores 24; microspores 12.	......	......	......	......	......	......	......	......	......	2
......	......	......	......	Lenticular.	14 to 17	......	......	......	......	......	......	......	......	......	3
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	4
......	......	......	......	Fusiform..	17	......	......	......	......	......	......	......	......	......	5
......	......	......	......	Oval or pyriform.	3·3 to 4	......	......	......	......	......	......	......	......	1, globular, 1·6 μ.	6
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	7
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	8
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	9
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	10
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	11
......	......	......	......	Top-shaped	17	10	6	......	......	......	......	......	......	......	12
......	......	......	......	Circular...	17 in diameter.	......	......	......	......	......	......	......	......	......	13

Tabular key.

Species No.	Myxosporidium.							Cyst.			Host.
	Size in μ.	Ectoplasm and endoplasm differentiated.	Pseudopodia.	Nuclei.	Pansporoblast.	Pansporoblast producing spores *ad plurimum.*	Vacuole.	Size in mm.	Shape.	Color.	
1	......	......	......	......	......	......	......	......	......	......	Sciæna umbra ......
2	Gregarine ovoid, 65 μ long, with a very voluminous nucleus and clinorhombic crystals.							1 to 2 in diameter.	Spherical; containing spores and rest of segmentation.	....	Echinocardium cordatum.
3	Spores develop endogenously, several within a globule, the latter sometimes with an enveloping membrane; spores at first unsplit.							....	....	....	Gadus morrhua.....
4	Amœboid mass 7·5 to 12 μ, with blunt processes and sometimes a tail; ends clear, center containing many dark corpuscles.							....	....	....	Salmo fario.........
5	......	......	......	......	......	......	......	2 to 4 by 0·7.	Oval ..	White.	Anas bosc[illegible] ......
6	7 by 3 to 20 by 6; plasmodes 18 by 8 to 48 by 23.	Probably not.	Blunt, lobulate, hyaline.	1, globular.	Apparently absent (cf. p. 179.)	....	contractile, postero-peripheral.	Diameter 10; plasmodecysts 30–60; elongate tubes 70 by 24.	Globular.	Dark ..	Cyclops (in par[illegible]lar C. strenuus), Diaptomus cœruleus, D. richardi.
7	Small and granule-free to larger and granular; processes rather sharp; in size not equal to a blood corpuscle of the fish; granules extremely small, held together by a mucoid substance.							Present; membrane transparent.			Abramis brama.....
8	Consisting of granular protoplasm; very similar to a *Chloromyxum mucronatum;* apparently very variable, oval, lenticular, or dendroidly branched; size 27 to 440 μ; with or without a structureless membrane; pansporoblast bisporogenetic.							Apparently no true cyst.			Percafluviatilis.....
9	......	......	......	......	......	......	......	....	....	....	Lota lota ....
10	......	......	......	......	......	......	......	....	....	....	Lota lota ....
11	Form variable, movements incessant, slow, amœboid.							....	....	....	Leptocephalus conger.
12	......	......	......	......	......	......	......	2·5 to (clusters) 7 by 5.	....	....	Notropis megalops.
13	......	......	......	......	Present??	....	......	1·09 to 2·18 by 0·44.	Cylindrical, rarely ellipsoidal or spherical.	....	Gasterosteus aculeatus.

Tabular key.

Seat.	Pathologic effect.	Remarks.	Genus.	Species.	Species No.
Branchio-abdominal septum.	....	Spore leathery, contents granular, colorless, amber or fuscous yellow, forming indefinite cylindrical, filamentous or spiral colonies; rarely isolated.	Psorospermia...	sciænæ-umbræ..	1
Body cavity; digestive tube.	....	A perfectly typical monocystid Gregarine. Gregarine stage passed usually in digestive tube. Spores contain 8 falciform corpuscles.	Lithocystis.....	schneideri	2
Air bladder........	Atrophy of tail muscles.	Pathologic mass whitish-yellow, pasty, drawing out into dirty white threads.	Genus incert ...	sp. incert	3
Blood	....	....	....do	sp. incert	4
Interstices of muscles.	....	....	Balbiania	rileyi	5
Body cavity, abdomen, thorax, tail, natatory feet, first antennæ.	....	....	Genus incert ...	sp. incert	6
Branchiæ; ? also of heart blood.	....	....	Genus incert....	sp. incert	7
Branchiæ	....	....	....do	sp. incert	8
Gall bladder	....	....	....do	sp. incert	9
Branchiæ..........	....	....	....do	sp. incert	10
Gall bladder	....	....	.... do	congri	11
Subcutaneous tissue.	....	....	....do *	sp. incert	12
Subcutaneous tissue.	....	Spore containing a central globule ("nucleus") 7 to 11 μ in diameter, surrounded by several fine granules.	Genus incert....	sp. incert	13

* "Myxosporidium;" name not in good standing, see p. 206.

Tabular key—Continued.

Species No.	Genera.	Spore. Capsules. 1 only. Obscure; spore minute.	Spore. Capsules. 1 only. Conspicuous; spore relatively large.	Spore. Capsules. 2 or more in— 1 group (at anterior end).	Spore. Capsules. 2 or more in— 2 separated groups. At each (anterior and posterior) end.	Spore. Capsules. 2 or more in— 2 separated groups. In each (right and left) wing.	Spore. Shell. Bivalve.	Spore. Shell. Inclination of valve-junction plane to longitudinal.	Spore. Vacuole. Aniodinophile.	Spore. Vacuole. Iodinophile.	Spore. Symmetry. Antero-posterior.	Spore. Symmetry. Bilateral.	Spore. Symmetry. Supero-inferior.
14	Genus incert. (most, possibly all, myxosporidian).												
15	...do			Capsules 2									
16	...do												
17	...do												
18	...do												
19	...do												
20	...do												
21	...do												
22	...do												
23	...do												
24	...do												
25	...do												
26	"Myxosporidium"						0		2 "vacuoles."				
I	Glugea	×					0		×				
27	...do	×									0		
28	...do	×					0		×		0		
II	Pleistophora	×					0		×		0		
29	...do	×							(?)				
III	Thelohania	×					0		×		0		
30	...do	×							×		0		

Tabular key—Continued.

Spore. Tail. Absent.	Spore. Tail. Present. Single. Undivided.	Spore. Tail. Present. Single. More or less bifurcate.	Spore. Tail. Present. Double from base.	Spore. Outline on vertical view.	Spore. Dimensions. Length in μ.	Spore. Dimensions. Breadth in μ.	Spore. Dimensions. Thickness in μ.	Spore. Dimensions. Length of capsules in μ.	Spore. Presence of filament; length in μ.	Index. Capsular.	Index. Caudal.	Index. Ridge; presence and index.	Presence of cornua of sporoplasm recognized.	Nuclei *ad plurimum*.	Species No.
×															14
									Very long; extruded by glycerin.						15
															16
															17
															18
															19
															20
															21
															22
															23
															24
															25
				Elongate-oval; sharp anteriorly, rounded posteriorly.											26
0															I
0															27
0				Regularly ovoid.	3 to 5	2 to 3.			50; extruded by iodine only.					4	28
0															II
				Ovoid	3	1·5 to 2·0			Present.					Chromatophile bodies 4.	29
0															III
0				Ovoid	2 to 3										30

Tabular key—Continued.

Species No.	Myxosporidium.							Cyst.			Host.
	Size in μ.	Ectoplasm and endoplasm differentiated.	Pseudopodia.	Nuclei.	Pansporoblast.	Pansporoblast producing spores *ad plurimum*.	Vacuole.	Size in mm.	Shape.	Color.	
14	......	......	......	......	......	2 or 3	......	......	......	......	Leuciscus cephalus.
15	......	......	......	......	......	......	......	......	......	......	Leuciscus cephalus.
16	......	......	......	......	......	......	......	......	......	......	Gobius fluviatilis...
17	......	......	......	......	......	......	......	......	......	......	"Crocodile"......
18	......	......	......	......	......	......	......	Present	......	......	Chondrostoma nasus.
19	......	......	......	......	......	......	......	......	......	......	Leuciscus rutilus...
20	......	......	......	......	......	......	......	......	......	......	Tinca tinca......
21	......	......	......	......	......	......	......	......	......	......	Leuciscus erythrophthalmus.
22	......	......	......	......	......	......	......	......	......	......	Gasterosteus aculeatus.
23	......	......	......	......	......	......	......	Small.	......	......	Stizostedion lucioperca.
24	......	......	......	......	......	......	......	......	......	......	Gasterosteus aculeatus.
25	......	......	......	......	......	......	......	......	......	......	Scomber scombrus..
26	20 to 200.	×	Hair-like, nearly always localized.	Very numerous.	?	......	......	......	......	......	Alcyonella fungosa.
I	......	......	......	......	Membrane not subpersistent.	Many; number inconstant.	......	......	......	......	......
27	......	×	......	......	Membrane not subpersistent.	Many.	......	None	......	......	Callionymus lyra...
28	......	......	......	......	×	Many.	......	Pin-head to pea.	Spherical or irregular.	White.	Gast. aculeatus, Pygosteus pungitius, Aphya alba.
II	......	......	......	......	Membrane subpersistent.	Many; number inconstant.	......	......	......	......	......
29	......	......	......	......	Sporophorous vesicle 15 to 18 μ in diameter.	Many.	......	None	......	......	Cottus scorpio......
III	......	......	......	......	Membrane subpersistent.	8; number constant.	......	......	......	......	Decapoda.........
30	......	......	......	......	......	8	......	None	......	......	Astacus fluviatilis..

Tabular key—Continued.

Seat.	Pathologic effect.	Remarks	Genus.	Species.	Species No.
			Genus incert	sp. incert	14
Air bladder			do	sp. incert	15
Body cavity			do	sp. incert	16
Mucosa and muscularis of intestine.			do	sp. incert	17
Roots of tongue			do	sp. incert	18
Heart; heart blood			do	sp. incert	19
Scales			do	sp. incert	20
Subsquamous			do	sp. incert	21
		Fish collected near Kiel.	do	sp. incert	22
Branchiæ			do	sp. incert	23
Branchial "copules"	See p. 187		do	sp. incert	24
			do.	sp. incert	25
Body cavity	Death of polyzoan colony.	Capsules not yet demonstrated.	"Myxosporidium."	bryozoides	26
			Glugea		I
Intra-fibrillar	Degeneration of muscle fiber.		do	destruens	27
Subcutaneous Subcutaneous. Subcutaneous.			do	anomala	28
			Pleistophora		II
Inter-fibrillar	No degeneration.	Diseased mass forming white streaks 5 or 6 by 3 mm.	do	typicalis	29
Striated muscles			Thelohania		III
Striated muscles	Crayfish epidemic?		do	contejeani	30

Tabular key—Continued.

Species No.	Genera.	Spore.											
		Capsules.					Shell.		Vacuole.		Symmetry.		
		1 only.		2 or more in—									
					2 separated groups.								
		Obscure; spore minute.	Conspicuous; spore relatively large.	1 group (at anterior end).	At each (anterior and posterior) end.	In each (right and left) wing.	Bivalve.	Inclination of valve-junction plane to longitudinal.	Aniodinophile.	Iodinophile.	Antero-posterior.	Bilateral.	Supero-inferior.
31	Thelohania	×	...	...	...	...	...	...	...	...	0	...	...
32	....do	×	...	...	...	...	...	...	×	...	0	...	...
33	....do	...	...	...	...	...	...	...	...	...	...	...	...
IV	Myxobolus	...	×	×	...	...	×	0°	...	×	0	× with few exceptions.	× very generally
34	....do	...	×	...	...	...	×	...	...	×?	0	Slightly imperfect.	
35	....do	...	×	...	...	...	...	...	...	...	0	×	...
36	....do	...	...	2 *unequal.*	...	...	...	...	...	...	0	Slightly imperfect.	...
37	....do	...	...	2	...	...	...	...	...	...	0	×	...
38	....do	...	...	(2)	...	...	...	...	...	...	0	×	...
39	....do	...	...	(2)	...	...	...	...	...	...	0	×	...
40	....do	...	...	(2)	...	...	...	...	...	...	0	×	...
41	....do	...	...	(2)	...	...	...	...	...	...	0	×	(×)
42	....do	...	...	2	...	...	...	...	...	×	0	×	...
43	....do	...	...	...	...	...	...	...	...	...	...	...	...
44	....do	...	...	...	...	...	...	...	...	...	0	×	...
45	....do	...	...	...	...	...	...	...	...	...	...	...	...
46	....do	...	...	2	...	...	×	0°	...	×	0	×	×
47	....do	...	...	...	...	...	...	...	...	...	...	...	...
48	....do	...	...	(2)	...	...	...	...	...	...	0	×	...

Tabular key—Continued.

Spore. Tail. Absent.	Spore. Tail. Present. Single. Undivided.	Spore. Tail. Present. Single. More or less bifurcate.	Spore. Tail. Present. Double from base.	Spore. Outline on vertical view.	Spore. Dimensions. Length in μ.	Spore. Dimensions. Breadth in μ.	Spore. Dimensions. Thickness in μ.	Spore. Dimensions. Length of capsules in μ.	Spore. Dimensions. Presence of filament; length in μ.	Index. Capsular.	Index. Caudal.	Index. Ridge; presence and index.	Presence of cornua of sporoplasm recognized.	Nuclei *ad plurimum*.	Species No.
0				Pyriform	3 to 4				Extruded by ether only.						31
0					5 to 6				15 to 20, extruded only by HCl and HNO_3.						32
				Pyriform											33
× 0	×	×	×												IV
×				Ovate											34
×				Lanceolate-ovate.	16 to 18	7 or 8.									35
×					11	7									36
×				Lanceolate-ovate.						Very sm'l					37
0 (sometimes ×?)															38
					7										39
															40
0 (sometimes ×?)				Oval or circular.											41
				Flattened ovoid.	10 to 12	8		6		Ab't 0·50				3	42
					18 (error?)	12 (error?)									43
															44
					8	6 to 7.									45
				Lenticular-oval.								Ridge tolerably thick.			46
×				Oval	In size = sp. 61.										47
×										Ab't 0·50					48

Tabular key—Continued.

Species No.	Myxosporidium.							Cyst.			Host.
	Size in μ.	Ectoplasm and endoplasm differentiated.	Pseudopodia.	Nuclei.	Pansporoblast.	Pansporoblast producing spores *ad plurimum.*	Vacuole.	Size, in mm.	Shape.	Color.	
31					Sporophorous vesicle 10 μ in diameter.	8		None			Palæmon rectirostris. Palæmon serratus.
32					Sporophorous vesicle spherical, diameter 12 to 14 μ	8					Crangon vulgaris.
33					Sporophorous vesicle elongate fusiform.	8					Palæmonetes varians.
IV					×	1 or 2 (3??)					
34											Labeo niloticus
35											Tinca tinca. Misgurnus fossilis
36											Pimelodus clarias
37					Oval vesicles	1					Tinca tinca
38								Present.			Tinca tinca
39					Destitute of a membrane?			Present.			Mugil auratus. Mugil capito
40											Nais proboscidea.
41								8 by 4·4			Lucius lucius.
42											Gobio gobio. Cyprinus carpio. Alburnus alburnus.
43											Cyprinus carpio
44											Abramis brama.
45											Abramis brama.
46		Visible in thin sections.		Very numerous.	See p. 218.	1		2 to 3	Elongate-oval.	White.	Leuciscus cephalus. Barbus barbus. Phoxinus phoxinus. Crenilabrus melops.
47											Pseudoplatystoma fasciatum.
48											Tinca tinca.

Tabular key—Continued.

Seat.	Pathologic effect.	Remarks.	Genus.	Species.	Species No.
Inter-fibrillar. Inter-fibrillar.	Muscular paresis.		Thelohania	octospora	31
			do	giardi	32
Muscles			do	macrocystis	33
			Myxobolus		IV
			do	unicapsulatus	34
Branchiæ; spleen. Kidney.			do	piriformis	35
			do	inequalis	36
Spleen; kidney; ?branchiæ(see p213).			do	brachycystis	37
Cornea			do ?	sp. incert	38
Branchial lamellæ. Branchial lamellæ.			do ?	mugilis	39
			do	sp. incert	40
Branchiæ			do	sp. incert	41
Fins and branchiæ. Branchiæ. Branchiæ.			do	oviformis	42
		Dimensions an error? (see p. 215).	do ?	cf. oviformis	43
Branchiæ			do	sp. incert	44
Branchiæ			do	sp. incert	45
Branchiæ. Branchiæ and fins. Branchiæ kidney. Ovary.			do	mülleri	46
Branchial arches			do	sp. incert	47
Branchiæ			do	bicostatus	48

Tabular key—Continued.

Species No.	Genera.	Spore. Capsules. 1 only. Obscure; spore minute.	Conspicuous; spore relatively large.	2 or more in— 1 group (at anterior end).	2 separated groups. At each (anterior and posterior) end.	In each (right and left) wing.	Shell. Bivalve.	Inclination of valve-junction plane to longitudinal.	Vacuole. Aniodinophile.	Iodinophile.	Symmetry. Antero-posterior.	Bilateral.	Supero-inferior.
49	Myxobolus	....	....	2! (see remarks)	......	......	×	0°	....	×	0	×	×
50	....do	....	....	2	......	......	......	......	....	......	0	×	....
51	....do	....	....	2	......	......	×	0°	....	......	0	×	....
52	....do	....	....	(2)	......	......	......	......	....	......	......	......	....
53	....do	....	....	(2)	......	......	......	......	....	......	0	×	....
54	....do	....	....	2	......	......	×	0°	....	?	0	×	×
55	....do	....	....	2	......	......	×	0°	....	×	0	×	×
56	....do	....	....	2	......	......	×	0°	....	×	0	×	×
57	....do	....	....	(2)	......	......	......	......	....	......	0	×	....
58	....do	....	....	(2)	......	......	......	......	....	×	0	×	....
59	....do	....	....	(2)	......	......	......	......	....	......	......	......	....
60	....do	....	....	(2)	......	......	×	......	....	? ("nucleus")	......	......	....
61	....do	....	....	2	......	......	......	......	....	......	0	×	....
62	....do	....	....	2	......	......	×	......	....	......	0	×	×
63	....do	....	....	2	......	......	×	......	....	× (?)	0	×	×
64	....do	....	....	2	......	......	......	......	....	×	0	×	....
65	....do	....	....	......	......	......	×	......	....	......	......	......	....
66	....do	....	....	......	......	......	×	......	....	......	......	......	....
67	....do	....	....	......	......	......	......	......	....	......	......	......	....
68	....do	....	....	2 (nature??).	......	......	......	......	....	......	0	×	....
	....do	....	....	......	......	......	......	......	....	......	......	......	....
	....do	....	....	......	......	......	......	......	....	......	......	......	....
	....do	....	....	......	......	......	......	......	....	......	......	......	....
	....do	....	....	......	......	......	......	......	....	......	......	......	....
69	....do	....	....	2	......	......	×	......	....	......	0	×	× (?)
70	....do	....	....	2	......	......	......	......	....	......	0	×	....

Tabular key—Continued.

Spore.															
Tail.					Dimensions.					Index.					
	Present.														
	Single.														
Absent.	Undivided.	More or less bifurcate.	Double from base.	Outline on vertical view.	Length in µ.	Breadth in µ.	Thickness in µ.	Length of capsules in µ.	Presence of filament; length in µ.	Capsular.	Caudal.	Ridge; presence and index.	Presence of cornua of sporoplasm recognized.	Nuclei *ad plurimum*.	Species No.
×				Flattened-ellipsoid.	12 to 15	9 to 11		4		Ab't 0·33				4	49
×				Resembling sp. 92.	11	7									50
×				Lenticular or oval.	12	10	6		×						51
×															52
×															53
×				Spatular.	14 to 17	8.5	5 to 6.	4 or 5.	×	0·30		About 0·33.		? (see p. 235).	54
×				Broadly elliptic.	13.9	11	8		×	×		×		4	55
×				Broadly elliptic.	14	10	5			A little less than 0·50.		0·25			56
×															57
×				Broadly round-elliptic.	12										58
														3	59
				Spherical.	9										60
× (see p. 240).				Almost exactly round.											61
×				Subcircular.	8	6 or 7.	5			About 0·60.		0·33		4	62
×				Transversely elliptic.	6 or 7	8	5		×	About ·50.				2	63
					Less than breadth.										64
															65
									×						66
															67
			2 (nature??)	Oval wider in front.					2 (nature ??).						68
×0	×	× (separation of halves).	× (separation of halves).	Fusiform.				5·1 to 5·9.		Less than in sp. 80.		×	47·9		69
0	×	0	0		15	5 to 6.					Hardly 0·50				70

Tabular key—Continued.

Species No.	Myxosporidium.							Cyst.			Host.
	Size in μ.	Ectoplasm and endoplasm differentiated.	Pseudopodia.	Nuclei.	Pansporoblast.	Pansporoblast producing spores *ad plurimum*.	Vacuole.	Size in mm.	Shape.	Color.	
49	......	......	Large and obtuse.	Many.	×	Usually 2.	......	Present or absent			Tinca tinca........
50	......	......	......	......	......	......	......	......	......	......	Leuciscus grislagine.
51	......	......	......	......	×	......	......	Present..............			Barbus barbus......
52	......	......	......	......	......	......	......	......	......	......	Leuciscus erythrophthalmus.
53	......	......	......	......	......	......	......	Pin's head.	......	Yellowish white.	Phoxinus phoxinus.
54	......	......	......	......	......	......	......	*Ad max.* 1.	Round or elliptic.	White.	Erimyzon sucetta oblongus.
55	......	......	......	......	......	......	......	None (?)............			Cyprinodon variegatus.
56	......	......	......	......	......	......	......	......	......	......	Carassius carassius.
57	......	......	......	......	......	......	......	......	......	......	Alburnus alburnus.
58	......	......	......	......	......	......	......	Present..............			Leuciscus rutilus ..
59	......	......	......	......	......	......	......	......	......	......	"Gardon" ....
60	......	......	......	......	......	......	......	0·25 to 0·33.	......	......	Coregonus fera......
61	......	......	......	......	......	......	......	1·09 to 2·18.	Flat pustules.	White.	Stizostedion lucioperca.
62	......	......	......	......	......	......	......	*Ad max.* 0·50.	......	......	Erimyzon sucetta oblongus.
63	......	......	......	......	......	......	......	......	......	......	Phoxinus funduloides.
64	......	0	......	......	No pansporoblast membrane.	......	......	......	......	......	Merlucius merlucius.
65	......	......	......	......	......	......	......	......	......	......	Gobio gobio........
66	......	......	......	......	......	......	......	Present	......	......	Perca fluviatilis ....
67	......	......	......	......	......	......	......	......	......	......	Leuciscus rutilus...
68	......	......	......	......	......	......	......	Pea to large nut.	Oval..	White.	Coregonus fera .....
	......	......	......	......	......	......	......	......	......	......	Tinca tinca........
	......	......	......	......	......	......	......	......	......	......	Lucius lucius.......
	......	......	......	......	......	......	......	......	......	......	Stizostedion lucioperca.
	......	......	......	......	......	......	......	......	......	......	Leuciscus erythrophthalmus.
69	......	......	......	......	......	......	......	......	......	......	Lucius lucius.......
70	......	......	......	......	......	......	......	......	......	......	Gasterosteus aculeatus. Pygosteus pungitius.

Tabular key—Continued.

Seat.	Pathologic effect.	Remarks.	Genus.	Species.	Species No.
Branchiæ air bladder, liver, spleen, intestine, ? gall bladder (see p. 224.)			Myxobolus	ellipsoides	49
			do ?	sp. incert	50
Muscles (see also pp. 227–228).	Barbel epidemic.		do	sp. incert	51
Splenic artery			do	sp. incert	52
Surface of head			do	sp. incert	53
Surface of head			do	oblongus	54
Sides of body		Diseased mass fungoid, 4 by 2 to 10 by 4 mm.	do	lintoni	55
Body cavity			do	sp. incert	56
			do ?	obesus	57
Inner surface of opercle, pseudobranchiæ.			do	cycloides	58
			do	sp. incert	59
Branchial mucosa			do	spheralis	60
Opercle, branchiæ, surface of head, fins.			do	sp. incert	61
Branchial lamellæ			do	globosus	62
Subsquamous			do	transovalis	63
Gall bladder		Each myxosporidium produces only 2 spores.	do ?	merlucii	64
Kidney, body cavity			do ?	sp. incert	65
Skin, scales			do ?	sp. incert	66
Muscles of sides of body.				sp. incert	67
Subcutaneous and superficial intermuscular tissue.			do? ?	zschokkei	68
Cornea			do	see sp. 38	
Branchiæ			do	see sp. 41	
Opercle; branchiæ			do	see sp. 61	
			do	see sp. 52	
Ovary			do	cf. creplini	69
Renal tubules and ovary.			do	brevis	70
do					

Tabular key—Continued.

Species No.	Genera.	Spore.											
		Capsules.					Shell.		Vacuole.		Symmetry.		
		1 only.		2 or more in—									
					2 separated groups.								
		Obscure; spore minute.	Conspicuous; spore relatively large.	1 group (at anterior end).	At each (anterior and posterior) end.	In each (right and left) wing.	Bivalve.	Inclination of valve-junction plane to longitudinal.	Aniodinophile.	Iodinophile.	Antero-posterior.	Bilateral.	Supero-inferior.
71	Myxobolus			(2)							0	×	
72	do			2			×				0	×	(×)
73	do			2							0	×	(×)
74	do			2							0	×	
75	do			2			×	0°		×	0	×	[illegible]
76	do			(2)									
77	do			2			×	0°		×	0	×	Sub-symmetric.
78	do			2							0	×	
79	do			2							0	×	
80	do			2						×	0	×	×
81	do			2							0	×	
82	do			2									
83	do			2							0	×	
V	Ceratomyxa			2			×	90°		0	0	× (sporoplasm unilateral).	
84	do												
85	do												
86	do												

Tabular key—Continued.

Spore.															
Tail.					Dimensions.					Index.					
	Present.														
	Single.														
Absent.	Undivided.	More or less bifurcate.	Double from base.	Outline on vertical view.	Length in μ.	Breadth in μ.	Thickness in μ.	Length of capsules in μ.	Presence of filament; length in μ.	Capsular.	Caudal.	Ridge; presence and index.	Presence of cornua of sporoplasm recognized.	Nuclei *ad plurimum*.	Species No.
0	×	...	...	Fusiform	20 to 30	...	...	...	...	...	...	...	...	...	71
0	×	...	...	Ventricose-elliptic.	17·3	5·8	...	...	...	...	1 or a little more.	...	...	...	72
0	×	0	0	...	Body 9	5·4	...	...	...	...	...	×	...	...	73
0	× (rarely).	0	0	Body lenticular or obovate.	...	...	...	...	...	...	2 to 3	...	...	...	74
0	×	0	0	Body round-elliptic.	Body 10 to 11.	6 to 8.	4	...	...	0·50	3 to 4 or less.	×	×	×	75
0	usually.	Many bifurcate-tipped.	...	...	...	...	...	...	...	...	...	...	...	...	76
0	×	× (separation of halves).	× (separation of halves).	Lanceolate.	Body 19	5 to 6.	3	...	×	0·40	2	...	...	2 (rarely 3).	77
0	×	×	Occasionally.	Body very narrow.	Of body, 3 to 4 times breadth.	...	...	...	...	...	...	...	...	...	78
0 (very rarely ×)	×	× usually.	×	Body oval	Body 12	6	About 3.	...	...	...	3 to 4	×	...	...	79
0	×	×	×	...	Total 30 to 40.	4	...	6 to 8.	...	...	1	×	...	3	80
0	×	×	×	Round or oval, sharp anteriorly.	...	...	...	...	×	...	...	×	...	a "nucleus."	81
0	0	0	×	Body lenticular.	Body 8 to 10.	...	...	...	...	...	...	...	...	...	82
0	0	0	×	...	...	...	...	...	...	...	...	...	...	...	83
×	...	...	...	Widely transversely extended.	...	...	...	...	...	...	...	...	...	...	V
...	...	...	...	...	5	40	...	...	...	...	...	...	...	...	84
...	...	...	...	...	...	60	...	...	...	...	...	...	...	...	85
...	...	...	...	...	5 to 8.	65	...	...	...	...	...	...	...	...	86

Tabular key—Continued.

Species No.	Myxosporidium.							Cyst.			Host.
	Size in μ.	Ectoplasm and endoplasm differentiated.	Pseudopodia.	Nuclei.	Pansporoblast.	Pansporoblast producing spores *ad plurimum*.	Vacuole.	Size in mm.	Shape.	Color.	
71						(1)					Gasterosteus aculeatus. Pygosteus pungitius.
72											Acerina cernua.
73								Length about 2·18.			Synodontis schal.
74								Large.	Lenticular.	White.	Aphredoderus sayanus.
75								Pin's head.	Roundish.	White.	Hybognathus nuchalis.
76								1			Coregonus fera.
77								1	Subspherical.	White.	Ameiurus melas.
78								Present.			Rhamdia sebæ. Pseudoplatystoma fasciatum.
79								0·44 to 1·09.		Whitish.	Lucius lucius.
80											Lucius lucius. Perca fluviatilis.
81								10 to 30 by 7 to 20.	Spherical or oval.	Yellowish white.	Coregonus fera.
82					×	1 (??)		Filbert to small walnut.			Coregonus fera.
83											Lota lota.
V								None.			
84	Form variable, maximum diameter 35 or 40 μ; endoplasm destitute of spherules; pseudopodia ectoplasmic, lobed, filiform variety absent; myxosporidium destitute of prolongations.							None.			Onus tricirratus.
85	Maximum length 85, maximum breadth 20 μ; form variable, usually subfusiform; anterior end round, posterior attenuate, round, or multilobate; pseudopodia ectoplasmic *ad plur.* 8, subfiliform, limited to anterior end, maximum length ½ that of myxosporidium; movements rapid.							None.			Dasyatis pastinica.
86	Form irregular, variable; prolongations 1 to 5 with endoplasmic axis and ectoplasmic covering, immovable, maximum length twice that of central portion of myxosporidium; pseudopodia ectoplasmic, lobed; place of origin variable.							None.			Lophius piscatorius.

Tabular key—Continued.

Seat.	Pathologic effect.	Remarks.	Genus.	Species.	Species No.
Renal tubules and ovary.	....	....	Myxobolus	medius	71
....do.	....	....	....do	creplini	72
Surface of head.....	....	....	....do	strongylurus ...	73
Subcutaneous intermuscular tissue.	....	....	....do	monurus........	74
Surface of head.....	....	....	....do	macrurus	75
Branchial arches....	....	....	....do	sp. incert	76
Base of second dorsal fin.	....	....	....do	cf. linearis	77
Membrane lining branchial cavity.	....	....	....do	linearis	78
Branchial lamellæ. Orbit	....	....	....do	schizurus.......	79
Branchiæ	....	....	....do	psorospermicus.	80
Branchiæ. Interstitial muscular connective tissue.	....	....	....do	kolesnikovi.....	81
Muscles	....	....	....do	sp. incert	82
Kidney	....	....	....do	diplurus	83
Gall bladder	....	Bisporogenesis a generic feature.	Ceratomyxa	....	V
Gall bladder	....	....	....do	arcuata	84
Gall bladder	....	Myxosporidium bisporogenetic.	....do	agilis...........	85
Gall bladder	....	Myxosporidium bisporogenetic.	....do	appendiculata ..	86

Tabular key—Continued.

Species No.	Genera.	Spore.											
		Capsules.					Shell.		Vacuole.		Symmetry.		
		1 only.		2 or more in—									
					2 separated groups.								
		Obscure; spore minute.	Conspicuous; spore relatively large.	1 group (at anterior end).	At each (anterior and posterior) end.	In each (right and left) wing.	Bivalve.	Inclination of valve-junction plane to longitudinal.	Aniodinophile.	Iodinophile.	Antero-posterior.	Bilateral.	Supero-inferior.
87	Ceratomyxa	....	....	2	....	....	×	90°	....	0	0	× (sporoplasm unilateral).	
VI	Chloromyxum (Sphærospora).	....	....	2	....	....	×	....	0	0	0	×	....
88	....do	....	....	2	....	....	×	....	....	0	0	×	....
89	....do	....	....	2	....	....	×	90°	....	0	0	×	×
90	....do	....	....	(2)	....	....	×	90°	....	....	0	×	....
91	....do	....	....	(2)	....	....	×	Apparently 90°.	....	....	0	×	....
92	....do	....	....	2	....	....	....	....	....	0	0	×	....
VI	Chloromyxum sens. strict.	....	....	4	....	....	×	90°(?)	....	0	0	×	....
93	....do	....	....	4	....	....	....	....	....	....	0	×	....
94	....do	....	....	4	....	....	....	....	....	0	0	×	....
95	....do	....	....	4	....	....	×	90°(?)	....	0	0	×	....
96	....do	....	....	4	....	....	....	....	....	....	0	×	....
VII	Cystodiscus	....	....	....	×	....	×	90°	....	....	×	×	×
97	....	....	....	....	× 1 at each end.	....	× (valves oblique to transverse plane.)	90°	....	....	×	×	×

Tabular key—Continued.

Spore.										Index.					
Tail.				Outline on vertical view.	Dimensions.										
	Present.														
	Single.														
Absent.	Undivided.	More or less bifurcate.	Double from base.		Length in μ.	Breadth in μ.	Thickness in μ.	Length of capsules in μ.	Presence of filament; length in μ.	Capsular.	Caudal.	Ridge; presence and index.	Presence of cornua of sporoplasm recognized.	Nuclei *ad plurimum*.	Species No.
×				Transversely subisosceles-triangular.	8 to 12	100			×			×			87
×															VI
×				Subspherical.	8 to 12							×			88
×				Transversely elliptic.	6	8		3 to 3·5.	×	About 0.50.		Very small.			89
×					Less than breadth.										90
×															91
×				Oval, pointed anteriorly.	10 to 12	7									92
×				Subspherical.											VI
×				Cuneate-ovate.											93
×				Cuneate-ovate.											94
×				Nearly spherical.	5 to 7							×			95
×				Subspherical, mucronate anteriorly.	*ad max.* 8.										96
×				Fusiform								(×)			VII
×				Round-fusiform.	12 to 14	9 to 10			4 to 5 times length of spore			×			97

Tabular key—Continued.

Species No.	Myxosporidium. Size in μ.	Ectoplasm and endoplasm differentiated.	Pseudopodia.	Nuclei.	Pansporoblast.	Pansporoblast producing spores *ad plurimum*.	Vacuole.	Cyst. Size in mm.	Shape.	Color.	Host.
87	Spherical or oval; young stages amœboid, colorless, older yellowish; pseudopodia lobed, motile; endoplasm riddled with spherules, 3 to 4 μ in diameter containing pigment granules.							None			Galeorhinus galeus Galeus mustelus.
VI											
88								None			Gasterosteus aculeatus. Pygosteus pungitius. Phoxinus phoxinus.
89								None			Bufo lentiginosus
90											Acerina cernua
91						1(?)					Lota lota
92	1250 to 1500.	Apparently membraneless.									Leuciscus rutilus, Leuciscus erythrophthalmus.
VI								None			
93	29 to 88.				1 to 4	1		None			Raja batis
94	29 to 147.	×	×	Many.	×	1		None			Galeus mustelus. Scylliorhinus canicula. Scylliorhinus stellaris. Pristiurus melanostomus. Squalus acanthias. Squatina squatina. Torpedo torpedo. Torpedo marmorata. Raja clavata. Dasyatis sp. Cephaleutherus aquila.
95		×	Ectoplasmic, lobed.					None			Leuciscus cephalus.
96	*ad max.* 75.	Membraneless.			Probably.	2 (??)		None			Lota lota
VII											
97	*ad max.* 1500 to 2000.	×					Numerous "vesicles".	None			Bufo agua. Cystignathus ocellatus.

Tabular key—Continued.

Seat.	Pathologic effect.	Remarks.	Genus.	Species.	Species No.
Free in gall bladder. Free in gall bladder.	....	Myxosporidium bisporogenetic.	Ceratomyxa	sphærulosa	87
....	....	....	Chloromyxum (Sphærospora).	....	VI
Renal tubules and ovary. Renal tubules and ovary. "Accidentally" in kidney.	....	....	....do	elegans	88
Renal tubules; urine and surface of bladder.	Pressure effects.	....	....do	ohlmacheri	89
....	....	....	....do	perlatum	90
Ovary	....	....	....do	sp. incert	91
Pseudobranchiæ ... Branchial lamellæ...	....	....	....do	dujardini	92
Free in gall bladder.	....	....	Chloromyxum ... (*sens. strict.*)	....	VI
Free in gall bladder.	....	Posterior border of spore radiate-toothed.	....do	incisum........	93
Gall bladder .... Gall bladder. Gall bladder. Gall bladder. Gall bladder. Gall bladder. Gall bladder. Gall bladder. Gall bladder. Gall bladder. Gall bladder.	....	....	....do	leydigii........	94
Gall bladder	....	....	....do	fluviatile	95
Free in urinary bladder.	....	....	....do	mucronatum....	96
....	....	....	Cystodiscus	....	VII
Gall bladder .... Gall bladder.	....	No "nucleus" seen .	....do	immersus.......	97

Tabular key—Concluded.

Species No.	Genera.	Spore.											
		Capsules.					Shell.		Vacuole.		Symmetry.		
		1 only.		2 or more in—									
					2 separated groups.								
		Obscure; spore minute.	Conspicuous; spore relatively large.	1 group (at anterior end).	At each (anterior and posterior) end.	In each (right and left) wing.	Bivalve.	Inclination of valve-junction plane to longitudinal.	Aniodinophile.	Iodinophile.	Antero-posterior.	Bilateral.	Supero-inferior.
98	Cystodiscus	....	....	....	2 at each end.	....	× (valves perpendicular to transverse plane)	90°	....	....	×	×	×
VIII	Sphæromyxa	....	....	....	2 groups (position ?).	....	×	......	....	0	?	?	?
99	....do	....	....	....	1 at each "extremity" (end ??).	....	×	......	....	0	......	......	....
IX	Myxidium	....	....	....	....	×	0	......	....	0	0	×	....
100	....do	....	....	....	....	1 or 2 in each wing.	0	......	....	0	0	×	....
101	....do	....	....	....	....	2, in 2 groups (position ?)	×	......	....	0	But 1 plane of symmetry, viz; the valve-junction plane.		
102	....do	....	....	....	....	1 in each wing.	....	......	....	....	?	×	....

Tabular key—Concluded.

Spore.										Index.					
Tail.				Outline on vertical view.	Dimensions.								Presence of cornua of sporoplasm recognized.	Nuclei *ad plurimum*.	Species No.
Absent.	Present.														
	Single.		Double from base.												
	Undivided.	More or less bifurcate.			Length in μ.	Breadth in μ.	Thickness in μ.	Length of capsules in μ.	Presence of filament; length in μ.	Capsular.	Caudal.	Ridge, presence and index.			
×				Parallel-sided fusiform.					1						98
				Elongated (? antero-posteriorly).											VIII
				Subfusiform with sharply truncate extremities.	"length" 13 to 16.	"width" 5.			Axis of coil perpendicular to that of capsule.					4 (including pericornual.)	99
0															IX
0				Transversely unequally biconvex lenticular.	4 to 6	15 to 20			2 to 3 times breadth of spore.					2	100
				See p. 290.	length(?) 4 to 5.	br'dth(?) 8 to 9.			12, extruded by HNO_3						101
0															102

Tabular key—Concluded.

Species No.	Myxosporidium.							Cyst.			Host.
	Size in μ.	Ectoplasm and endoplasm differentiated.	Pseudopodia.	Nuclei.	Pansporoblast.	Pansporoblast producing spores *ad plurimum.*	Vacuole.	Size in mm.	Shape.	Color.	
98	......	......	......	......	......	......	......	......	......	......	Tortrix viridana....
VIII	......	......	......	......	......	......	......	......	......	......	......
99	Small	×	......	......	......	......	......	......	......	......	Onus tricirratus.... Onus maculatus ....
IX	......	......	......	......	......	......	......	None	......	......	......
100	*ad max.* 300 by 136.	×	2 kinds, obtuse and filiform.	Numerous.	×	2	Inconstant as regards presence, position and number	None	......	......	Lucius lucius.......
101	Small	×	Lobed, sometimes bristly.	......	......	......	......	......	......	......	Onus tricirratus.... Syngnathus æquoreus. Biennius pholis.... Callionymus lyra... Siphostoma acus.... Raja batis ....
102	......	......	......	......	......	......	......	......	......	......	

Tabular key—Concluded.

Seat.	Pathologic effect.	Remarks.	Genus.	Species.	Species No.
Body cavity			Cystodiscus??	diploxys	98
			Sphæromyxa		VIII
Gall bladder Gall bladder.			do	balbianii	99
Excretory tract (see p. 107).			Myxidium		IX
Urinary bladder			do	lieberkühnii	100
Gall bladder Gall bladder.			do??	incurvatum	101
Gall bladder. Gall bladder. Gall bladder. Bile ducts			do?	sp. incert	102

NON-MYXOSPORIDIAN.

1. **Psorospermia sciænæ-umbræ** Robin, 1853.[1] Pl. 1, figs. 1-4.
Hist. Nat. des Végét. Parasites, pp. 314-321, pl. 14, figs. 14, 15; pl. 15.

Robin defined the species as follows:

Cellulæ ovoideæ vel raro sphericæ aut ovoideo-elongatæ; coriaceæ, intus granulosæ, achromaticæ, luteo-succineæ vel luteo-fuscæ. Long., mm. 0·027; lat., mm. 0·018; sphericæ, mm. 0·017. In stratis (coloniæ) indefinitis, vel cylindricis, filamentosis, circulatim flexuosis, continuis cohærentes, raro isolatæ.

Hab. Infra membranam mucosam cavi branchialis insitam in septo abdomino-branchio sciænæ-umbræ.

The species consists of three varieties. The description is Robin's condensed and rearranged.

VARIETY 1.—(Robin's plate 15, figs. 2*a*, *b*; 4*a*, *b*; 6.)

Microscopic.—Cells ovoid (27 by 18 μ) or spherical (diameter 17 μ), a little flattened on one side, having an amber-yellow tint with a white shining reflex, strongly refringent, resembling fat drops; ovoid cells a little flattened with clearly defined borders and double contoured walls (1 μ thick) rupturable by pressure, cell-contents then escaping. Contents clear, yellow, homogeneous, strongly refracting, liquid, in which float 5 to 8 or more, strongly refringent granules, 1 μ in diameter. Cells not altered by acetic acid or ammonia.

Macroscopic.—Cells cohering into grayish yellow, flexuous cylinders (colonies) 0·5 mm. in diameter (plate 15, fig. 1); length sometimes 1 m. or more. Cylinders convoluted, *circular*, *endless*, usually united in pairs by a double or triple delicate transparent connective tissue sheath (fig. 2*c*, *f*, *g*), the whole forming a delicate string rolled upon itself, in every direction (pl. 1, fig. 1*a* of this paper) into a flattened spherical, lobulated or nonlobulated mass, whose size varies from that of a nutlet to that of a fist.

VARIETY 2.—(Robin's plate 15, figs. 2*c*, *d*; 4*c*, *d*.)

Microscopic.—Cells ovoid, white, colorless, transparent, with a shining reflex, with more numerous and larger granulations than the other varieties.

Macroscopic.—Cells united into opaque, milk-white, filamentous, continuous, endless cylinders, either by simple cohesion or by amorphous matter, which latter forms around each cylinder a (hardly perceptible) thin enveloping membrane (plate 14, figs. 2*c*, *d*; 4*c*, *d*). These filaments are only visible under a lens, being only $\frac{1}{10}$ to $\frac{1}{8}$ as thick as the cylinders of the first variety.

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[1] This species was first described as a constituent part of the body of the host by Robin, in his paper "Anatomie d'un organe découvert sur l'ombre (*Sciæna umbra*) read to the *Société philomatique* Nov. 28, 1846 (Procès verb. d. la Soc. philomat. Paris, 1846, p. 140; also Journ. l'Institut No. 683, Feb. 3, 1847, Paris, xv, p. 41). Not seen; *fide* Robin, 1853, p. 314.

VARIETY 3.—(Robin's plate 15, figs. 3; 5*a*, *b*; 8.)

Microscopic.—Cells regularly or irregularly ovoid, a little smaller than those of the first variety, brownish yellow, presenting a peculiarity found in no animal cell, viz, a round opercle.[1] Cells unaffected by acetic and nitric acids, and by ammonia.

Macroscopic.—Colonies of variety 3, consisting of small lenticular, or irregular brown or white masses scattered here and there at the base of or below the lobes, and especially over the submucous surface of the parasitic convoluted-string mass.

(1) Brownish masses.—2 to 4 mm. thick, composed of masses or colonies of irregular, cupped, operculate cells, the whole enveloped by a layer of cellular tissue containing very fine capillaries. Masses sometimes sufficiently numerous to color quite an area of the mucosa blackish brown. Further, when the convoluted-string mass is absent, brown bodies may occur in the same situation. These bodies are ordinarily accompanied by small pea-sized, whitish corpuscles, composed of round granules measuring about 0·20 mm., formed of strongly united fibers of cellular tissue wound around a small transparent, apparently calcareous, body. It contains in the center 1 to 8 or 12 cells, furnished with an opercle similar to that above described.

(2) Whitish masses.—Composed of grains formed of 2, 3, 4, or 12 (rarely 1) cells, surrounded by a thick cellular tissue layer, the fibers of which are strongly united by amorphous finely granular matter, the whole forming rather hard, white, spherical or ovoid grains, $\frac{1}{8}$ to $\frac{1}{4}$ mm. in size, often clearer in the center.

Calcareous granules forming an oval or circular mass (fig. 5) with sharply defined borders (the latter sometimes split); granules forming whitish, more or less flattened, friable, irregularly lobulated, pea-sized miliary masses. Granular mass destitute of vascularity, the vessels being confined to the tissue sheath.

Some masses are hard, yellowish white, of variable form, composed of operculate cells, calcareous granules, and a great number of very large, quadrilateral or rhomboidal, tabular crystals, the latter often piled up, insoluble in acetic acid, in which only the calcareous granules disengage some bullæ of gas. Calcareous granules also occur without crystals, being in this case whiter and less yellowish.

The convoluted string (*cordon enroulé*).—As described above, the cells of varieties 1 and 2 form continuous (endless) cylindrical filaments, those of variety 1 forming *yellow* filaments, those of variety 2 forming *white* filaments. The convoluted string is usually[2] formed of 6 of these

[1] Robin gives the size of the opercle as 0·06 mm., but as he says the cells are smaller than those of the first variety (whose length is 0·027 mm.) this must be an error, possibly for 0·006 mm.

[2] Sometimes, however, only 2 filaments (instead of 6) are present, viz, 1 large yellow filament (instead of 2), and 1 (not 4) thin white filament. Also (very rarely) the convoluted string contains only 1 (instead of 6) white filament (variety 2) and 2 or 3 successive enveloping sheaths.

filaments (arranged in two series, *a* and *b* below) together with a connective tissue sheath (*c* below).

(*a*) First series, composed of one yellow filament (variety 1) and two white filaments (variety 2), the latter applied one along each side of the yellow filament. One of the white cylinders is always flexuous, the other always straight and without undulations.

(*b*) Second series, consisting, like the first, of a yellow filament (variety 1) accompanied by two semitransparent, hyaline, whitish filaments, which resemble the previously described filaments in being continuous and endless, *but which appear not to be composed of cells.* They consist only of a thin wall filled with a semiliquid, finely granular substance. One of these whitish filaments is flexuous and undulating; the other, instead of being straight throughout its whole length, undulates a little from place to place.

(*c*) Sheaths formed of connective tissue of the host, penetrated by delicate capillaries.

Parasitic mass (as a whole).—Showing through the thin covering of transparent mucous membrane of branchial cavity as a grayish or whitish mass of convoluted strings (varieties 1 and 2), strewn with small brown masses (variety 3) of the size of a pea. Size of parasitic mass varying from that of a millet seed to that of a large goose egg. Sometimes voluminous on one side and small on the other; sometimes composed of two or three separate lobes. Form inconstant, generally consisting of round or elongated lobes. Arteries and veins few, extremely delicate; derived from vessels of neighboring muscles, which, with the loose submucous tissue, form the only bond between the mass and the tissues of the host. Injection with mercury (of the connective tissue sheath, described above under variety 1) demonstrates that the mass consists of closed lobules. When filled with mercury, no escape of the metal occurs unless greater pressure produces rupture. When very small, the mass may be unrolled and shown to consist of a convoluted string.

Habitat, etc.—Submucous connective tissue of branchio-abdominal septum (between scapular and last branchial arch) of *Sciæna umbra.* Among 9 fish (male and female) examined in September, it was absent in 4. The size of the 5 hosts varied from 1·30 m. to 1·70 m. Sometimes, but rarely, variety 3 exists alone, the usual condition, however, being that varieties 1 and 2 are present together and are accompanied by small colonies of variety 3.

Nature.—Robin regards it as referable to the Diatoms. Lieberkühn[1] says that:

> The psorosperms of some marine fishes recently described by Robin behave in every respect like Trematode eggs.

Whatever other view be taken of its affinities, this species is certainly not myxosporidian. As remarked above (p. 72), the generic name must follow the type species.

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[1] Müller's Archiv., 1854, pp. 10–11.

2. Lithocystis schneideri Giard, 1876. Pl. 2, figs. 1, 2.

Sur une nouvelle espèce de psorospermie (*Lithocystis schneideri*) parasite de l' *Echinocardium cordatum;* Compt. Rend. Acad. Sci. Paris, 1876, LXXXII, pp. 1208–1210; transl. Ann. Mag. Nat. Hist., London, 1876, XVIII, pp. 192–194; also see Bütschli, Bronn's Thier-Reich, I, pp. 590, 602; figured in Schneider's Tablettes Zoologiques (*fide* Pfeiffer, Die Protozoen als Krankheitserreger, p. 49); *ib.* Perrier, 1893, Traité de Zool., p. 459.

Cyst unknown.

Plasmodium.—Forming shining black (pigmented) irregular masses. Size varying from that of a point to 10 mm. by 4 or 5 mm., aspect and consistence similar to that of the myxomycete plasmodia; surface of mass showing hyaline cysts with a structureless membrane, 2 mm. or less in diameter, containing one or more, rarely several, white points (crystal masses) and spores, the latter arranged in an irregular sphere. Spores situated at the extremities of filaments, which radiate from a central point, at which is a nucleus of a yellowish substance. Each spore is sustained by 2 filaments tangential to the extremities of its shorter axis. Wherever possible (principally in the larger cysts), the spores become, at maturity, so rearranged as to form a number of little groups; spores cohering by their previous peripherally-placed portions.[1] At the same time the two filaments become applied to each other so as to form a single tail-like filament 3 or 4 times the length of the spore. The little groups then resemble colonies of *Flagellata*, but the tail-like filament remains motionless. The coherence of the spores is due to a secretion produced at the adhering ends of the spores.

Crystals insoluble in acetic acid, soluble in nitric acid, broken up at maturity of cyst, forming a sort of network, which seems to function somewhat similarly to the capillitium of the Myxomycetes in the dissemination of the spores. Pigment of plasmodium believed to be derived from host. The amœbæ present in the fluid of the body cavity of the host are regarded as originating from the falciform corpuscles, which are seen to slowly lose their form, and Giard believes them to produce by their union and growth the plasmodia.

Spores.—Fusiform, length 6 to 10 μ, breadth 1 to 2 μ. Some cysts (apparently the smaller) produce microspores, others megaspores, both of which classes differ from the ordinary variety of spore mainly in being more inflated towards the middle. Spore with 2 filaments (subsequently becoming 1, as above described) tangential to the shorter axis. Contents of spores merely a granular protoplasm, or from 3 to 6 falciform corpuscles in course of formation, arranged around a central residual mass, which latter is finally reduced to 2 or 3 strongly refringent granules, and may disappear at maturity.

Effects.—The parasite causes the formation of small nodosities on the inner surface of the test, which may enable us to recognize the presence of this parasite in fossil *Echinodermata*.

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[1] I. e., the portion corresponding to the "anterior pole" of a myxosporidian spore.

Habitat.—Body cavity of *Echinocardium cordatum* (sea-urchin), particularly against the test between the mouth and subanal plastron, and especially toward the conical point which terminates the plastron inferiorly; also frequently on the inner side of the actinal curvature of the intestine.

Nature.—Giard says:

I have found nothing resembling the Gregarines, and the whole of the facts observed lead me to approximate the parasite not to the lower animals, but to the lower plants (Myxomycetes and *Chytridineæ*); on the other hand, the spores being identical with those described as arising in the cysts of the Gregarines, one may ask whether the relation of the *Psorospermiæ* to the Gregarines is not a relation of parasitism rather than of genetic bonds.

Prof. Bütschli, the only other author who has (as far as I know) commented upon this form, says:[1]

It may indeed be possible that an organism as yet unfortunately only briefly described by Giard, his so-called *Lithocystis schneideri*, occupies a sort of middle ground between Gregarines and *Myxosporidia*, since it combines the plasmodioid nature with the production of spores similar to the *Myxosporidia*, together with the development of sickle-shaped germs in these spores. Unfortunately, however, as said, *Lithocystis* has not yet been fully described, so that the decision is at present somewhat difficult.

Prof. Lankester[2] places *Lithocystis* among the genera of the *Myxosporidia*. Pfeiffer[3] says that this species forms "a transition to a still unknown side."

Remarks.—First as to Giard's opinion, which is entitled to especial weight as being derived directly from a study of the form itself, while Bütschli's is here to a certain extent an opinion of an opinion. In Giard's article I fail to find the slightest indication of a desire to approximate *Lithocystis* to the *Myxosporidia*. True he calls it a "psorosperm," but he uses this term in a very vague sense, its scope appearing to be at least equivalent to that of the term *Sporozoa*. Further he states that:

The whole of the facts observed lead me to approximate the parasite not to the lower animals but to the lower plants (Myxomycetes and *Chytridineæ*).

Then he argues that since the spores of *Lithocystis* are identical with the spore-like contents of the gregarine cysts, perhaps the latter (which he also denominates "psorosperms") are not gregarine spores, but gregarine parasites.

Prof. Bütschli, however, says that while its spores agree with those of the Gregarines in containing falciform germs, *Lithocystis* possesses in common with the *Myxosporidia*, a plasmodioid nature and the production of similar spores.

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[1] Es wäre sogar möglich, dass ein bis jetzt leider nur flüchtig von Giard beschriebner Organismus, seine sogenannte *Lithocystis schneideri*, eine Art Mittelstufe zwischen Gregariniden und Myxosporidien einnimmt, da er das plasmodienartige Wesen mit Erzeugung ähnlicher Sporen wie die Myxosporidien, sowie der Hervorbildung sichelförmiger Keime in diesen Sporen vereinigt. Leider ist jedoch, wie gesagt, die *Lithocystis* noch nicht eingehend beschrieben so dass ihre Beurtheilung bis jetzt etwas schwer fällt (Bronn's Thier-Reich, 1882, I, p. 602).

[2] Encycl. Britan., 1885, 9 ed., XIX, p. 855.

[3] Die Protozoen als Krankheitserreger, 1890, 1 ed., p. 49.

However much (or little) this may prove as to the stability of body-form in the Gregarines, I can not see that it proves anything as regards the *Myxosporidia*. Further, I can not see any resemblance between the spores of *Lithocystis*, which contains falciform germs and no capsules, and the capsulate myxosporidian spores.

Perrier includes it among the *Myxosporidia*.

Finally, the following excellent paper (seen and incorporated at the last moment) seems to settle the question beyond doubt, and serves to remove almost the last "transition" form from the taxonomic doubtful list:

L. Cuénot: Commensaux et parasites des Échinodermes; Rev. Biolog. Nord France, Lille, v, Oct. 1, 1892; *Lithocystis schneideri* Giard, pp. 4-6, plate 1, figs. 1, 2.

The following is an abstract:

L. schneideri is a perfectly typical monocystid Gregarine; the gregarine stage probably occurs in the digestive tube, being rarely encountered in the body cavity, the Gregarine probably encysting soon after traversing the intestinal walls. In fact, cysts are encountered upon, but not attached to, the intestinal wall. In the body cavity the Gregarine was always found (whether accidentally or otherwise) in the midst of a mass of cysts. Gregarine ovoid, about 65 μ long, protoplasm very vacuolate, inclosing a rather large number of clinorhombic crystals, which also occur in the cysts; a voluminous nucleus, with large nucleoli, is present.

Masses of the spherical cysts, well described by Giard, occur of all dimensions (*ad max.* 1 to 2 mm.) in different regions of the body, especially on the intestine and on the oral surface. They inclose a considerable number of spores and a voluminous rest of segmentation riddled with the same crystals that occur in the Gregarine.

Spores of variable dimensions (megaspores 24 μ, microspores 12 μ), ovoid, distal end neatly truncate, proximal end rounded; spores limited by a unique refringent integument (endospore) situated at the extremities of small, very delicately walled tubes, which latter form a sort of more or less undulating epispore.

Spores arranged, at least in the large cysts, in a number of small, radial groups, formed by the convergence of the tubes to a common center. Contents of young spores granular; of mature spores 8 falciform corpuscles (4 at each end), and a central rest of segmentation. The falciform corpuscles are probably expelled on the death of the host, and other Echinocardiums naturally become infected by swallowing the sand containing them.

Pigment identical with the products of dissimilation spread through the tissues of the host; if specially condensed around the cysts, it is as a result of the [increased tissue] expenditure necessitated by their considerable growth.

The presence of small nodosities on the test could not be determined.

The cysts, united into more or less voluminous masses, are surrounded by a considerable mass of black pigment and of amœboid cells, the latter very evidently *Echinocardium* amœbocytes accumulated around the foreign bodies. The latent life of the cysts is probably not very long, as there are frequently seen, apparently in process of degeneration, small ones inclosing only empty spores absolutely devoid of nuclei.

As in all the other Monocystids studied, the *Lithocystis* spore has dissimilar poles, the one truncate, the other rounded and furnished with a long tube. The structure of the cysts is appreciably different from all other known Monocystids.

3. Genus et sp. incert. Pl. 2, fig. 3.

Parasite of *Gadus callarias*, Müller & Retzius, 1842, Ueber parasitische Bildungen; 1. Ueber eine eigenthümliche Krankheit der Schwimmblase beim Dorsch, *Gadus callarias*, Müller's Archiv., pp. 193–8, pl. 8, fig. 1; *ib.*, Rayer, 1843, Rayer's Archiv. de Méd. comp., I, pp. 284, 287–9, pl. 9, fig. 14; *ib.*, Leydig, 1851, Müller's Archiv., p. 22, mention only; psorosperms of *G. callarias*, Robin, 1853, Hist. Nat. Végét. Parasites, pp. 291, 309, pl. 14, fig. 1; ? psorosperm of bladder of codfish, St. George, 1879, Ueber die Feinde der Fische, Circ. 3, Deutsch. Fisch-Verein, p. 178, and Rep. U. S. Fish Com. for 1878 (1880), VI, p. 510; Myxosporidian? Coccidian? Bütschli, 1882, Bronn's Thier-Reich, I, p. 591, footnote; psorosperm of *Gadus merluccius* (error)[1] Balbiani, 1883, Journ. de Microgr., VII, pp. 145, 280; *ib.* (error),[1] Balbiani, 1884, Léçons sur les Sporozoaires, p. 122; ? psorosperms of cod, v. d. Borne, 1886, Handb. d. Fischzucht-u. Fischerei, p. 211.[2]

Adult unknown.

Cyst.—Unknown. Pathologic formation consisting of a whitish-yellow, pasty mass drawing out into threads of a greasy, dirty character, mostly diffluent (evidently less advanced), with a firmer portion surrounding the softer, in quantity about 6 fluid ounces, odorless even after several days exposure to the air; microscopic examination showing it to consist of the below-described corpuscles with a small amount of granular matter, the whole imbedded in and held together by a mucoid substance.

Spore.—Best described by comparison to a ribless ventricose *Navicula* or to Agardh's *Frustula caffeaformis*, elliptic, length pretty uniformly 14 to 17 μ, consisting of two valves, the substance of which is shown by complete decomposition upon ignition to be nonsiliceous; their carbon incinerates with difficulty; each valve of an elliptic outline with a convex outer and a concave inner surface, usually in contact with its fellow of the opposite side by the inwardly convex middle portion of its border, the borders of the valves diverging towards their ends; sometimes obliquely set so as to be in contact by one end only, sometimes in contact for their whole length, thus forming a lenticular corpuscle, along the median line of which the junction can be plainly traced; middle of valves cemented together by a mass occupying part of the body cavity; mass showing more or less plainly a number of large and small granules, and apparently destitute of a surrounding membrane.

Development.—By far the largest number of the corpuscles are destitute of a surrounding membrane; some were, however, observed heaped

[1] Prof. Balbiani misquotes the name of the host as "the merluche, *Gadus merluccius*." The context (he refers to the diseased air bladder) renders it evident that this is an error for *G. callarias*, and not (as might be expected) for *G. merlangus*. Inferentially from his language he regards the form as myxosporidian. Perugia (Boll. Scientif., Pavia, 1890, XII, p. 134) has followed Balbiani's misquotation.

[2] "With the cod [*Gadus morrhua*] and mackerel [*Scomber scombrus*] the development of large psorosperm-lumps with great emaciation and later ulceration is very well known, and not rarely there occurs in freshwater fishes, from the same cause, a great mortality."

3 or 4 together into irregular clumps. Many such clumps had no surrounding membrane, but some showed such a membrane containing several corpuscles. The features of the latter bodies were plainly discernible through the enveloping membrane. The corpuscles at this stage are unsplit, the valves being united for their whole length, forming a lenticular corpuscle. Further, similar cysts were seen which showed no developed corpuscles, but only large granules. Finally, a number of separated valves may be seen. From these facts Müller concludes that the corpuscles in question develop several in a cyst, are set free unsplit, subsequently the valves separate, at first partially, at last probably entirely, and then perhaps the cycle is repeated.

Habitat.—Air bladder of *Gadus morrhua* (= *callarias*), cod.

Nature.—Robin includes it among the "psorosperms."

Dr. L. Wittmack [1] refers to this as a "psorosperm."

Concerning this form Prof. Bütschli [2] says:

> It appears to me quite questionable whether these psorospermiform corpuscles of the air bladder of *Gadus callarias* are to be referred to the *Myxosporidia* proper or to the *Coccidia.* Their structure appears to approximate itself rather to the latter; especially in the absence of the polar capsules so characteristic of the *Myxosporidia.*

I can see no myxosporidian structure in it, and have, therefore, omitted it from the subclass.

Effects.—Mucous membrane of the air bladder red and swollen, infiltrated by the parasitic mass. Tail unusually thin and shrunken, the soft parts being markedly atrophied, the muscular tissue having disappeared. Further observation must determine the constancy and causality of relation between the two conditions. Such atrophy is apparently not rare in *Gadus*, as the fishermen at Bohuslän knew the disease and informed Müller that it rendered the fish unfit for food.

Müller says that the difference between this form and the psorosperms of fresh-water fishes is as great as that between different genera of animals.

Atrophy of tail of Merlangus merlangus.[3]

The following observation probably can not be better placed than as an appendix to the similar disease of *G. morrhua* just described. Among the Mediterranean fishes collected by Mr. Peters, Müller and Retzius noted a *Gadus merlangus* affected with complete atrophy of the tail muscles, the tail being composed of nothing but skin and bone—not the slightest trace of muscular tissue remaining. The junction of the normal and atrophied tissue was abrupt and was situated at the root of the tail. Unfortunately, the air bladder had not been preserved.

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[1] Beiträge zur Fischerei-Statistik d. deutsch. Reichs, 1875, p. 191, footnote.

[2] Bronn's Thier-Reich, 1882, I, p. 591, footnote.

[3] Müller and Retzius, 1842, Müller's Archiv., p. 198; see also p. 172.

4. Genus et sp. incert. Pl. 4, fig. 1.

Entozoan of *Salmo fario*, Valentin, Ueber ein Entozoon im Blute von Salmo fario, Müller's Archiv., 1841, pp. 435, 436, pl. 15, fig. 16; *ib.* Leydig, 1851, Müller's Archiv., pp. 11, 12; cf. Davaine, Traité des Entozoaires, Paris, 1860, p. III.

Amœboid stage.—In blood obtained by puncture of the abdominal aorta of *Salmo fario* (brown trout) Valentin found, besides the blood corpuscles, some dark globules similar to round pigment cells. They have a quick, tremulous motion, also a definitely locomotive one. Observed for some time, a clear "tail" comes into view, which later elongates; there thus becomes revealed an elongate animal with a rapid motion, mostly of rotation, effected by 1 to 3 variable processes of one side of the body. Anterior and posterior parts clear; middle portion containing numerous dark corpuscles, perhaps pigment particles which it had eaten. When rolled up into a ball it often had the appearance as though each club-shaped process of the body contained one of the globules (pl. 4, fig. 1*e*). No finer structure could be detected. Size 7·5 to 12·5 μ. Sometimes a round opening appeared to be present at the anterior end. The posterior end is somewhat striate. The variable processes always appear in the drawing as they would be seen in the microscope on the right side. Perhaps the club-shaped peduncles are to be reckoned as such. In drawn blood they remain living from 6 to 8 hours.

Nature.—These bodies are, Valentin says, probably referable to *Proteus* or to *Amœba*, of which they certainly form a new species, different from all of Ehrenberg's. Doubting at first whether these organisms really belonged to the blood, Valentin investigated the whole fish. He failed to find, either on the peritoneum, or in the kidneys, intestines, air bladder, brain, etc., any trace of these infusorial Entozoa. Only in the fourth ventricle (the favorite seat of the microscopic intestinal worms) did he find a single specimen. On the contrary, they were so numerous in the blood that often a single droplet contained 10 or more. The blood itself presented nothing worthy of note. The fishes examined showed numerous examples of *Ascaris obtuso-caudata* Zedér. No other intestinal worms were found.

Leuckart[1] says:

> Still less is the gregarine nature of the entozoan found by Valentin in the blood of the trout to be mistaken.

Lieberkühn regarded it as an amœba. It could not, he says, be a Gregarine, as it lacks a nucleus.[2]

Although this form has been referred to the *Myxosporidia* by Leydig, the evidence to sustain such reference is wanting, and at present its myxosporidian affinities can not be regarded as proven.

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[1] Archiv. f. physiol. Heilkde, 1852, XI, p. 431.

[2] Muller's Archiv., 1854, pp. 11, 12. For Lieberkühn's subsequent change of view as to the necessity of the presence of a nucleus in the Gregarines, see pp. 95, 96.

5. Balbiania rileyi Stiles, 1893. Pl. 3, figs. 1–5.

(Psorosperms of mallard duck, Leidy, 1875, Proc. Acad. Nat. Sci. Phila., XXVII, p. 125).

Balbiania rileyi, Bull. 3, Bur. An. Ind., Dept. Agric., pp. 80–84, pl. 2, figs. 1–5.

Dr. Leidy's description may be summarized as follows:

Cyst, oval, white, 2 to 4 mm. long, 0·7 mm. thick. Contents, myriads of fusiform corpuscles. Spores fusiform corpuscles resembling minute navicellæ; length 17μ; habitat, encysted in interstices of muscles of the mallard duck (*Anas boschas* L.).

Nature.—Leidy says that—

Similar bodies were first discovered by the late Prof. Müller and described by him under the name of psorosperms. They have been repeatedly observed since by Retzius, Robin, and others, in the muscles and other parts of fishes, and they are usually regarded as vegetable parasites. Though the mallard is not a fish-eater, the bird may have become infected by eating infected fish.

From this extract it might not unnaturally be supposed that in this instance "psorosperm" referred to a myxosporidian.

Recently Dr. C. W. Stiles has reëxamined the subject. He studied material from two hosts and five localities, including one lot labeled:

Oval, smooth bodies, no limbs. In muscles of Mallard. *Anas boschas.* Dr. E. Coues. Ex. Jan. 29, 1890.

The following is the diagnosis:

Parasite 1 to 6 mm. long by 0·48 mm. broad; rather fusiform, ends not sharply pointed. Cuticle not striated, about 2μ thick. Central core not coloring and not containing falciform bodies. Peripheral zone as broad as central core (0·16 mm. to 0·16 mm.) or even broader, coloring in various liquids (acid carmine; methyl blue), containing numerous falciform bodies. Form of meshes irregular but elongated radially. Falciform bodies 12 to 14μ long, more pointed at one extremity than at the other; containing a very distinct nucleus (2μ) which stains clearly in acid carmine or methyl blue, and which contains several chromatophile granules; vacuole quite indistinct.

Habitat.—Intermuscular connective tissue of ducks, the shoveler or shovelbill duck or spoonbill duck (*Spatula clypeata*), and the mallard or tame duck (*Anas boschas*). Development unknown.

North America. (?) Philadelphia, Pa. (Coues; Leidy); St. Louis, Mo. (Riley); Clear Lake, Cal. (Brett); Minnesota (Lüger); Quebec (Bélanger).

Type material deposited in the U. S. National Museum, in the Bureau of Animal Industry, and in collection of Stiles, Washington, D. C. Specimens are also to be found in the Army Medical Museum, Washington, D. C., and in collection of Leidy, University of Pennsylvania, Philadelphia, Pa.

In conclusion, although "measly duck" is not very appetizing in appearance, there are no grounds for believing that it is dangerous to man.

6. Genus et sp. incert. Pl. 4, figs. 2–8; pl. 5, figs. 1–11.

Pilzsporen of *Cyclops*, Claus, 1863, Die freilebenden Copepoden, Leipzig, p. 87; *Myxosporidia?* of *Cyclops*, of *Diapt. cœruleus* and of *Diapt. richardi*, Schmeil, Beiträge z. Kenntn. d. freilebenden Copepoden Deutschlands, Ztschr. f. Naturwiss. Halle, 1891, LXIV, pp. 19–21; Entoparasitische Schläuche der Cyclopiden Schewiakoff, Ueber einige ekto-, and entoparasitische Protozöen der Cyclopiden, Bull. Soc. Imp. Nat. Moscow, 1893, pp. 2, 15–26, pl. 1, figs. 17–34.

Claus says:

The bodies formerly[1] designated by me "spores of fungi," with which I have many times found the body-cavity of *Cyclops* entirely filled, I have unfortunately not been able to observe again in later times. From the earlier period, sufficient notes on these bodies unfortunately are lacking, so that I am compelled to leave undetermined their nature and their relation to *Parhistophyton ovatum*, so full of significance through the disease of the silk-worm.

To his quotation of part of the above Schmeil (p. 21, footnote 1) adds:

"*The organisms observed by me are, however, certainly not spores of fungi*" [italics his own].

Schmeil further says (abstract):

I have observed another parasite in nearly all the *Cyclops* of the Halle
[Page 19] region, further in the specimens seen of *Diapt. cœruleus* Fisch. and *D. richardi* Schmeil.

As this parasite is relatively very frequent—though absolutely (*ständig*)
[Page 20] rare—one soon learns to tell the affected animals with the naked eye by their striking gray color. Their movements are unaffected. Microscopic examination shows individual parts of the body strikingly dark (in Cyclopids and *D. richardi* Schm., black; *D. cœruleus* Fisch., dark brown); often the whole thorax, the abdomen, and even the tail, the first antennæ, and natatory feet are either entirely or partly filled by this dark mass. On closer examination this dark color is seen to be due to an innumerable host of small fusiform or crescentic corpuscles, whose form (plainly perceived by pressure-rupture of the copepod shell) places them as psorosperm-like bodies. From Schmeil's description and drawings, Bütschli considered them *Myxosporidia*. Size very variable; besides very small corpuscles, one meets with larger ones 3 or 4 times the smallest, but the sizes of all those occurring in the same individual are always nearly equal. These corpuscles appear to possess a firm membrane, immediately within which a clear zone is situated. No differentiation of contents could be observed. Water and glycerin do not alter the form.

Origin of these corpuscles unknown; repeated attempts to infect
[Page 21] healthy animals failed. Multiplication by division seems proven by the occurrence of two or several corpuscles lying close together, often in contact lengthwise; often, however, with their blunt poles surrounded by a common membrane. Therefore, in case the explanation generally given is correct, a double division in the transverse and longitudinal axes appears to take place.

On account of the lack of infected animals it is exceedingly difficult to reach safe conclusions concerning these conditions.

Such was the state of the subject when Schewiakoff began his investigations. The following are his results:

This condition has been observed at all seasons, first on *Cyclops strenuus* Fisch. taken from under the ice of a pool (clay ditch near Schlettau).

[1] Place not stated; or whether published.

Tubes rather frequent in very many fresh-water copepods, the affected [Page 15] individuals being distinguishable at first glance from the healthy by their opacity, the places where the parasites lie appearing dark. If in great number, the *Cyclops* appear completely opaque, and, indeed, according to [Page 16] Schmeil (loc. cit., p. 20), may appear dark brown to black. Discoloration caused by larger or smaller tubes filled with pyriform, spore-like corpuscles; tubes occurring in body-cavity, and various other places, as the thorax, abdomen, tail, natatory feet, and first antennæ; sometimes in so great numbers that no part of the body is free from them. Spores in some places not in tubes but free in body-cavity, then always found directly on the muscles.

These parasites were probably those which Claus observed in copepods and regarded as spores of fungi; also extremely probably those noted by other observers, in various crustacea, e. g., Henneguy in *Palæmon rectirostris* and *P. serratus*, Henneguy and Thélohan in *Crangon vulgaris* and *Astacus fluviatilis*, and Garbini in *Palæmonetes varians*. However, it can not with certainty be asserted that the parasites found in the last-mentioned crustaceans are identical with the *Cyclops* parasite, as to the short communications no figures[1] are added, and the authors in question were unable to follow the whole developmental history.

Technique.—The affected *Cyclops* was isolated in a drop of water on the [Page 17] slide and covered with a cover glass provided with wax feet, fixed in position by careful pressure on the angles of the cover-glass, so that it remains quiet and can be conveniently observed even with a high power (apochr. 4 mm.). Between the observations the *Cyclops* was at first kept in a hanging drop in the moist chamber, but lived only a few (2–3) days, dying partly from starvation, partly from other unfavorable conditions. Consequently the *Cyclops* was next kept in a watch-glass of water, thus securing necessary food supply. Thus kept, it lived 14 days, allowing the development of the parasites to be followed. Several individuals were kept simultaneously and examined 2 to 4 times a day. Investigation of dead or crushed specimens is not to be recommended, as great bacterial development soon disturbs the study. For observation of the finer anatomical features and the developmental stages, the parasites were isolated by crushing the host and observed with very high powers (homog. immers. apochr. 2 mm., oc. 12 and 18). For fixation, picro-sulphuric, and chromo-aceto-osmic acids; for stains, alum carmine, hæmatoxylin; also methyl violet, safranin, and fuchsin. Examinations were made partly in water, partly in glycerin.

1. *Amœbiform stage.*—Met with in all parts of the body; most easily [Page 18] observed on the first antennae. Form amœboid-variable, globular or elongate; dimensions varying from 7μ long by 3μ broad, to 20μ long by 6μ broad. Plasma finely granular, capable of emitting on all sides blunt, lobulate, hyaline pseudopodia, always possessing a nucleus (pl. 4, fig. 2 N) and a small contractile vacuole (*c. v.*). Nucleus globular, showing the familiar vesicular structure, that is, in its interior, a globular, homogeneous, more strongly refringent and more deeply staining nucleolus [*Binnenkörper*]. Contractile vacuole constantly situated near the border, in the end of the body which during progression is hindermost, pulsating about once every 30 seconds; no food vacuole perceptible.

This amœba ordinarily creeps about over the epithelial and muscle cells and probably feeds upon the same, as, although not directly observed, many epithelial cells were seen destroyed, and upon them amœbæ.

After attaining a certain size the amœbæ gradually cease their movements, draw in their pseudopodia, and encyst themselves.

The amœbæ may fuse to large plasmodes; several such fusions of 2 or 3 amœbæ (pl. 4, fig. 8) were directly observed. Size of plasmodes varying with size and

[1] The author is partly in error as regards the absence of figures. They will be found in the papers of Henneguy and Garbini.

number of constituent amœbæ from 18μ long by 8μ broad to 48μ long by 23μ broad. In fusing the amœbæ adhere closely to one another, finally after some time fusing into one mass, which can then undergo further movements. Nuclei (pl. 4, fig. 8 N) of plasmode vesicular, 2 to 3 according to the number of constituent amœbæ. Union or fusion of the nuclei not directly observed; regarded, however, as very probable, as frequently pretty large plasmodes of 22μ and 18μ (doubtless
[Page 19] formed by fusion of 2 or 3 amœbæ) were seen containing only 1 large, vesicular nucleus (pl. 5, fig. 2 N). Besides, plasmodes seen to originate by fusion of 3 amœbæ and to contain nuclei, showed on the next day only 1 large nucleus.

Contractile vacuole not demonstrable with certainty in fusion plasmodes; its presence, however, not regarded as impossible; the plasma, on the contrary, contains so many vacuoles as to appear vacuolate or frothy. Motion of plasmodes rather slow. Plasma in the next 24 hours undergoing a change; the frothy, vacuolate structure changing to a finely granular condition, the vacuoles vanishing. Nucleus, also, no longer visible; probably transformed by division into several globular strongly refringent bodies (pl. 5, fig. 3 N), though this was not directly observed. Motion of plasmode in this stage quite slow, ceasing entirely after some time; encystment following in 1 or 2 days.

2. *Encystment.*—The encystment of simple small amœbæ and the alterations in their body plasma is first described; afterward the process with the fusion plasmodes. With the small amœbæ encystment begins when they have attained a certain size. They gradually draw in their lobulate pseudopodia and acquire an irregular, more or less oval or pyriform shape. Locomotion still takes place, though very slowly, small ragged pseudopodia being still emitted. After about 1 hour this movement also ceases and the amœba revolves slowly, gradually rounding itself off and assuming with a state of rest a nearly globular form. After about 10 hours it has transformed itself into a proper cyst (pl. 4, fig. 3) about 10μ in diameter,
[Page 20] consisting of a plainly bordered, extremely thin membrane and finely granular contents, in which individual, small, strongly refringent granules, a vesicular nucleus (N), and a contractile vacuole (*c. v.*), which now pulsates markedly more slowly, are perceptible.

After about 24 hours (pl. 4, fig. 4) the membrane appears markedly thicker, double contoured, and the strongly refringent granules have increased in number. The nucleus no longer appears vesicular, but homogeneous and rather strongly refringent. Contractile vacuole still always visible, although now pulsating extremely slowly (about once in 5 minutes).

After another 24 hours (pl. 4, fig. 5) the protoplasm appears strongly brilliant, the contractile vacuole has vanished, and the nucleus is not perceptible. In their places are observed several round, strongly refringent structures (probably proceeding from division of the nucleus), differentiated from the other cyst-plasma granules already mentioned, by their more considerable size and their affinity for stains. Though the falling to pieces of the nucleus was not directly observed, the granules may with tolerable safety be admitted to have originated through nuclear division. Schewiakoff thinks that first the nucleus divides, and about 10 hours later the spores (pl. 4, fig. 6) are formed, since around every nucleus a portion of the protoplasm delimits itself from the remainder.

Encystment of plasmodes occurs in the same way. Locomotion becomes continually slower until finally it is extinguished. The plasmode then rounds itself off, acquires a somewhat elongate oval form, which, as also the size, varies greatly. It then secretes a thin membrane, which envelops it closely on every side (pl. 5, fig. 4).

[Page 21] In 1 to 2 days the membrane becomes markedly thicker, then appearing homogeneous, strongly refringent and double contoured. During the next day spore formation begins.

Plasmode encystment thus differs from that of simple amœbæ only in the fact that the conditions observed in the amœba cyst (granular state of the protoplasm, vanishing of the nucleus, or, in other words, its peculiar falling to pieces into individual small nuclei) wear themselves off with the plasmodes during their motile stage.

3. *Spore formation.*—Beginning about 3 days after encystment; not originating through successive division of the nucleus and protoplasm, the nucleus falling to pieces into several small, strongly refringent corpuscles (pl. 4, fig. 5 N), around which, later, portions of protoplasm segregate themselves from the remainder. In this way the spores are formed. Thus in a simple amœba cyst, 10 hours after the falling to pieces of the nucleus, 6 spores (pl. 4, fig. 6) were seen, each with a small globular nucleus. Besides these, the cyst still contained plasma in which were seen, along with many small, strongly refringent granules, isolated small, round nucleiform structures (N). About 24 hours later the number of spores had doubled; nevertheless, there was still present undifferentiated plasma as well as nuclei. After 24 hours more the number of spores had so increased as to entirely fill the cyst; no free protoplasm remained (pl. 4, fig. 7).

Spore formation in the plasmode cysts (also accurately followed) takes place in the same way. In plasmode cysts containing numerous small nuclei (very probably originating through successive divisions of the nucleus) are formed small bodies, globular to oval, delimited from the surrounding protoplasm by a delicate membrane (pl. 5, fig. 4), fine-grained, some allowing a small, globular nucleus to [Page 22] show through. After about 6 hours these bodies acquire a somewhat pyriform shape, the membrane becomes thicker and sharper, the protoplasm more hyaline, the nucleus thus becoming more distinctly visible. This transformation proceeds so that after 24 to 36 hours the bodies are pyriform, sharply contoured, completely hyaline spores (pl. 5, fig. 5), in which a globular nucleus is always plainly visible. Along with this transformation new spores are formed from the surrounding protoplasm, until all the free protoplasm is used up, the cysts transforming themselves into spore cysts or spore tubes. Number of spores in cyst variable, dependent upon the size of the cyst, whose diameter varies from about 10μ (simple amœba cysts) to 30 to 60μ (plasmode cysts); often also elongate-oval spore tubes are found 70μ long and 24μ broad.

Spores: Length, 3·3 to 4μ, oval or pyriform (pl. 5, fig. 8), rather strongly refringent, completely hyaline, bounded exteriorly by an extremely thin homogeneous layer, the *pellicula.* In the broader end of the body a globular, very strongly refringent, homogeneous nucleus (N), $1·6\mu$, is found. The spores thus originating still further increase through a somewhat oblique-running, transverse division, the nucleus dividing karyokinetically (pl. 5, fig. 10*a*–*l*). Division was followed *intra vitam,* and the study completed in specimens fixed with chromo-aceto-osmic acid and stained with hæmatoxylin. Nuclear division, requires about ½ hour, and proceeds in about the same way as that of the micronucleus of the ciliated Infusoria. The membrane or external border-layer of the nucleus remains quiescent during the whole process, only in the last stages (pl. 5, fig. 10*h*) appearing some- [Page 23] what indistinct preliminary to reappearing with distinctness in the daughter nuclei.

Owing to the small size of the nucleus, karyokinesis could be followed only in the principal steps. The first alteration observed in the nucleus is a marked increase in size; simultaneously it loses its homogeneous character, acquiring a netted, honeycomb-like structure (pl. 5, fig 10*a*) with tolerably strongly staining granules. This netted form passes into an elongate, striate-fibered structure (*b*), the nucleus at the same time enlarging and assuming an ellipsoid form whose long axis coincides with that of the spore. Between the nuclear poles run meridional striæ, in which the chromatin granules are imbedded. These latter become concentrated toward the equator, when a so-called nuclear plate (*c*) forms, which consists of baculiform chromosomes which lie close to the delicate but perceptible threads of the achromatic spindle. Regarding the spore from the posterior end (*d*), the chromosomes are seen to be 8, and to lie rather peripherally. After the formation of the nuclear plate, a halving of the chromosomes takes place in the equator (*e*), the halves receding until they reach the poles of the nucleus (*f*). Meanwhile the spore has changed from pyriform to ellipsoidal, and the hyaline protoplasm has become by degrees granular.

As soon as the chromosomes have reached the poles an annular constriction becomes visible at the equator of the spore as well as of the nucleus (*g*); between the daughter chromosomes, achromatic spindle fibers are very plainly observed. Soon at the equatorial constriction, an annular thickening of the spore membrane forms (*h*), running obliquely to the longitudinal axis, from above downward. In this stage the membrane (or external border) of the nucleus becomes indistinct and the fibers of the achromatic spindle also do not stand out so sharply. The annular constriction grows gradually inward and subsequently forms the partition wall dividing the 2 spore halves. Meanwhile the familiar after-formation of the chromosomes (*i*) takes place in the daughter nuclei, the nuclear membrane becomes again more distinct, and the achromatic fibers are scarcely visible.

[Page 24] In the next stage (*k*) a distinct division wall between the 2 spore-halves is observed and the daughter nuclei show a finely reticular appearance, whence result later homogeneous nuclei (*l*). Division of the daughter spores soon takes place.

A somewhat peculiar phenomenon was often observed. Among the many dividing spores some were encountered with their anterior (narrower) ends more or less intimately united (pl. 5, fig. 11*a–b*). Schewiakoff could observe neither the union nor the division of the 2 spores. As, however, they differ essentially from the observed division stages, it may be questioned whether we have not here to do with a conjugation. This conjecture is strengthened by the presence, in the usually homogeneous nucleus, of structures (pl. 5, fig. 11*a*), which remind one of the nuclei of many conjugating Infusoria.

The spores increase considerably in number, the spore cyst becoming ultimately entirely filled by them. After a couple of days the cyst bursts at one place (pl. 5, fig. 6) and the spores are scattered with considerable force around the body cavity. They then mostly lie (pl. 5, fig. 7) in great masses, or in groups of 3–5, on the muscles.

As to the further fate of the spores nothing definite is known. After about 2 days they lose their homogeneous appearance and show an indication of a granular condition. Four days later they possess an irregular form (pl. 5, fig. 9) with finely granulated protoplasm and a distinct homogeneous nucleus. Size 3 to 4 μ. No movement or transition into the amœboid stage (which transition is, however, regarded as very possible) could be demonstrated. The manner of infection also remains unexplained.

Nature.—Without doubt Schewiakoff says, sporozoan. Schmeil, he says, considered it myxosporidian. (See above; the conjecture was Bütschli's.) These parasites, especially the spores, have a great similarity to those found by Henneguy and Thélohan in some decapods and by them ranked with the *Myxosporidia.*

Schewiakoff, however, doubts the myxosporidian nature of the *Cyclops* parasite. Henneguy and Thélohan gave their forms this place on account of their discovery of the filament. They only observed this extrusion a few times under the action of hydrochloric or nitric acid, and it was difficult to evoke. Since Schewiakoff could not discover either filament or capsule, he did not feel justified in referring the *Cyclops* parasite to the *Myxosporidia.* He, however, neglected to employ strong acids and alkalies, which is, he says, perhaps the reason of the failure.

It appears tolerably certain that the *Cyclops* parasite is not identical with their *Thelohania* species, as the latter have no amœboid stage, the globular cysts (sporoblasts of H. & Th.) are of constant size (14μ), and have always 8 spores with a different structure.

The presence of a contractile vacuole in the adult, the peculiarities in the process of spore formation, the falling to pieces of the nucleus, the apparent absence of pansporoblasts, the occurrence of reproduction only at and as the end of the life cycle, and the further multiplication by the division of fully formed spores, all absolutely contraindicate any myxosporidian affinities. Further, the constant presence of pigment[1] corroborates this conclusion, which is still further enforced by negative evidence from the structure of the spore, the most prominent feature of which is, of course, the absence of the capsule. Indeed it seems safe to go further and say that no organism with a contractile vacuole can, in the present state of our knowledge, be regarded as sporozoan (cf. Lankester, Encycl. Britan., 1885, 9 ed., XIX, p. 854).

PROBABLY MYXOSPORIDIA. (Imperfectly described.)

7. Genus et sp. incert.

Amœbiform corpuscles of gills of *Cyprinus brama*, Lieberkühn, 1854, Müller's Archiv., pp. 6, 7; ? ib. of heart-blood of same fish,[2] p. 14; cf. also Müller, Müller's Archiv., 1841, pp. 491–2.

Cyst.—Membrane so transparent that all details could be as well seen before as after expression of its contents. Contents "psorosperms" and amœbiform corpuscles, or amœbiform corpuscles only.

Myxosporidium.—Numerous, partly granular, partly granule-free, the latter usually smaller than the former, alterations of appearance very manifold, processes rather sharp than blunt, size not equal to that of a blood corpuscle of the fish; granules extremely small, held together by a mucoid substance.

Spore.—Unknown.

Habitat.—Encysted in the gills of *Abramis brama* L. (bream) in November.

Remarks.—Its habitat suggests that this species is probably a *Myxobolus*.

8. Genus et sp. incert.

Sarcode masses of *Perca fluviatilis*, Lieberkühn, 1854, Müller's Archiv., p. 353.

Cyst.—Apparently no true cyst (see mention below of membrane).

Myxosporidium.—Consisting of granular protoplasm presenting a great similarity to that of *Chloromyxum mucronatum*, very variable in appearance, oval, lenticular or dendroidly branched. Size 27 to 440 μ ($\frac{1}{80}$ to $\frac{1}{5}'''$); some specimens surrounded by a structureless membrane, others not; sometimes the whole substance is seen to have fallen apart

[1] While it is, of course, not contended that this alone would suffice to prove a species nonmyxosporidian, pigmentation, such as exists in the *Cyclops* cyst, would raise a strong presumption against its myxosporidian nature.

[2] Those [amœbiform corpuscles] of the heart blood of *Cyprinus brama* completely parallel in their form the above-described amœbiform masses found on the gills of the fish, and are differentiated among themselves in the same way as the gill forms [*i. e.*, they are either granular or granule-free]. Their movements are, on account of their small size, difficult to observe.

into globules (pansporoblasts) every one of which contains 2 spores or perhaps only faint indications of such.

Spore.—Not described.

Habitat.—On branchiæ of *Perca fluviatilis* L. (yellow perch).

9. **Genus et sp. incert.** Pl. 6, fig. 1.

Myxosporidium of *Lota vulgaris*, Lieberkühn in Bütschli, 1882, Bronn's Thier-Reich, I, pl. 38, fig. 20.

No description.

Habitat.—Gall-bladder of *Lota lota* L. (=*vulgaris*), ling.

10. **Genus et sp. incert.** Pl. 6, fig. 2.

Myxosporidium of *Lota vulgaris* Lieberkühn in Bütschli, 1882, Bronn's Thier-Reich, I, pl. 38, fig. 24.

No description.

Habitat.—Branchiæ of *Lota lota* L. (=*vulgaris*), ling.

11. **Genus incert. ("Myxosporidium") congri** Perugia, 1891. Pl. 6, figs. 3–8.

Myxosporidium congri Perugia, Boll. Scientif., Pavia, XIII, pp. 24–5, figs. 15–20; *ib.*, Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 166; *Chloromyxum ?? congri*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 419; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Myxosporidium.—Found attached to a calculus-like compact mass consisting of fungus (probably *Penicillium*), bacteria, and crystals. Individuals numerous, form variable, movements incessant, slow, amœboid. Perugia observed in some a clear space which he believed to be a "vacuole" (pansporoblast), but careful examination failed to detect the spores.

Habitat.—Gall-bladder of *Leptocephalus conger* (=*Conger vulgaris*), eel, collected in August, 1890.

The generic name *Myxosporidium* is not in good standing (see p. 206). In the absence of knowledge of the spores the generic reference of this form is entirely uncertain.

12. **Genus et sp. incert.** Pl. 7, figs. 1–3.

Psorosperm of *Notropis megalops*, Linton, Bull. U. S. Fish Com. for 1889 (1891), IX, pp. 359–61, pl. 120, figs. 1–3; *ib.* Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIII, p. 97.

Cyst.—Globular, discrete or aggregated into clusters, white, with minute patches of black pigment from host; size varying from 2·5 mm. (single cysts) to 7 by 5 mm. (clusters); wall composed of connective tissue, thin, collapsing when punctured, indistinguishable from deeper layers of derma, staining deeply with ammonia-carmine. Contents, a milky fluid.

Myxosporidium unknown.

Spore.—Somewhat top-shaped, one end broadly rounded, slightly flattened, the other tapering to a point, length 17 μ; breadth 10 μ; thickness 6 μ. Shell, thick and strong, resisting for a long time the action of sulphuric acid and of potassium hydrate solution; shape not changed by those reagents, by acetic acid or by glycerin, not staining with carmine; showing when viewed on edge an elevated ridge [junction of valves?]. Capsules could not be detected. Protoplasmic contents appear in most cases to be finely granular. Tail absent.

Habitat.—Subcutaneous tissue of all regions of the body of *Notropis megalops* Raf. (red-finned minnow) taken in Black River, Lorain County, Ohio, 6 miles above Lake Erie, September 1, 1890 (also October 5, 1891; see below). Collector, Mr. L. M. McCormick. Identification by Dr. D. S. Jordan.

With this species of fish were taken *Noturus miurus*, *Catostomus teres*, and *Moxostoma macrolepidotum*, and, in the immediate neighborhood, *Ictalurus* and *Roccus*. None of these, however, were affected.

Effects.—The epidermis of the fish is sometimes marked by dark purplish blotches. Scales are absent from the surface of the cyst in most cases, although a few were observed quite loosely attached to one of the larger clusters. All of the fishes appeared to be in fair condition.

Mr. McCormick has kindly furnished me the following additional information:

The fish were taken in the pool formed by Day's Dam, near the center of Sheffield Township, Lorain County, Ohio. Although he has diligently explored the streams of Lorain County for material for his "*Descriptive List of the Fishes of Lorain County, Ohio,*"[1] he has never seen *N. megalops* infested by this parasite except in this very limited locality. The same day that specimens were first secured there he seined Black River thoroughly from Elyria to below Day's Dam (distance 10 miles), but saw no other diseased specimens. In spite of the admitted fallibility of negative results, he believes this parasite to be restricted to a very narrow geographical range. Fish first taken September 1, 1890 (about a dozen); a few more October 5, 1891 (the first time of seining the pool that year).

13. Genus et sp. incert. Pl. 7, fig. 4.

Psorosperms of *Gasterosteus aculeatus*, Lieberkühn, 1854, Muller's Archiv., pp. 9–10, 22, 24, 354–7, pl. 2, fig. 28, pl. 14, figs. 9–12.

The following observations by Lieberkühn relate to a puzzling form found on *Gasterosteus aculeatus* (stickleback). His remarks are to me somewhat obscure, and I am not certain that I always understand his meaning. For that reason the translation is a literal one.

[Page 9] I am still in entire ignorance as to what becomes of the psorosperms of *Gasterosteus.* In the skin of this fish Gluge found cysts filled with entirely structureless granules which had a marked similarity to those of the Gregarines. Johannes Müller has confirmed this discovery. I investigated about 100 cyst-bearing specimens selected from a corresponding number of healthy sticklebacks. Among 10 fishes there was, in the spring, about 1 available; in late autumn, on the contrary, only 1 in about 100. The cysts varied greatly in size; the largest attract attention at once, the smaller are only to be discovered upon close examination. They have a very irregular form, mostly rod-shaped, and contain ordinarily the structureless granules mentioned by Gluge. A few contained bodies with more definite structure and characters, reminding one of the psorosperms, for which reason I will so name them. They are all nearly globular and somewhat smaller than the ordinary psorosperms; they consist of a transparent membrane, within which I have observed 3 kinds of contents, namely, in some a single small globule which is not large enough to come in contact with the membrane by its upper surface; in others lay, between the surrounding membrane and the upper surface of this [Page 10] small globule, a small mass of exceedingly fine granules; in still others the globule appeared to have divided, as 3 or 4 smaller globules were present. Several of the smaller cysts contained a far more finely granular mass than

[1] Bull. 2, Oberlin College, Ohio.

that described by Gluge; I was not able to discover anything definite therein. So far I have found the largest cysts to contain only Gluge's structureless granules. In any case these facts are not yet sufficient to establish a developmental series.

In recapitulating and summarizing his results (the order of such summary and the place therein of the following extract showing that it refers to and is intended as the summary of the preceding quotation) Lieberkühn says:

In the skin of *Gasterosteus* occur, besides the grain-containing cysts discovered by Gluge, also such as contain psorosperms of peculiar species.

In a subsequent article Lieberkühn again discusses these problematical organisms. He says:

[Page 354] As regards the psorosperm-like bodies of the stickleback, to which I have already, in my preceding article, devoted some words, I have now succeeded in making the requisite observations preliminary to a knowledge of their developmental history. After I had, in the course of the preceding autumn and winter, examined in vain several thousand specimens of *Gasterosteus* for those cysts, I refound them first in March of this year in great numbers. Of the cysts discovered by Gluge I am not at present able to give any explanation, other than that they are entirely different from the ones now to be discussed. [Page 355] The latter I have frequently found, to the number of 30 or more, distributed over the skin, the fins, and the cornea; some had bored through the fins and floated with both ends free in the water; others lay closely appressed to the skin for their whole length; others again were detached on one side. Individual fishes had their tail-ends so beset that scarcely anything of the scales could be seen. Their usual form is cylindrical; rarely they are ellipsoidal or spherical. They strike the eye with the first glance at the fish. The length of the rod-shaped is from $\frac{1}{2}$ to 1 line; the greatest diameter of a cross-section about one-fifth line or more. The membrane of the cyst is plainly visible, and one can easily obtain it for examination by removing it by means of a knife. I could not discover any structure in it. The contents present great variations. In some I found nothing but an albuminous substance, in which fat-like granules were suspended in great numbers; these were globular and measured 0·001‴. If one moves them to and fro under the cover glass for some time many of them flow together to large oily drops. Other cysts contain partly these, partly much smaller but apparently similar granules. In still other cysts the granules of the smaller variety were united by a mucous substance into globules; many of these were distinguished by a much larger fatty granule lying in the middle between the smaller ones, and which often had an irregular form.

In still others this was seen to be 2 or 3 times as large, and in these cases the small granules were usually entirely absent; furthermore, the whole psorosperm had a proportionately greater size. The diameter of such a body was 0·008‴, of the nucleus [*Kern*] 0·005‴, of the fine granules about 0·0007‴. In the largest, granules began to appear anew, and it sometimes seemed as though they separated themselves from the nucleus. The expression nucleus has here no further significance than that which it receives through the investigation. Sometimes I was able to observe the same isolated, when for some unknown reason the surrounding membrane became ruptured and expressed its contents. It showed nothing but what one could see through the surrounding membrane. When the psorosperm dries on the cover glass it acquires an entirely different refrangibility, the sharp contour disappearing and not reappearing when water is added. In some cases I found also in fresh cysts such nuclei of feebler refrangibility within the smaller psorosperms. They vary greatly in size; were often simultaneously provided with granules, such being, however, often absent. In order to learn the further alterations of the cyst contents, I kept a number of cyst-bearing fish alive for some weeks in my room. Apparently the thin cysts increased in circumference, and then contained only the largest kinds of psorosperms. Several fish lost their cyst contents entirely. In an apparently half-empty cyst microscopic investigation showed the following objects:

1. The largest form of the psorosperms, with a nucleus [*Kern*] of 0·005‴ in diameter and containing many of the smallest granules.

2. The largest form of the psorosperms, with a much smaller "nucleus," namely, of 0·003‴ in diameter, and filled with a much larger number of the smallest granules.

3. Corpuscles of the same size with the same striking "nucleus," with the same granules, but with a far less prominent surrounding membrane.

4. Corpuscles of the same kind, but without demonstrable membrane, slowly projecting a part of the body substance and again withdrawing it, whence resulted marked changes of form.

[Page 356] 5. Corpuscles with all these characters; also provided with such a "nucleus," but with a diameter twice as great.

In order to determine whether the structures described occur in the organism of fishes and migrate in the spring to the external skin for the purpose of [Page 357] reproduction, I examined a series of the individual parts of the fish. In the blood I found moving colorless corpuscles, which agreed not with those of the fish, but much more closely with those destitute of grains and nuclei, originating from the psorosperms. And I also discovered in the kidneys of *Gasterosteus* receptacles with tailed psorosperms and the various developmental stages of the same, just as they occur in the gills of the pike. As the cysts often beset the skin of the stickleback in such great numbers that their substance forms a not inconsiderable fraction of that of the whole fish, it would have been difficult for them to have escaped me in my frequent examinations had they been present within the body of the fish. Everything speaks much more for the view that certain aquatic animals attach themselves in the spring to the skin of the stickleback, surround themselves with a cyst membrane, and in reproduction fall apart into the psorospermiform bodies. It is this animal which consists of a mucous substance, and which contains many scattered fat-like granules, and measures as much as 1‴ long and about ⅓‴ thick. The fat-like granules are employed in reproduction; they break up first into smaller parts and then form with a certain quantity of the structureless substance a globule which already constitutes the embryo of the new being. This grows gradually, one of the granules progressively increases in size and the remainder vanish. Growth then continues for a long time, until granules show themselves anew, which increase at the expense of the nucleus; the heretofore plainly visible surrounding membrane becomes apparently thinner or vanishes entirely, and thus a body is formed consisting of a mucous mass containing many small scattered granules and a nucleus [*Kern*] only a little larger, a body capable of motion and growth.

14. Genus et sp. incert.

Psorosperms of *Leuciscus dobula*, Leydig, 1851, Müller's Archiv., p. 229.

Cyst not mentioned.

Myxosporidium.—Two or three spores develop in each pansporoblast (*Tochterblase*).

Spore.—Untailed.

Habitat.—On *Leuciscus* (*Squalius*) *cephalus* (=*dobula*).

15. Genus et sp. incert.

Spores of *Squalius cephalus*, Schneider, 1875, Archiv. de Zool. Expér., Paris, IV, pp. 548–9.

Cyst and myxosporidium not mentioned.

Spore.—Capsules 2, with very long filaments, extruded under action of glycerin.

Habitat.—Air bladder of *Leuciscus* (*Squalius*) *cephalus*.

16. Genus et sp. incert.

Psorosperms of *Gobius fluviatilis*, Leydig, 1851, Müller's Archiv., p. 223, name only; *ib.* of *Gobio* [error] *fluviatilis* Ludwig, 1888, Jahresber. d. rhein. Fisch-Vereins, 1888, p. 30.

Habitat.—Body cavity of *Gobius fluviatilis* L.[1] (goby).

17. Genus et sp. incert.

Psorosperm of crocodile, Solger, 1877, Jahresber. schles. Gesellsch. f. Vaterl. Cultur, LIV, p. 45.

Name only, with statement that it will be fully described elsewhere.

Habitat.—In mucosa and muscularis of intestinal canal of "crocodile."

18. Genus et sp. incert.

Psorosperm of *Chondrostoma nasus*, Leydig, Müller's Archiv., 1851, p. 222.

No description or figure.

Habitat.—Cysts in roots of tongue of *Chondrostoma nasus* L.

19. Genus et sp. incert.

Psorosperms of *Leuciscus rutilus*, Leydig, Müller's Archiv., 1851, pp. 222–3.

No description or figure.

Habitat.—White clumps of "psorosperms" in the heart (auriculo-ventricular valve) of *Leuciscus rutilus;* also in heart blood of same fish.

20. Genus et sp. incert.

Psorosperms of *Cyprinus tinca*, Lieberkühn, 1854, Bull. Acad. Roy. Belg., XXI, pt. 2, p. 22.

No description.

Habitat.—Scales of *Tinca tinca* L. (tench).

21. Genus et sp. incert.

Psorosperms of *Cyprinus erythrophthalmus*, Lieberkühn, 1854, Bull. Acad. Roy. Belg., XXI, pt. 2, p. 22.

Mention of occurrence only; no description.

Habitat.—Subsquamous, on *Leuciscus* (*Scardinius*) *erythrophthalmus.*

22. Genus et sp. incert.

Psorosperms of *Gasterosteus aculeatus*, Hensen,[2] in Wittmack, 1875, Beiträge z. Fischerei-Statistik d. deutsch. Reichs, p. 190.

Mention only; no description.

Habitat.—On *Gasterosteus aculeatus* L. (stickleback) near Kiel.

23. Genus et sp. incert.

Psorosperms of *Lucioperca sandra*, Heckel & Kner, 1858, Die Süsswasserfische der östreichische Monarchie, Leipzig, p. 12; *ib.* Wittmack, 1875, Beiträge z. Fischerei-Statistik d. deutsch. Reichs, p. 190.

Heckel and Kner say:

Their gills are often beset with small cysts filled with a gelatinous fluid (the so-called psorosperms) and in this condition they are regarded as unfit for food.

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[1] The great similarity of name between the present fish and *Gobio fluviatilis*, and the presence of a species upon the latter in the same situation (body cavity, see p. 243) suggests the possibility of an orthographic error.

[2] In response to an inquiry, Dr. Wittmack kindly informed me that Prof. Hensen's observation is unpublished, having been made upon a statistical question sheet.

I am indebted to the kindness of Dr. Wittmack for this reference.

Habitat.—Branchiæ of *Stizostedion lucioperca* (pike perch).

24. Genus et sp. incert.

Cyst of branchial "copules" of *Gasterosteus aculeatus* Thélohan, 1890, Annal. de Microgr., II, p. 203.

No description.

Effects.—Pressure on the heart caused death.

Habitat.—Branchial "copules" of *Gasterosteus aculeatus* (stickleback).

25. Genus et sp. incert.

Psorosperms of mackerel, v. d. Borne, 1886, Handb. d. Fischzucht u. Fischerei, p. 211.

No description (cf. p. 172).

Habitat.—On *Scomber scombrus* (mackerel).

26. Gen. incert. ("Myxosporidium") bryozoides Korotneff, 1892. Pls. 8, 9.

Korotneff's myxosporidian of *Alcyonella fungosa*.	bryozoides.	Date.	Authority; reference.
	Myxosporidium*.	1892	Ztschr. f. wiss. Zool., LIII, pp. 591–6, pl. 24, figs. 1–12.
	Do	1892	Henneguy & Thélohan, Annal. de Microgr., IV, p. 617.
	Do	1893	Braun, Centralbl. f. Bakt. u. Parasitenkde, XIII, p. 97.
×		1893	Ohlmacher, Journ. Amer. Med. Assoc., XX, p. 562.
×		1893	Braun, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739.

Myxosporidium ? (development of).—For study of development, the polyzoan spermatoblasts offer a very rich material, comprising all stages of alterations. The earliest stage (pl. 9, fig. 1*a*) is a healthy, well-preserved cell, containing a large, round nucleus and, lying near it, the nucleus of the intruded myxosporidium, which latter is small, elongate-oval, dark-staining, and which, but for the complete series of changes exhibited by it, might be supposed to be a *Nebenkern*. The myxoplasm has, Korotneff inclines to believe, from the moment of its entrance so completely mixed with the polyzoan cytoplasm that we can no longer speak of a plasma differentiation.

The nucleus divides by mitosis (pl. 9, fig. 1*b*). Simultaneously or somewhat later the polyzoan cell-nucleus divides, but this latter division is never by mitosis, and is rather to be regarded as an externally induced fragmentation. The nonvital and artificial character of the cell-nucleus division is further shown by the variable size of the nuclei, resulting from the division, the nucleus having lost the capability of growth. Its division results from an irritation of, or better, an impulse from, the presence of the intruded myxosporidium. This artificial stimulation of the powers of the infected cell constitutes the peculiarity in the action of the parasite which thus prepares for itself an artificial ground without which its existence would be impossible. Sometimes cell-nucleus division takes place somewhat later than that of the parasite, so that we already find the parasite with 4 daughter nuclei (1 of which was

* Name not in good standing (see p. 206).

seen in way of further division), the cell-nucleus being as yet unaltered. With continually progressing division, both of the myxosporidium and the cell nuclei, and with progressive growth of the cell body, the originally simple cell metamorphoses itself into a plasmodium. Thus a young plasmodium was seen in which 1 of the 2 daughter nuclei of the host-cell had fallen apart into 2 granddaughter nuclei, while the myxosporidian nuclei had in the same time increased much more. In the next developmental steps of the plasmodium the number of the nuclei increases very rapidly, and with such increase their energy becomes exhausted; the nucleoli vanish and the nuclear reticulum appears as a fine-grained granulation. Finally, the nuclear membrane shrinks and assumes an irregular contour. The cell nuclei then soon entirely vanish and we get a plasmode in which only myxosporidium nuclei are found

With age the myxosporidia become displaced from the funicle and occupy the whole cavity. The zooid, thus become a myxosporidium-filled tube, closed at both ends. At this time the increasing mutual pressure produced by the continually growing myxosporidia results in their fusion to large plasmodes. Further growth produces rupture of the wall of the zooid and the myxosporidia come directly into contact with its chitinous investment.

The morphological characters of the adult myxosporidium are here interpolated.

Myxosporidium? (*structure of adult*).—Naked, membraneless, amœboid-variable, size 20 to 200 μ; form varying greatly with age, the youngest being globular, the older ones oval or lobulated from adaptation to external pressure-conditions. Ectoplasm perfectly transparent and hyaline. Nuclei very numerous, consisting of clear round vesicles showing in the fresh state round nucleoli. Applied against the outside of (never within) each nucleolus is a small glittering globule. Pseudopodia formed by the ectoplasm, very fine, delicate and hair-like, ordinarily confined to a part and seldom covering the whole surface, often also forming small ramified tufts. Korotneff was unable to state whether the pseudopodia serve for attachment, but with the young myxosporidia the fixation to the funicle appeared really to occur through these structures.

Probably the direct influence of the water is injurious to them, and occasions a falling apart of the plasmodes and a freeing of the spores, which then fill the spongy chitin-masses of the atrophied colony. In this state the spores remain the whole winter, and in April follows, probably, the infection of the young *Alcyonella* (just out of the statoblast) by the amœba-brood from the spores.

The time of the appearance of the myxosporidia corresponds with the development of the spermatoblasts, which ordinarily begins (around Moscow) at the end of May, and the number of parasitic individuals increases *pari passu* with that of the spermatoblasts. While at the first their existence is appreciable by the microscope, soon (July) they are visible to the naked eye, the lower end of the zooid tube losing its transparency and becoming milk white. In August the alteration becomes very marked, the cavity of the zooid being distended and completely opaque.

Spore formation.—How and whence do the spores originate? In any case their origin is endogenous (in the endoplasm) and probably occurs in the manner observed by Prof. Bütschli in *Myxidium lieberkühnii*, where a spore membrane is formed around a trinucleate globule. In our case are often found, in the plasmodium, nuclei in state of division. Around such nuclei, which are still united by the threads of the spindle, a resistant shell appears often to be present. Could this be a spore? Korotneff is able to confirm Bütschli's observation that spore formation does not mark the end of the life cycle. In *M. bryozoides*, however, the spores always appear at a definite period of that cycle, viz, after the complete disappearance of the nuclei of the host-cell.

Spore.—Elongate-oval, resembling a melon seed, sharp anteriorly, rounded off posteriorly. Shell extremely hard, very resistant, lustrous, apparently with an opening at the sharp (anterior) end; no bivalve structure demonstrable, though empty spores are not rare. Often, but not always, two vacuoles are visible. In the spring he was able to distinguish at the anterior end of the spore a glittering point whose signification was unknown. It might possibly be a capsule (nematocyst; *Nesselkapsel*).

Habitat.—In very considerable numbers in the body cavity of *Alcyonella fungosa* (a fresh-water polyzoan) in the neighborhood of Moscow, in the beginning of summer. The infection appears to be endemic, as Korotneff has never observed it in southern Russia and as it appears to be absent from western Europe.

Seat and pathological anatomy.—Principally grouped around the funicle upon which the spermatoblasts (which serve as food for the young myxosporidia) are produced. No tissue except the spermatoblasts is attacked. Repeated careful investigations showed the absence of myxosporidia from the polyp and from the walls of the zoœcium.

Effects.—The extensive infection exerts a direct (but only a mechanical) influence on the polyp, producing, as a result of its continued growth, a progressive atrophy, which, by the end of August, results in the complete disappearance of the polyp. The infection extends itself through the colonies, scarcely a single zooid escaping. The death of the colonies occurs much earlier than it would naturally under the influence of cold.

Remarks.—Henneguy and Thélohan believe the reference of this form to the *Myxosporidia* absolutely justified, although the capsule has not been demonstrated.

TRUE MYXOSPORIDIA.

Ordo I. Cryptocystes Gurley, 1893.

Etymology: *κρυπτος*, concealed, *κυστις*, capsule.

Bull. U. S. Fish Com. for 1891, XI, p. 409; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Myxosporidia in which the pansporoblast produces many (8 or more) spores; the latter minute; without distinct symmetry; with but a single capsule; type (and only) family *Glugeidæ*.

Fam. GLUGEIDÆ Gurley, 1893.

("Glugeidées" Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173–4; Glugeidea [Thél.] Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739).

Glugeidæ, Bull. U. S. Fish Com. for 1891, XI, p. 409; Glgeidæ (error), Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Definition (provisional as regards negative characters).—*Cryptocystes* destitute of a bivalve shell, with the capsule at the anterior extremity; an aniodinophile vacuole; type genus *Glugea*.

This family now includes *Glugea*, *Pleistophora*, and *Thelohania*. Before the proposition of *Pleistophora*, only 2 genera had been proposed. Their distinction was practically based upon 3 characters, a comparison of which indicated very strongly that either there were too many genera or too few. If, as Henneguy and Thélohan and the writer believe, these characters are competent to determine generic lines at all (in the opposite case *cadit quæstio* and everything reduces to *Glugea*), then the spore of *Cottus scorpio* should form the type of a new genus, for (see table below) of the 3 characters but 1 is common to it and *Glugea*, and, although 2 are common to it and *Thelohania*, the third (divergent) character is one of no slight importance in *Thelohania*, as it is common to all the 3 (probably 4) typical species. For this genus I have proposed the name *Pleistophora*.

Myxosporidium.	Pansporoblast producing spores.	Pansporoblast membrane.	Genus.
Present	Inconstant, numerous	Not subpersistent	Glugea.
Absent	Inconstant, numerous	Subpersistent	Pleistophora.
Absent	Constant, 8	Subpersistent	Thelohania.

I. GLUGEA Thélohan, 1891.

Etymology: Gluge.

Compt. Rend. hebdom. Soc. Biol. Paris, III, p. 29; *Gluega* [error] Thélohan, 1891, Compt. Rend. Acad. Sci. Paris, CXII, p. 171; *ib.* Thélohan, 1891, Journ. de Microgr., Paris, XV, p. 147; *Glugea* Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 174; *ib.* Henneguy and Thélohan, 1892, Annal. de Microgr., IV, pp. 630, 636; *ib.* Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 409; *ib.* Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *ib.* Braun, 1894, *ibid.*, XV, p. 86.

Definition.—Glugeidæ possessing a myxosporidium, and in which the pansporoblast produces an inconstant but large number (always more than 8) of spores; pansporoblast membrane not subpersistent; type, *G. microspora* Thél. (synonym for *anomala* Moniez).

27. Glugea destruens Thélohan, 1892.

Callionymus lyra, "corpuscles," etc., of	destruens.	Date.	Authority; reference.
×	....	1891	Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, III, p. 28.
×	....	1891	Thélohan, Compt. Rend. Acad. Sci. Paris, CXII, pp. 168–71.
×	....	1891	Thélohan, Journ. de Microgr., XV, pp. 145–6.
×	....	1891	Pfeiffer, Die Protozoen als Krankheitserreger, 2 ed., p. 115.
×	....	1892	Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, IV, pp. 83–4.
....	Glugea.	1892	Thélohan, Bull. Soc. philomat. Paris, IV, pp. 165, 174, footnote.
×	....	1892	Henneguy & Thélohan, Annal. de Microgr., IV, pp. 618, 619, 636.
....	Glugea.	1893	Gurley, Bull. U. S. Fish Com. for 1891, XI, p. 409.
....	Glugea.	1893	Braun, Centralbl. f. Bakt. u. Parasitendke. XIV, p. 739.
....	Glugea.	1894	Braun, Centralbl. f. Bakt. u. Parasitendke, XV, p. 86.

Cyst none.

Myxosporidium.—Ectoplasm and endoplasm recognizable.

Spore formation.—Pansporoblast membrane thin, disappearing soon after spore formation. Sporoblasts, consisting of small globules with clear nuclei, sometimes disposed in very great numbers, sometimes isolated in groups of 4, 10, or 12 within the pansporoblast membrane.

Spore.—A little smaller than the similar parasite of *Cottus scorpio*, 2·5 to 3 μ long; 1 to 1·5 μ broad; characters otherwise identical (Thélohan, 1891). Length, 3 to 3·5 μ; breadth, 2 μ (Thélohan, 1892, p. 174). Capsule present (Henneguy & Thélohan, p. 619).

Habitat.—Upon section of the muscles affected, the parasite is seen to have its seat in the interior of even the primitive fibrillæ of the muscles of *Callionymus lyra*. Not encysted, but forming a parasitic mass, destitute of an envelope, in which ripe spores are seen with others in course of development.

Effects.—Unlike the otherwise very similar condition in *Cottus scorpio*, the muscular fibers soon break up and undergo vitreous degeneration,

28. Glugea anomala Moniez, 1887. Plate 10, figs. 1–3.

Gasterosteus aculeatus, "corpuscles," etc., of.	Pygosteus pungitius, "corpuscles," etc., of.	Aphya alba,* "parasite," etc., of.	anomala.	microspora.	Date.	Authority; reference.
×					1838	Gluge, Bull. Acad. Roy. Belg., V, pp. 772–6, figs. I, II.
×					1841	Gluge, Anatom.-micros. Untersuchgn. z. allgem. u. spec. Morphol., II, pl. 5, fig. 4 *a–e*.
×					1841	Müller, Müller's Archiv., p. 491.
	×				1842	Creplin, Wiegm. Archiv. f. Naturgesch., I, pp. 64–5.
×					1843	Müller, Rayer's Archiv. de Méd. comp., I, pp. 266–268.
×	×				1843	Rayer, Rayer's Archiv. de Méd. comp., I, pp. 266–70, pl. 9, figs. 11, 12.
cf.					1854	Lieberkühn, Müller's Archiv., pp. 9–12. (See also p. 183.)
			Nosema†		1887	Moniez, Compt. Rend. Acad. Sci. Paris, CIV, p. 1312.
		×			1888	Henneguy, Mém. publiées Soc. philomat. Paris, l'Occas. Centen. Fond., p. 170.
×					1889	Thélohan, Compt. Rend. Acad. Sci. Paris, CIX, p. 921.
×	×	×			1890	Thélohan, Annal. de Microgr., II, pp. 202–4, 211–12, pl. 1, figs. 4, 17.
		×			1891	Garbini, Rend. Real. Accad. Lincei Roma, VII, Sem. 1, p. 153.
				Glugea	1891	Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, III, p. 29.
				Glugea	1891	Compt. Rend. Acad. Sci. Paris, CXII, p. 170.
				Gluega,	1891	Thélohan, Journ. de Microgr., XV, p. 147.
				Glugea	1892	Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, IV, pp. 82–4.
				Glugea	1892	Thélohan, Bull. Soc. philomat. Paris, IV, pp. 165, 174.
				Glugea	1892	Henneguy and Thélohan, Annal. de Microgr., IV, pp. 619, 631, 633–6.
				Glugea	1893	Braun, Centralbl. f. Bakt. u. Parasitenkde, XIII, p. 96.
			Glugea		1893	Gurley, Bull. U. S. Fish Com. for 1891, XI, p. 409.
				Glugea	1893	Braun, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739.
			Glugea		1894	Braun, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

* The species is (*fide* Henneguy, letter to author, 1893) *Gobius albus*. This identification was made by a "specialist." Dr. Gill informs me that the name *Aphya alba* should be used.

† *Nosema* Nægeli, 1857, was founded upon *N. bombycis* Nægeli, which was regarded as a Schizomycete (Tagebl. 33 Versamml. deutsche Naturf. u. Aerzte, im Bonn, 1857, p. 27).

Cyst development.[1]—In a *G. aculeatus* kept under observation for nearly a year there existed at first a single cyst, quite regularly spherical, attaining nearly the volume of a pea. Very soon small secondary vesicles, at first scarcely distinct, appeared upon its surface, progressively enlarged and finally, instead of the primary cyst shelling out as a whole, it split open at the most prominent point and a great part of its contents escaped, leaving in place of the tumor an excavation irregularly limited by a ridge formed by the non-empty part of the small sphere. The small secondary vesicles then developed rapidly and very soon formed an irregular strawberry-like mass.

[1] Thélohan (Annal. de Microgr., 1890, II, p. 204; Compt. Rend. hebdom. Soc. Biol. Paris, 1892, IV, p. 82) also saw cysts enlarge, become subcutaneous, shell out from their attachments into the water, and there burst.

Cyst structure.[1]—Number, 1 to 4 (sometimes a dozen, Thélohan), rarely more, in contact or more or less widely separate; the majority as large as a small pea, some, however, attaining only the size of a pin's head; size of tumor bearing no relation to that of the fish, being variable in the same individual; shape regularly spherical or only a little rounded; color usually whitish—when covered by the epidermis of the fish, silvery. Membrane always present, resistant, usually covered by the epidermis, which forms an outer cyst; surface granulated by alcohol; Contents consisting of a small quantity of a colorless fluid coagulable by alcohol, holding in suspension immense numbers of corpuscles which yield bubbles of gas (CO_2?) with mineral acids. Müller (1841, p. 491) found also some microscopic crystals. Thélohan (1890, p. 204) adds that the average thickness is 5 μ; under high powers the membrane shows a fibrillary structure parallel to the surface of the cyst. Thélohan believes the membrane to be nonnucleated and considers this a strong argument in favor of its derivation from the similarly nonnucleated myxosporidian ectoplasm.

Myxosporidium.—Spore formation:[2] Myxoplasm containing small nucleated globules which surround themselves with a thin membrane, divide, and end by forming small spheres filled with very numerous rounded nucleated elements which later will yield the spores.

Spore.—Very numerous, transparent, regularly ovoid, 3 to 5 μ long, 2 to 3 μ broad, size and form constant in spores from the larger cysts, less clear in those from the smaller. Shell bivalve; structure not demonstrable; chemical characters the same as those of other spores. Interior of spore showing a shaded portion at the smaller, and a clear portion filling the larger, extremity. Capsule 1, filament very long (50 μ), extruded under the influence of iodine. No other reagent produced such extrusion. The central (iodinophile) vacuole appears to be absent; a vacuole uncolorable by iodine is present, however, usually in the larger end, less frequently subcentral. Thélohan (1890, p. 212) has traced the division of the nuclei up to 4, a number which he has never seen (but which he does not wish to assert may not be) exceeded.

Micro-chemistry.—Acetic acid produces no change. Sulphuric acid causes evolution of bubbles of gas (Co_2?), the corpuscles at the same time becoming less clear but not dissolving. Potassium hydrate causes an agglomeration similar to the "rouleaux" of blood corpuscles (Gluge). The best stains for this species, Thélohan found to be gentian violet; but above all, safranin by the Gram-Bizzozero method.

Habitat.—Subcutaneous cysts of *Gasterosteus aculeatus* (stickleback) in European rivers, occurring only once in every 20 or 30 fishes examined (Müller). Subcutaneous cysts of *Pygosteus pungitius* (9-spined stickle-

[1] Description Gluge's unless otherwise stated.

[2] Thélohan's observations on a myxosporidium in *G. aculeatus* (Journ. de Microgr., 1891, xv, p. 147).

back. The forms habitant on these 2 fishes are identical, differing only a little in the size of the cysts (all *fide* Thélohan). Subcutaneous cysts of *Aphya alba* (= *Gobius minutus* and *G. albus*). In the last the deformity is even greater than in *G. aculeatus*.

Nature.—For Gluge's opinion, see p. 93.

Effects.—Even where the tumors occupy the internal surface of the opercle the fish did not appear to be hampered in its functions. Those which carry the tumors on the fins, nevertheless move the latter as freely and actively and execute all movements with the same facility as the sticklebacks not so affected. The tumors may be carefully removed without injuring the fish, which appears as well as ever after the operation. Upon careful dissection, Gluge was unable to find any change in the intestine or in the blood. Thélohan (1890, p. 203) states that in certain cases the muscles are compressed and atrophied by pressure of the tumors, and the viscera are also compressed and no longer present their normal position or relations.

II. PLEISTOPHORA Gurley, 1893.

Etymology: πλειστος, very many; φερειν, to carry.

Bull. U. S. Fish. Com. for 1891, XI, pp. 409, 410; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Definition (provisional as regards negative characters).—*Glugeidæ* destitute of a myxosporidium and in which the pansporoblast produces an inconstant but large number (always more than 8) of spores; pansporoblast membrane subpersistent as a polysporophorous vesicle; type, *P. typicalis*.

29. Pleistophora typicalis Gurley, 1893.

(Corpuscles of *Cottus scorpio* Thélohan, 1890, Annal. de Microgr., II, pp. 203, 212; *ib.* Thélohan, 1891, Journ. de Microgr., XV, pp. 145, 146; *ib.* Thélohan, 1891, Compt. Rend. hebdom. Soc. Biol. Paris, III, pp. 27, 28; *ib.* of *Coltus* (error) Thélohan, 1891, Compt. Rend. Acad. Sci. Paris, CXII, p. 170; *ib.* Pfeiffer, Die Protozoen als Krankheitserreger, 2 ed., pp. 113–115; *ib.* Thélohan, 1892, Compt. Rend. hebdom. Soc. Biol. Paris, IV, pp. 82, 83; *ib.* Thélohan & Henneguy, 1892, *ibid.*, p. 586; *ib.* Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 165, 174; *ib.* Henneguy & Thélohan, 1892, Annal. de Microgr., IV, pp. 618, 619, 622, 631, 636.)

Pleistophora typicalis, Bull. U. S. Fish Com. for 1891, XI, p. 410; *ib.* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Cyst.—None.

Spore formation.—Thélohan observed between the fibrillæ small separate masses of protoplasm, each with a distinct membrane and nuclei. These masses were 4μ[1] long by 2·5 to 3μ broad. Thélohan believed them to represent the first stages of development, but emitted this opinion with reserve, not having seen a sufficient series of stages. Some protoplasmic masses inclosing several nuclei exhibit, however, intermediate stages between the masses already described and the pansporoblasts.

[1] "4 Cent." in Journ. de Microgr., XV, p. 146.

Pansporoblast spherical, average diameter 15 to 18 μ; membrane thin, transparent, containing, besides fully developed spores, sporoblasts in different stages of development, some of them measuring 2·5 to 3 μ, and containing one or several colored granules representing nuclei.

Spore.—Ovoid, resembling that of *Glugea anomala;* length, 3 μ; breadth, 1·5 to 2 μ; a single capsule with a filament is present; large extremity showing a mass refractory to staining fluids, the remainder of the spore cavity containing sporoplasm, and a body apparently representing the nuclear element of the spore, staining strongly with reagents, and in certain cases decomposable into separate granules whose number never exceeds 4.

Habitat.—Muscles of *Cottus scorpio* (sculpin); position interfibrillar.

Effects.—Diseased mass forming small white streaks of an average size of 5 to 6 mm. by 3 mm., consisting of spores. The fibers affected increase in bulk; they are filled with the pansporoblasts disposed without regular order between the fibrillæ, which latter become separated and distorted, without, however, presenting any alteration of structure or diminution in the clearness of their tranverse striation.

III. THELOHANIA Henneguy, 1892.

Etymology: Thélohan.

In Thélohan, Bull. Soc. philomat. Paris, IV, p. 174, footnote; *ib.* Henneguy, in Henneguy and Thélohan, Annal. de Microgr., Paris, 1892, IV, p. 639; *ib.* Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, pp. 409–410; *ib.* Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 739–740; *ib.* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Definition[1] (provisional as regards negative characters).—*Glugeidæ* destitute of a myxosporidium and in which the pansporoblast produces constantly 8 spores; pansporoblast membrane subpersistent as an octosporophorous vesicle; type *T. giardi.*[2]

Henneguy and Thélohan remark that in this genus the spores unquestionably approximate those of *Glugea anomala* and those of *Pleistophora.* The number of spores formed in the pansporoblast and the absence of a myxosporidium differentiate *Thelohania* from *Glugea.* On the contrary, the last character and the subpersistence of the pansporoblast membrane as a sporophorous vesicle, approximate it to *Pleistophora.*

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[1] Henneguy's definition is:

"Spores pyriform, with one polar capsule at the small extremity and, at the opposite extremity, a clear vacuole with contents not colorable by iodine. Sporoblasts producing only 8 spores surrounded by an envelope persisting after the formation of these last; no plasmic mass, properly speaking."

As constituted by Henneguy the genus included only 3 species, *T. octospora*, *T. giardi* and *T. contejeani.*

[2] Type proposed by the author in Bull. U. S. Fish Com. for 1891 (1893), XI, p. 410.

30. Thelohania contejeani Henneguy, 1892. Pl. 10, figs. 4, 5.

(Parasite of crayfish, Henneguy and Thélohan, 1892, Compt. Rend. hebdom. Soc. Biol. Paris, IV, p. 749.)

Thelohania contejeani, in Thélohan, Bull. Soc. philomat. Paris, IV, p. 174, foot-note; *ib.*, Henneguy and Thélohan, 1892, Annal. de Microgr., IV, pp. 637–9, pl. 4, figs. 26–7; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 739–740; *ib.*, Dubois[1] (Raphæl) 1893, Recherches de pathologie comparée sur la peste des écrevisses, Compt. Rend. hebdom. Soc. Biol. Paris, V, pp. 158–9, figs. A, B; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 410; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86; cf. La Maladie des Écrevisses en Allemagne; Bull. Mensuel Soc. Nat. d'Acclimat. France, February, 1884, p. 200 (transl., Bull. U. S. Fish Com. for 1884, IV, pp. 299–302).

Cyst.—None. Parasitic mass producing an opacity of the affected muscles, as in *Palæmon* and *Crangon*. Opacity more difficult of observation than in the last, on account of the greater thickness of the test; easily detected, however, on the inferior surface of the abdomen.

Adult.—In some places only spores are seen; in others small plasmaspheres, containing a variable number of nuclei, occur. These are evidently developmental stages, but a full series could not be found.

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[1] This observer noted 2 (entirely distinct) parasites, viz: one which Henneguy and Thélohan pronounced a fungus, and one which he determined to be *Thelohania contejeani*.

1. The former he describes as follows:

Spore.—Cellules elongate, ovoid, cylindrical, or strangulated toward the middle, according to the degree of development. Shell double-contoured; protoplasm vacuolate, escaping amœboidly through a small lateral orifice. Spores apparently not capable of growth in nutritive fluids.

Habitat.—Confined to the intestinal canal of the diseased crayfishes. The observations were made in June and July (1892), the months of maximum severity of the epidemic.

Crayfish epidemic.—Causes: Alterations of streams by industrial or agricultural products can have only a subordinate and local influence.

Area invaded divisible into 3 zones: (1) Lake Mantua (and its outlet to the sea, the river Ain); formerly renowned for its crayfishes, which constituted an important revenue; now destitute of crayfishes. (2) The Merloz rivulet, an affluent of the lake, containing sound and diseased crayfishes, the latter showing the symptoms of the pest. (3) The sources or *Doye des Neyrolles* feeding the lake and the Merloz rivulet, from which latter it is separated by a dam, above which all the crayfishes are healthy.

The stoppage of its advance by the dam and its inability to grow in nutritive fluids caused Dubois to suspect it to be an animal (possibly a sporozoan) which ascended the watercourse from the sea, perhaps brought by a fish. Thélohan and Henneguy, however, from an examination of his material, believed the form to be a fungus.

The Distome described by Baer in 1827 (when no epidemic existed), to which Harz attributes the crayfish epidemic, was sought for in vain.

2. *Thelohania contejeani.*—Feeding experiment: Sound crayfishes were isolated in reservoirs and fed, some with butcher's meat, and others with the flesh of trout, carp, pike, and roach. After three months those fed on roach showed parasites in the abdominal muscles. This parasite was identical with *Thelohania contejeani*. Dubois asks: Do relations exist between the parasite found in the muscles and the intestines in October, and that found in July in the abdomen?

Spore formation.—Number of spores found in each sporigenous area variable, always, however, more than 8, in which respect the present species differs from the spores of *Palæmon* and *Crangon*.[1] Spores sometimes free, sometimes 8 together in a common envelope, as in *Palæmon*.[2]

Spore.—Size approaching and appearance the same as that of *T. octospora*; ovoid, length 2 to 3 μ, with a clear vacuole in the larger end.

Habitat.—Striated muscles of *Astacus fluviatilis* (crayfish) from the Department of Doubs, France; collected by M. Contejean in 1890.

Pathological anatomy.—On section the muscles show nearly the same appearance as in *Palæmon* and *Crangon*; the fibrillæ being separated by parasitic masses, which in transverse sections appear as numerous deeply stained punctules, and which in longitudinal sections assume the appearance of irregular chains separating the fibrillæ; the latter have preserved their normal appearance, the striæ being perfectly distinct.

Nature.—The material was available only in alcohol, to which it had been transferred from Fol's liquid. Owing to this, Henneguy and Thélohan were unable to demonstrate the capsule with filament. The similarity to the other species leads them, however, to believe it a myxosporidian.

Effects.—A notable diminution of muscular vigor was clearly established with the myograph by M. Contejean.

Epidemics.—In the Department of Doubs this disease has raged with intensity among the crayfishes during several years and has caused the death of a very great number of individuals. It seems now to have disappeared. Moreover, this parasite can hardly be special to the watercourses of Doubs, and, remembering the considerable mortality caused by it in that Department, it is to be presumed that this hitherto unknown organism has played a rôle in the genesis of the epidemic which raged for several years in the East, and which has almost completely destroyed the crayfishes of that region.

31. Thelohania octospora Henneguy, 1892. Pl. 10, fig. 6; pl. 11, figs. 1–5.

(Parasite of *Palæmon rectirostris* and of *P. serratus*, Henneguy, 1888, Mém. publiées Soc. philomat. Paris l'Occas. Centen. Fondation, pp. 163–71; *ib.*, Thélohan, 1891, Journ. de Microgr., XV, p. 146; *ib.* of *P. rectirostris*, Thélohan, 1891, Compt. Rend. hebdom. Soc. Biol. Paris, III, p. 28, name only; *ib.*, Thélohan, 1891, Journ. de. Microgr., XV, pp. 146–7; *ib.*, Pfeiffer, 1891, Die Protozoen als Krankheitserreger, 2 ed., pp. 114–5; *ib.*, Thélohan and Henneguy, 1892, Compt. Rend. hebdom. Soc. Biol. Paris, IV, p. 586.)

Thelohania octospora in Thélohan, Bull. Soc. philomat. Paris, IV, pp. 165–6, 174, footnote; *ib.*, Henneguy and Thélohan, 1892, Annal. de Microgr., IV, pp. 621–27, 629–632, pl. 4, figs. 1–8; *ib.* Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 410; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 739–40; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

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[1] Henneguy and Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, 1892, IV, p. 749.
[2] Henneguy and Thélohan, 1892, Annal. de Microgr., II, p. 638.

Life history.—All the individuals, whether wholly or only partly invaded, showed the same developmental stage. It seems fair to suppose the first stage to be a plasmodioid mass in which the spores form. The constant presence of 8 spores suggests their origin by successive bipartition, as occurs with the falciform corpuscles of Gregarines (Henneguy, 1888). The stage of development of the parasite of *P. serratus*, taken in connection with the date of capture, indicates that the course of development of the parasite is the same in this crustacean as in *P. rectirostris* (Henneguy and Thélohan, 1892).

Cyst.—Henneguy vainly endeavored to detect, even under very high powers and with different reagents, in material, fresh or fixed, dissociated or sectioned, a cyst membrane, and believes the cyst to be absent. This view is, he thinks, confirmed by the irregularity of the distribution of the pansporoblasts between the fibrillæ.

Pansporoblast ("vesicles" of Henneguy, 1888).—Rounded, diameter, 10 μ; membrane thin, transparent, resisting potassium hydrate solution, apparently not presenting local thickenings as in *T. giardi.*

Spore formation.—Each pansporoblast produces 8 spores, which fill only a portion of its cavity and are disposed without order.

Spore.—Length, 3 to 4 μ; pyriform, very refringent; capsule present; length of filament 40 to 50 μ; exit, produced, after failure of all other reagents, by ether, whose action is rapid and perfectly definite, and affects a large number of spores; usually extruded completely, sometimes, however, only partially uncoiled; capable of staining with anilin stains, among others violet 5B. The electivity of the filament for ether is a striking peculiarity.

Habitat.—Interior of muscular fibers (between the ultimate fibrillæ) of *Palæmon rectirostris* Zadd (prawn), from the salt marshes at Le Croisic; the same seat in *P. serratus* from Concarneau and from Roscoff. In *P. serratus* less common than in *P. rectirostris*, in which latter it is (at least at Le Croisic) extremely frequent. It is never found in the digestive tract, nervous system, glands, sexual organs, or anywhere but in the muscles.

Affinities.—By its exclusive seat in the muscles, and by the form and grouping of the spores, the parasite appears to be incontestably a sarcosporidian, differing from those of the *Mammalia* in the absence of a surrounding membrane.. The spores, also, are a little different from those of the other *Sarcosporidia.* They recall certain myxosporidian spores. This form also presents much affinity with the *Microsporidia* of the *Arthropoda*, the latter having the same refringent aspect and more or less oval shape of the present species, and being, like it, inclosed in "vesicles." One finds them in all tissues, but not in the interior of the muscle fiber. There, then, probably exists a rather close relation between the *Micro-*, *Myxo-*, and *Sarcosporidia*, and the parasite of *Palæmon* appears to represent a transition form between the 3 groups (Henneguy, 1888).

The discovery of the capsule settles the question in favor of its myxosporidian nature. It is thus neither a sarcosporidian nor a transitional form (Henneguy and Thélohan, 1892).

Microscopic technique.—Henneguy fixed by alcohol, osmic acid solution, Flemming's, Perenyi's, or Kleinenberg's liquids, dehydrated, paraffined, sectioned, affixed with Mayer's albumen, and stained, preferably with gentian violet (Ehrlich's) and eosin. Parasites (also nuclei of muscles, connective tissue, epithelia, nerves; which, however, can be washed out) violet; muscles rose-red. Picro-carmine; muscles red, spores yellow. Safranin; tissue nuclei red, spores same, but fainter.

T. octospora differs from *T. giardi* in the smaller size of the pansporoblast, and apparently also in the absence of thickening of its membrane.

Pathological anatomy.—Macroscopic: Easily recognizable by the chalky or porcelaneous opacity[1] which forms a constant and characteristic sign of the presence of these *Myxosporidia.* Opacity limited to the muscles invaded, consequently varying in extent with the degree of infection; in slight (and in the beginning of all) cases being limited to some white striæ in one or several abdominal segments, or only one or two segments (most frequently then the first ones, the disease appearing to progress from before backwards) are opaque white. *Ad maximum*, the entire body becomes white except the region of the heart and stomach which always, and some parts of the claws, antennæ, beak, and abdominal segments which usually, remain transparent. These exceptions constitute the only difference between this condition and the opacity produced by heat or alcohol.

Microscopic.—Low powers: In examining a teased or slightly compressed muscle fragment, one immediately perceives, besides the normal primitive fiber bundles (easily recognizable by their transverse striation), elongated spaces parallel to these bundles, contrasting strongly therewith, and apparently filled with a peculiar finely granular substance. Dimensions of spaces approximating those of the normal fiber bundles; their transverse diameter, however, a little greater. Number of spaces varying *pari passu*, and the intervening sound tissue varying inversely, with the intensity of the infection, the opaque spaces being in contact or more or less widely separated by sound fiber bundles. The proportion of the fibrillæ invaded is best appreciated in transverse sections of the muscles. In extreme cases nearly all the fibers may be affected. Longitudinal sections show the parasite in the form of violet chains between the rose-red normal fibrillæ (gentian violet; safranin).

Higher powers: At first sight one would believe that each of these productions is entirely composed of a parasitic mass interposed between the primitive fibers, but a more thorough examination shows

[1]The same opacity is found in the muscles of *Callionymus lyra, Cottus scorpio,* and *Barbus barbus,* and outside the muscles the parasites exhibit the same color.

that each space corresponds to a primitive fiber bundle whose normal aspect is profoundly modified by the presence between its fibrillæ of elements of a parasitic nature, whence results a slight increase of width of the fiber bundle. Most often the fibrillæ do not present a sensible alteration. Sometimes (probably when a great quantity of the parasitic element has led to a considerable separation) the elasticity of the fibrillæ is overcome, rupture resulting. Even under these conditions, however, the muscle striæ remain exceedingly clear, no degeneration ever having been observed, as in *Callionymus* and the barbel.

The nuclei of the muscle fiber are more numerous and smaller than normal; this feature is particularly well shown by safranin (Henneguy, 1888).

Effects.—The muscular vigor is considerably diminished. Thus, if a number of *P. rectirostris* living in the rivulets of the salt marshes be frightened out of their shelter among the vegetation, even although the new shelter sought by them be near at hand, the diseased white individuals (immediately recognizable against the strongly contrasted muddy rivulet bottom) lose ground and remain considerably behind the sound ones. Further, one knows with what ease the prawns jump out of the vase in which they are held captive. If sound and opaque prawns be placed together in a basin, after some hours the sound ones have nearly all dispersed around the vessel, while the opaque are there still, or have only succeeded in sticking to the wall of the basin, however small the bound required to overleap the barrier. Considering the intensity and universality of the muscle infection, the diminution of muscular vigor is quite natural; indeed, the surprising feature is the relatively great agility retained by muscles the bulk of whose contractile substance is much inferior to that of the parasite, and in some cases it is truly astonishing that muscular power is not completely destroyed. Among the diseased Palæmons no egg-bearing females were seen. Perhaps this may be a case of "parasitic castration." The diseased individuals do not survive very long, all succumbing by the end of autumn, as during the winter not one can be found.

Conditions and mode of infection.—The prawns affected are usually found in small shallow ditches containing a layer of water 0·10 m. to 0·20 m. deep, along the slope separating the compartments from the salt marshes. The water of these ditches is rarely renewed and acquires an elevated temperature. These are probably the conditions favorable to the development of the parasite. It is difficult to decide whether the parasite finds an entrance by way of the alimentary canal. Henneguy seems to favor the contrary view, as the first lesions are found at places remote from the digestive tract.

Artificial infection.—Captive Palæmons fed for several months with diseased tissue showed no signs of infection. It was impossible to prolong the experiment to see whether infection would ultimately ensue (Henneguy, 1888). *P. rectirostris* fed for months with diseased tissue never showed, under the most careful microscopic examination, the slightest trace of infection (Henneguy and Thélohan, 1892).

Season.—Disease most frequent and at maximum of development from about July 15 to the end of August; number affected diminishing in September; diminution more pronounced in October; disappearing entirely after November 15; reappearing about March 15 or the first days of April.

32. **Thelohania giardi** Henneguy, 1892. Pl. 12, figs. 1, 2.

Crangon vulgaris, "parasite" etc., of.	giardi.	Date.	Authority; reference.
×	....	1892	Thélohan & Henneguy, Compt. Rend. hebdom. Soc. Biol. Paris, IV, pp. 586–7.
	Thelohania .	1892	Henneguy in Thélohan, Bull. Soc. philomat. Paris, IV, pp. 165, 174, footnote.
	Thelohania .	1892	Henneguy & Thélohan, Annal. de Microgr., IV, pp. 621, 624, 626–31, pl. 4, figs. 9–25.
× *		1893	Ohlmacher, Journ. Amer. Med. Assoc., XX, p. 562.
	Thelohania .	1893	Gurley, Bull. U. S. Fish Com. for 1891, XI, p. 410.
	Thelohania .	1893	Braun. Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 739–740.
	Thelohania .	1894	Braun. Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

* Crangnon; error.

Cyst unknown.

Spore formation.—Pansporoblast spherical; diameter 14 μ (12 to 14 μ); in the young stages consisting of a very thin membrane resisting potassium hydrate, inclosing a very transparent, scarcely granular, slightly refringent protoplasm, having at its center a rather large nucleus (pl. 12, fig. 1*a*, *b*), often visible in the fresh state, becoming much clearer under the action of reagents.

(1) Segmentation of the pansporoblast: The nucleus first presents the typical resting structure with a distinct membrane. The chromatin can take on different arrangements, sometimes forming one grain much larger than the others, sometimes a variable number of smaller subequal grains, or sometimes crowded back against the membrane, presenting here and there thicker portions (pl. 12, fig. 1). Subsequently a remarkable modification occurs: the chromatin has become arranged in filaments, the membrane has disappeared, and the nucleus assumes the arrangement known as the chromatic coil; very soon the chromatic filaments orient themselves into a very distinct equatorial plate, which becomes double, the process resulting in the formation of 2 daughter-nuclei. We thus have a true karyodieresis. The achromatic filaments were not seen, doubtless owing to their rather small size and partly, Henneguy and Thélohan believe, to the nature and optical properties of the protoplasm. Protoplasmic segmentation soon follows nuclear division, and one sees, within the primitive pansporoblast membrane, 2 small distinct nucleated masses. In their turn these 2 masses divide and redivide, the process ending with the formation of 8 small plasmic bodies (*sporoblasts*) within the original pansporoblast membrane. The divisions do not take place very rapidly, and between successive ones

the nuclei have time to return to a state of rest, whence they again pass through the same stages preliminary to division.

The sporoblasts have no regular arrangement within the pansporoblast membrane; their shape is inconstant, varying with their arrangement; they generally approximate a truncate-pyramidal form. Each sporoblast develops into a spore. Spores thus contained 8 in each pansporoblast membrane, without regular arrangement, not nearly filling the cavity. This is the last stage of development reached in the muscles of the host.

Pansporoblast membrane retaining its original dimensions, perfectly transparent, very thin, although the double contour is easily visible, showing in optical section marked thickenings, often 2 in number (pl. 12, fig. 1*k*).

(2) Development of sporoblast into spore: Owing to the very minute size of these bodies, it is almost impossible to follow this development in detail or to confirm the facts discovered in the larger forms by Thélohan, viz, sporoblast segmentation, number of nuclei, etc.

Development of capsule: A peculiar arrangement, believed to be connected with the development of the capsule, was noted, viz: often in the body of the sporoblast, near the nucleus, a clear rounded space, into which a small protoplasmic button projects. This observation is, however, a very delicate one, and the figures are slightly diagrammatic.

Morphology of the sporophorous vesicles.—The constitution and development of the spore-producing vesicles permit us to consider them only as the morphological equivalent of the pansporoblasts of the other *Myxosporidia*. These octosporophorous pansporoblasts form a transition from the oligosporogenetic pansporoblasts of the larger species to the polysporogenetic pansporoblasts of *Glugea*, which latter produce a considerable and inconstant number of spores. Above all, one fact is here to be noted, viz, the entire absence of a myxosporidium. No structure whatever could be detected which could be regarded as its morphological or physiological equivalent.

But whence come these spore-producing vesicles? Evidently they do not represent the first stage of development. Now if, as is usual, they are formed in the interior of a protoplasmic mass, what has become of the latter? In all other known species a considerable protoplasmic residue remains, even of myxosporidia whose development is completed, and in which young pansporoblasts are no longer to be found, but only entirely mature spores. But here are young pansporoblasts at their simplest (uninucleate spherules) with not the slighest trace of a surrounding protoplasm. As long as we had only found these organisms in the mature state (as sporophorous vesicles) that absence might have been explained, in case of necessity, on the supposition of a complete previous transformation of the myxosporidium into pansporoblasts, the myxosporidium vanishing in the process or leaving only insignificant vestiges. But in the presence of the now known earlier phases of development this hypothesis seems hardly admissible.

Henneguy and Thélohan add:

Is it necessary to admit the existence of a plasmic mass [myxosporidium] which is completely transformed into sporoblasts? This mode of view can evidently be defended; no fact, however, comes to its support, and it has the grave fault of deviating widely from what one knows of the development of the other species. On the whole we must admit that there is here a point in the history of our parasite which our researches have not elucidated, and the state under which it is presented constitutes a curious peculiarity which, at least in appearance, establishes an important distinction between it and the other *Myxosporidia.*

Abnormalities of development.—One rather frequently encounters spores which are larger than the others and which exhibit a constriction (pl. 12, fig. 1 *l*). At first view one is tempted to question whether this is not a phase of division. Similar productions are rather frequent in *Glugea* and in the *Microsporidia* (whose spores offer much resemblance to those of *Thelohania*), where they have been seen by Pasteur,[1] who considered them as corpuscles in process of division. On the contrary, Balbiani, who has studied them with care, regards them as the result of malformations, a view which Henneguy and Thélohan adopt in the present species. If fig. 12, pl. 1 *l*, be considered, it is quickly seen that this is the only interpretation admissible. One sees there 4 normal spores, and 2 larger structures constricted toward their middle and presenting attenuated extremities similar to the small ends of normal spores. The appearance of these elements and their dimensions cause one to think of 2 spores soldered by their large extremities. There can no longer remain any doubt in this respect if one considers that by supposing these spores separated the typical number of spores in the pansporoblast is made up. In reality, then, the 2 spores in question have, in consequence of an accident which has occurred in the course of their development and by a process which we have not been able to follow, contracted an intimate adhesion at the level of their large extremity, the point where this soldering has taken place remaining marked by a constriction. The limited number of spores in each pansporoblast renders the proof much more easy here than in *Glugea* and the *Microsporidia,* where the number of spores is much greater and not constant.

[I can not see why these could not be more simply and better explained as malformations, the result of development from imperfectly segmented pansporoblasts, i. e., as developing from a quarter-segment of the pansporoblast which failed to divide completely. The partial fusion of 2 spores where no pressure-atrophy of the shell could be assumed, seems very improbable. (cf. p. 180). R. R. G.]

Finally, although not pertaining directly to the *Myxosporidia*, in this connection the following from Kunstler and Pitres[2] may be quoted:

The small forms often show themselves constituted in such a manner that they appear to be in way of division (figs. 8–12). The multiplicity, the variety, and the constancy which these appearances present seem to show well that this is really a

[1] Études sur les maladies des vers à soie, Paris, 1870.

[2] Journ. de Microgr., 1884, VIII, p. 522.

process of division. Some divide into 2 equal parts (fig. 8); in others the parts are of unequal dimensions (figs. 9, 10), and often this division recalls strongly a phenomenon of terminal or lateral budding (fig. 11).

Spore.—Very refringent, pyriform; anterior end much more acute; length 5 to 6 μ; shell with very fine longitudinal striæ; could not determine whether bivalve or not.

Capsule: In fresh material the highest powers reveal nothing suggestive of a capsule, the anterior extremity appearing merely more shaded, seemingly occupied by a homogeneous, refringent substance. One sometimes sees, however, near the anterior end, a clear streak (pl. 12, fig. 1*o*) believed to be due to the capsule, but it is too indefinite and exceptional to prove the existence of that structure. Stained sections afford no aid here.

Filaments: Extrusion not produced by iodine, potassium or sodium hydrates, glycerin, heat, acetic or formic acids, or by ether. Hydrochloric and nitric acids produced extrusion; the latter difficultly obtainable, observed only in a very small number of cases in spite of repeated efforts. Strangely enough, this method failed completely to produce extrusion in *T. octospora* and, on the contrary, ether, the only agent which succeeded in that species, was without effect on the spores of *T. giardi*. Filament 15 to 20 μ long; usually extruded completely, sometimes, however, extruded only partially uncoiled; susceptible to anilin stains, among others violet 5B.

Sporoplasm: Safranin or gentian violet (apparently the best stains for these organisms) yield 2 different appearances, according to the degree of decoloration. If slightly decolorized, the vacuole alone is visible, but when decolorized *ad maximum* only some colored grains remain in front of the vacuole. Sometimes two or three are distinguishable; most frequently, however, only a small colored band (apparently formed of fused granules of indeterminate number) is seen. Vacuole aniodinophile.

Habitat.—Seen only once in *Crangon vulgaris* Fabr. (shrimp), from Boulogne. Probably the course of development is the same as in *Palæmon*, as in the single specimen taken the state of development of the parasite corresponded to the state of development in *Palæmon* at the same date.

Pathology.—Everything under *T. octospora* relative to the opacity produced in the host applies equally to *T. giardi*, except that, by reason of the less perfect normal transparency in, and the pronounced tegumentary pigmentation of, *Crangon vulgaris*, the modification is less striking, though it is always sufficiently sharp to permit the recognition of the infected individuals without any difficulty.

Effects.—Ehrenbaum[1] noted abnormal individuals of a paler, more opaque color, destitute of the normal greenish tone, apparently considerably enfeebled, dying more rapidly than the normal ones when

[1] Zur Naturgeschichte von *Crangon vulgaris*, Berlin, 1890, pp. 11, 12.

thrown out of the water. The abnormal individuals never included egg-bearing females.

This, Henneguy and Thèlohan think, recalls the aspect of Crustacea infected by *Myxosporidia*. They have also never seen egg-bearing females among the infected Palæmons. Perhaps we have here, they think, another case of "parasitic castration."

Infection experiments.—A *Caradina desmuresti* fed for 71 days with the muscles of an infected *Crangon*, showed, on the most careful examination, no sign whatever of infection.

33. **Thelohania macrocystis** Gurley, 1893. Pl. 12, fig. 3.

(Sarcosporidian of *Palæmonetes varians* Garbini,[1] 1891, Rend. Real. Accad. Lincei Roma, VII, Sem. 1, pp. 151, 152 with fig.; myxosporidian of *ibid.*, Thélohan and Henneguy, 1892, Compt. Rend. hebdom. Soc. Biol. Paris, IV, p. 586.)

Thelohania macrocystis, Bull. U. S. Fish Com. for 1891, XI, p. 410; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Sporophorous vesicle.—Elongate fusiform. This is the principal character distinguishing this species from *T. octospora*, which has perfectly rounded vesicles.

Spores.—Eight in number, pyriform, shell difficultly stainable, coloring only in a 0·5 per cent boiling solution of eosin; spores easily stainable by Gram's method; in the larger posterior end a distinct round "nucleus" more clear and transparent than the surrounding sporoplasm. Together with these forms are others with a thicker and more difficultly stainable shell, within which 8 corpuscles are with difficulty discernible; probably these represent more advanced stages of the same parasite. Garbini failed to find other developmental stages corresponding to those found by Henneguy in *T. octospora*. Inoculation of healthy animals proved a failure.

Habitat.—Occurring in great numbers in the muscles of *Palæmonetes varians* (prawn) from the Mincio in the neighborhood of Verona.

Nature.—This species has much analogy with *Thelohania octospora*, but presents some noteworthy differences that warrant its specific separation.

Ordo II. Phænocystes Gurley, 1893.

Etymology: φαινω, I appear; κυστις, capsule.

Bull. U. S. Fish Com. for 1891, XI, pp. 409, 410; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Definition.—*Myxosporidia*, in which the pansporoblast produces few (1 or 2) spores; the latter relatively large, with distinct symmetry and 2 or more capsules;[2] type family, *Myxobolidæ*.

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[1] First described in Garbini's "Intorno ad un nuovo microorganismo parassita del *Palæmonetes varians* (title only); Atti Real. Accad. Lincei Roma, 1890, VI, p. 526; unpublished.

[2] Except *Myxobolus unicapsulatus* and *M. piriformis*. This qualification is omitted by Braun.

Fam. MYXOBOLIDÆ Gurley, 1893.

(*Myxosporidieæ*[1] Perugia, 1891, Boll. Scientif., Pavia, XIII, p. 23; Myxobolées Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 176.)
Myxobolidæ, Bull. U. S. Fish Com. for 1891, XI, p. 413; Myobolea [Thél.] Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Definition.—*Phænocystes*, whose spores are destitute of antero-posterior, but possess bilateral, symmetry;[2] capsules 2, in 1 group at the anterior end; a bivalve shell, the plane of junction of whose valves is parallel to the longitudinal plane; an iodinophile vacuole; type (and only) genus *Myxobolus.*

IV. MYXOBOLUS Bütschli, 1882.

Etymology not given.
Bronn's Thier-Reich, I, pl. 38, figs. 6–10, and of subsequent authors; *ib.*, Lankester, 1885, Encycl. Britan., 9 ed., XIX, p. 855; *ib.*, Thélohan, 1890, Annal. de Microgr., II, p. 213; *Myxosporidium*[3] Perugia, 1891, Boll. Scientif., Pavia, XIII, p. 23; *ib.*, Weltner, 1892, Sitzgsber. Gesellsch. Naturf. Freunde Berlin, p. 34; *Myxosporidium, ibid.*, p. 35; *Myxobolus* et *Henneguya*[4] Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 176, 177; *Myxobolus*, Perrier, 1893, Traité de Zool., p. 460; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, pp. 411–13; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Definition.—Characters, those of the family.

Henneguya is separated from *Myxobolus* by only 2 characters, viz, (1st) capsules constantly 2, and (2d) the presence of a tail. Inasmuch, however, as all the numerous typical *Myxobolus* species have 2 capsules, and only 2 species are known to deviate in this respect in the direction of capsule-reduction, the typical number of capsules in *Myxobolus* is 2; so that the 2 differential characters in reality reduce to the single one of the presence of a tail. This in itself is not sufficient to warrant a generic separation, especially in view of the entire accord between the tailed and untailed forms in regard to symmetry, similar position of the valves, exactly similar vacuole, nuclei, etc. Besides, it may be noted that it has been several times asserted that tailed and untailed forms occur in the same cyst. Thus Müller,[5] Lieberkühn,[6] and Bütschli[7]

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[1] *Myxosporidium* Perugia (synonym for *Myxobolus* Bütschli?) proposed as type of Fam. *Myxosporidieæ* Perugia, by the author in Bull. U. S. Fish Com. for 1891, XI, p. 413.

[2] Except species which have suffered reduction of characters (*Myxobolus unicapsulatus*, *M. piriformis*, *M. inequalis*). Perhaps *M. strongylurus* should be added.

[3] *Myxosporidium merlucii* proposed by the author (Bull. U. S. Fish Com. for 1891 (1893), XI, p. 413) as the type species. The name *Myxosporidium*, having been proposed as a new name for a genus formed by the fusion of several good genera each of which already possessed a name in good standing, must be suppressed.

[4] *Henneguya psorospermica* proposed as the generic type by the author (Bull. U. S. Fish Com. for 1891 (1893), XI, p. 413).

[5] See *Myxobolus sp.* 61, p. 240.

[6] Müller's Archiv., 1854, p. 6; Mém. Cour. et Mém. Sav. Étrang. Acad. Roy. Belg., 1855, XXVI, p. 37.

[7] Bronn's Thier-Reich, 1882, I, p. 597. This is probably only an opinion as to the consensus, and not an independent one.

have all asserted this condition. It is, however, almost impossible for me to believe that a tailed species is ever (except of course from breakage, and I have seen many spores deceptively broken) untailed or that an untailed species is ever tailed. I do not recognize as true tails those processes evidently monstrous (as shown by their aspect, their great rarity, their wide divergence from the typical forms, and the lack of transitions thereto) which are very rarely observed in untailed species. Thus I have seen among hundreds of spores of *Myxobolus oblongus* such a form. But that (and also those reported by others belong, I suspect, to the same category) should not be confounded with a true tail. In other words, I believe the presence or the absence of a tail to be a good *specific* character, but not a generic one. Finally, even if the above observations should be admitted to be accurate, might not the conjunction be better explained on the supposition that the 2 forms were in the same *tumor*, but not necessarily (at least until proven) in the same *cyst*, i. e., produced by the same myxosporidium. Although such a close approximation of 2 different species in the same tumor has not been seen, Thélohan is authority for an equally close approximation of 2 different genera in the renal tubules of *Gasterosteus aculeatus* and those of *Pygosteus pungitius*. Finally, in this connection pp. 245, 246 should be consulted. I saw Weltner's results long after writing the above, and perhaps they may demand some modification of it.

Shell.—This structure is bivalve throughout the whole of the genus, the valves being superior and inferior.

Ribbons ("elastic ribbons" of Balbiani).—These curious and probably abnormal modifications of the ridge are found only in, and are described under, *Myxobolus ellipsoides* (p. 223).

Tail (see also pp. 245, 250, 254).—This structure is found only in some species of *Myxobolus*. It was first noted by Müller, who says[1] that it is merely a solid prolongation of the shell substance not containing any extension of the body cavity. This is also, I believe, the view of its structure entertained by all subsequent observers.

Balbiani regards the tail as formed by the coaptation along the median line of his "elastic ribbons" (p. 223). The tail would thus consist of 2 *lateral* halves. This view may be safely rejected, as, if the tail is really composed of two halves, the latter must be *superior* and *inferior*, and not right and left. The latter view of its structure (2 halves, superior and inferior) is taken by Thélohan,[2] who says that the tail is composed of 2 halves (the respective superior and inferior positions of which are necessarily implied, since he says the bifurcation always takes place in the longitudinal plane), whose occasional imperfect coaptation results in the bifurcate condition frequently observed.

Finally, since writing the above, I have been enabled, by the kindness of Prof. Seth E. Meek, to examine *Myxobolus cf. linearis* (p. 253), in

[1] Müller's Archiv., 1841, p. 479.

[2] Annal. de Microgr., 1890, II, p. 206.

which the composition of the tail by the coaptation of a superior and an inferior half is easily demonstrable.

In at least one species, however, this structure of the tail appears not to obtain. In *Myxobolus macrurus* the structure in question seems not to be a shell process at all, but an independent structure with different optical and chemical properties. Although at first inclined to suspect the existence of the two lateral pieces (without the median piece; see p. 250) in the untailed forms, I was unable to detect any trace of them, as iodine failed to separate such a structure. Further, I was unable to prove the constancy of the initial *posterior* divergence of the valves which in *M. macrurus* I suspected to be correlated with the described structure of the tail.

Sporoplasm.—Correlated with the typical number and position of the capsules is the characteristic peltate shape assumed by the sporoplasm. The shape and the topographic features of this structure are described in detail under *Myxobolus macrurus* (p. 251). The sporoplasm contains nuclei, an iodinophile vacuole, and "granules."

Nuclei (see also "granules" below).—These were first observed by Thélohan. He describes[1] the condition as follows: A series of spores properly stained shows some with 1 nucleus (frequently situated at or near the median cornua) and others with 2, 3, or 4 nuclei, everything pointing to their origin by division from the single one. The subsequent ones appear to migrate at first outward and then backward.

Vacuole (iodinophile).—Although visible on some of Müller's figures, Bütschli[2] was the first to direct attention to this structure. He described it as a nucleus, remarking that, though sometimes visible in the fresh state, it became more distinct upon the addition of acetic acid or iodine solution. He failed in his efforts to stain it, a result that he attributed to failure of penetration through the shell of the staining fluid.

In 1889 Thélohan[3] corrected this erroneous interpretation, showing that the structure in question is a vacuole. Little differentiated in the fresh state (on account of similar refrangibility) from the sporoplasm, it becomes evident when the latter is coagulated by alcohol, acetic, nitric, or osmic acids, or by silver nitrate solution (2 per cent). Its chief micro-chemical characteristic is its extreme resistance to nuclear stains, which affect all the surrounding parts.[4] Iodine alone stains it a brownish red, the remainder of the protoplasm taking a pale yellow hue. The iodine reaction exactly resembles that exhibited by glyco-

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[1] Annal. de Microgr., 1890, II, p. 210.

[2] Ztschr. f. wiss. Zool., 1881, XXXV, p. 636.

[3] Compt. Rend. Acad. Sci. Paris, CIX, pp. 919–920. For Perugia's confirmation see *M. merlucii*, p. 243.

[4] Bütschli, indeed, states the contrary, but my own results are throughout in accord with those of Thélohan, as are also those of Perugia (Boll. Scientif., Pavia, 1891, XIII, p. 24).

genic matter. The vacuolic contents further resemble the latter in being insoluble in alcohol. Spores kept in this liquid preserve their reaction towards iodine. The vacuolic matter shows a further resemblance to glycogen in its solubility in alkalies. Acids modify it so that after their action it no longer exhibits the iodine reaction. Thélohan was never able to obtain the reduction of the cupro-potassium solution.

Pfeiffer[1] regards it as a nucleus, as does also Weltner.[2]

My own observations are in entire accord with those of M. Thélohan. The structure in question never colors with any staining reagents, nuclear or plasmic. It stains (alcoholic specimens) with iodine, exactly as stated by Thélohan, and is, I think, unquestionably a vacuole.

The vacuole is single, subglobular, usually central or subcentral, differentiated negatively (unstained against a dark ground) by staining reagents, and positively (dark brown against a light ground) by iodine.

Granules ("globules," etc.).—As late as 1884, Balbiani[3] regarded these as latent capsular germs, destined to develop into accessory capsules at the period of reproduction.

These granules appear to be of three kinds:

1. "Globules" present in fresh material. Those situated far forward (usually found at the side of, and apparently connected with, the capsule) were first observed by Bütschli[4] in *Myxobolus mülleri*, and subsequently by Thélohan[5] in *M. oviformis*. I have also seen them in *M. macrurus*. According to Thélohan, these are fatty, as they blacken strongly with osmic acid and dissolve in alcohol.

2. "Granules" distributed irregularly through the plasma are mentioned by Bütschli (*loc. cit.*).

3. The pericornual nuclei. The "granules" forming this series are 2 in number, minute, brilliant, subsymmetrically situated near both the lateral cornua and the posterior extremity of the capsule. These bodies were first noted by Müller.[6] Subsequently (as above mentioned), Balbiani regarded them as capsular germs.

In 1881 Bütschli described at some length the different appearances presented by these bodies in *Myxobolus mülleri* (p. 220).

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[1] Die Protozoen als Krankheitserreger, 1891, 2 ed., p. 17.

[2] Sitzungs-Ber. Ges. Naturf. Freunde Berlin, 1892, p. 32.

[3] Compt. Rend. Acad. Sci. Paris, 1863, LVII, p. 160; Leçons sur les Sporozoaires, 1884, p. 144. In the latter place he says:

"One remarks in the cavity of the psorosperm other small corpuscles which appear as refringent globules to the number of 3 or 4, symmetrically disposed, often placed at the base of the twin vesicles. I have considered these small globules as vesicles with a filament in a rudimentary state, destined to be developed at the moment of reproduction, for at this moment the psorosperm contains 3 or 4 vesicles with filaments. Bütschli has attacked this manner of view, nevertheless I believe I should maintain it."

[4] Ztschr. f. wiss. Zool., 1881, XXXV, p. 637, pl. 31, fig. 2.

[5] Annal. de Microgr., 1890, II, p. 211, pl. 1, fig. 8.

[6] *See* p. 240, pl. 28, fig. 6*g*.

Thélohan[1] was the first to recognize their nuclear nature. He first believed them to belong to the sporoplasm, supposing them to be situated at its 2 antero-external angles (lateral cornua). Subsequently, from a study of capsule development, he[1] regarded the bodies in question as persistent embryonal nuclei, the remnants of such development. He further expressed the belief that these nuclei could in some cases become detached from the capsules and engulfed in the sporoplasm.

Pfeiffer[2] terms them "safranophile corpuscles," but does not comment upon their nature. In *Myxobolus macrurus* I have studied these bodies (which, from their position, may be termed pericornual nuclei) with great care, and with the following results, which apply especially to *M. macrurus*, but equally well to *M. lintoni:*

1. There can be no question whatever that they are nuclei, as they take nuclear stains and show nuclear structure.

2. Their presence or absence and their position (at least in the fully developed spore) appears constant for the same species. As regards constancy of position they contrast strongly with the third and fourth nuclei.

3. The only question is as to their seat. It will be seen above that they have been regarded as belonging to the capsule and also as belonging to the sporoplasm. As is implied by this difference of opinion, their seat is by no means easy of determination, and, after much study, I am as yet uncertain whether they are capsular or sporoplasmic.

Three appearances may sometimes be seen on the same specimen: (*a*) They appear in one focus-plane almost certainly connected with the infero-lateral cornu; or, (*b*) they appear almost as certainly attached to the drawn-out posterior end of the capsule; or, (*c*) they appear disconnected from both and appear to be borne on a broad triangular spur projecting inwards from the shell.

An interpretation which seems possible is that each nucleus is imbedded in the sporoplasm near the tip of the *supero*-lateral cornu, whence it happens that optically its position almost exactly coincides with that of the posterior end of the capsule.

In some species (*Myxobolus cf. linearis, M. transovalis*) I failed to find any bodies which on account of the constancy of their position, etc., I could regard as the pericornual nuclei, and this absence appears to be here as definite a specific character as does their presence in *M. macrurus* and *M. lintoni.*

34. Myxobolus unicapsulatus Gurley, 1893. Pl. 13, fig. 1.

(Psorosperm of *Labeo niloticus* Müller, 1841, Müller's Archiv., p. 487, pl. 16, fig. 5 *a–d; ib.* Robin, 1853, Hist. Nat. d. Végét. Parasites, p. 299, pl. 14, fig. 7.)

Myxobolus unicapsulatus, Bull. U. S. Fish Com. for 1891, XI, p. 414; *ib.* of *Labro* [error] *niloticus* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Cyst and myxosporidium unknown.

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[1] Compt. Rend. Acad. Sci. Paris, 1889, CIX, pp. 920–1; *ibid.*, 1892, CXV, p. 1097.

[2] Die Protozoen als Krankheitserreger, 1891, 2 ed., p. 7.

Spore.—Of the form and size of *Chloromyxum dujardini.* Capsule only 1, situated on one side of the anterior end, obliquely directed.

Habitat.—On *Labeo niloticus* from the Nile.

35. Myxobolus piriformis Thélohan, 1892. Plate 13, fig. 3 (*pars*), 4 (*pars*)[1]; pl. 18.

(Psorosperms of the tench (*pars*) Balbiani, 1883, Journ. de Microgr., VII, pp. 197–198, fig. 66 *b, c, ? d–f; ib.* (*pars*) Balbiani, 1884, Léçons sur les Sporozoaires, pp. 125–6, fig. 47 *b, c, ? d–f*; pl. 4, figs. 1, 2, 3A (*pars*)[1], ? 3B, C; ? *ib.* (*pars*) Pfeiffer, 1890, Die Protozoen als Kranheitserreger, 1 ed., pp. 48, 55, fig. 16; ? *ib.* (*pars*) 1891, 2 ed., p. 132, fig. 56.

Myxobolus piriformis, Bull. Soc. philomat. Paris, IV, p. 177; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 414; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 86.

Synonymy.—M. Thélohan informs me (letter, 1893) that :

M. piriformis has very probably been seen by Remak, although his figures and his descriptions do not prove it absolutely (pl. 5, fig. 5). He does not figure the polar capsules, but his figures almost certainly belong to the species in question.

Fig. 8 represents 2 spores from the kidney[2] of the tench, which I do not know to what species to approximate. The presence of 2 capsules separates them from *M. piriformis*. The form of its spores and the small size of the capsules do not permit of its approximation to any of the forms that I have encountered.

The typical spore of *M. piriformis* contains but *1 polar capsule.* As in all species, one can find monstrous spores which inclose 2 capsules, but they have seemed to me very rare. This species is often accompanied, above all in the spleen of the tench, by *M. ellipsoides.* Almost all the spores with 2 capsules, represented by the authors, belong, I believe, to the spores, more or less monstrous, of this last species.

Balbiani considered *M. piriformis* a degraded form of *M. ellipsoides.* I have been able to convince myself that this mode of view is not correct. It is a species absolutely distinct and well characterized, as I have been able to determine by numerous observations.

After reading the above, I restudied the synonymy as between this species and *M. brachycystis*, and can not but feel that all of Remak's figures are referable to 1 species, which probably is, as Thélohan thinks and contrary to my former opinion,[3] distinct from his *M. piriformis.* The following are the conclusions at which I have arrived:

(*a*) Remak's figures are referable to 1 species. His fig. 8 (referred to in the second paragraph of the above quotation) is not from the kidney but from the spleen. There appears to me to be, especially in view of Remak's statements which tend to show that he considered the question carefully, no ground for a separation between these 2 developed spores

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[1] The figures in the rows on Balbiani's plate IV, fig. 3, are numbered in order from left to right, in the reproduction of it on pl. 13, fig. 3. The proper specific references of some of the figures of groups 3 and 4, on that plate, are dubious. The following is about all that can be safely said at present:

Indeterminate: Figs. 3 B, C; 4*d–f.* (either *M. piriformis* or *M. ellipsoides*).

Myxobolus piriformis: Figs. 3 A, Nos. 1, 2, 6; 4*b, c.*

Myxobolus ellipsoides: Figs. 3 A, Nos. 3, 4, 5, 7 (the last with some certainty, the rest probably, "abnormal" spores); 4*a.*

[2] These spores (Remak's fig. 8) are from the spleen.

[3] Bull. U. S. Fish Com. for 1891, XI, p. 409, second footnote, where it is stated that 1 *Myxobolus* species possesses, perhaps inconstantly, a single capsule. At that time I inclined to fuse *M. brachycystis* with *M. piriformis.*

of the spleen and the noncapsulate spores (developing spores; sporoblasts), also from the spleen, shown in Remak's fig. 5. And, finally, between the immature forms of fig. 5 from the spleen and the similarly immature forms from the kidney represented in Remak's fig. 7, specific identity seems almost certain. Another argument which is especially worthy of note is the fact that the spores represented in all 3 figures are *almost exactly the same size.* Remak does not, it is true, state the dimensions in the text, but on the plate he gives the multiplication ratio for the figures, and calculations from careful measurements of them show that all of them agree very closely. I therefore think, with Remak, that they are all one species.

(*b*) That species is distinct from *M. piriformis.* Among the 3 criteria cited by Thélohan as distinguishing *M. brachycystis* from *M. piriformis*, viz, spore-form, presence of 2 capsules and their small size, especial emphasis should be laid upon the latter, that is upon the small capsular index.

Cyst and myxosporidium unknown.

Spore.—Pyriform; closely resembling a pumpkin seed; being flattened-ovoid with a very acutely attenuated anterior extremity. Length, 16 to 18 μ; greatest breadth, 7 or 8 μ.

Habitat.—Branchiæ and spleen of *Tinca tinca* L.; kidney of *Misgurnus fossilis.*

36. **Myxobolus inequalis** Gurley, 1893. Pl. 13, fig. 2.

(Psorosperms of *Pimelodus blochii* Valenc., Müller, 1841, Müller's Archiv., p. 487, pl. 16, fig. 6*a, b*; *ib.* Müller, 1843, Rayer's Archiv. de Méd. comp., pl. 9, fig. 6; *ib.* Robin, 1853, Hist. Nat. des Végét. Parasites, p. 299, pl. 14, fig. 8.)

Myxobolus inequalis, Bull. U. S. Fish Com. for 1891, XI, p. 414; *Myxobolus inæqualis* [error] of *Pimelodes* [error] *blochii*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst and myxosporidium unknown.

Spore.—Length, 11 μ (0·0052‴); breadth, 7 μ (0·0033‴); capsules 2, of unequal size.

Habitat.—On *Pimelodus clarias* Bloch (= *Silurus clarias* Valenc.) from Guiana and Surinam.

37. **Myxobolus brachycystis** sp. nov. Pl. 14, figs. 1–3.

(Psorosperms of *Tinca chrysitis*, Remak, 1852, Müller's Archiv., pp. 144–146, pl. 5, figs. 5, 7, 8.)

Compare carefully p. 211. Remak compares it (by reference to Müller's figures) to *Chloromyxum dujardini.*

Spore formation.—Pansporoblast: Oval vesicles usually situated on the walls of the blood vessels of the kidney or spleen; either in connection with, or separate from, the pigment follicles; pansporoblast always monosporogenetic. In the developing spores Remak not infrequently missed the capsules, but comparison with developed forms which occurred in other cases left no doubt as to their nature.

Spore.—Pyriform, long drawn out.

Habitat.—Remak gives this as the pigment follicles of the spleen and of the kidney of *Tinca tinca* L. (tench). He further asserts that the same form is found on the branchiæ, but as he does not figure any spores from the last seat it may perhaps be a question whether the branchiæ yield the present species in addition to *M. piriformis*.

In the kidney a 3-chambered pigment cyst was seen 27 μ ($\frac{1}{80}'''$) long, the end compartments of which were occupied by pigment and the central one by a pyriform spore.[1] The pigment-follicles of the spleen almost always contain untailed psorosperms in considerable numbers, lying without order between the pigment-holding cells. The pigment follicles of the kidneys always contain the same species as that found in the spleen and upon the gills (Remak).

38. Myxobolus ? sp. incert. Pl. 14, fig. 4.

Psorosperms of *Cyprinus tinca*, Lieberkühn, 1854, Müller's Archiv., pp. 6, 24, 353, pl. 2, figs. 21–27.

Lieberkühn's description is substantially as follows:

Cyst imbedded in cornea immediately under the inner surface. Upon slight pressure very many spores, partly with and partly without tail-like appendages, and whose shell was no longer smooth but wrinkled, and whose capsules were no longer together but occupied unusual positions, were seen. Individual shells contained only 1, and others no capsule. A number of free "nuclei" which had preserved the club-shape of those within the spore also were seen. Finally, very small diaphanous, nongranular, amœbiform corpuscles occurred, which plainly, though slowly, moved with blunt or sharp processes.

Habitat.—Encysted in cornea of *Tinca tinca* L. (tench).

Concerning these figures, Thélohan (letter to author, 1893) says that they are not to be approximated to *M. piriformis*. Lieberkühn's fig. 21 would, he says, rather suggest *Chloromyxum dujardini*.

39. Myxobolus ? mugilis Perugia, 1891. Pl. 14, figs. 5, 6.

Myxosporidium mugilis Perugia, Boll. Scientif., Pavia, XIII, pp. 23–24, plate, figs. 7, 8; *ib.*, Weltner, 1892, Sitzungsber. Gesellsch. Naturf. Freunde Berlin, p. 35.

Myxobolus mugilis Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 166; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 414; *ib.* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst membrane.—Having removed with care one of the cysts from the branchiæ of *M. capito*, Perugia observed it to consist of 3 (others contain 2) separated myxosporidia surrounded by a common investing membrane evidently derived from the branchial lamella, which latter at no point showed any solution of its continuity. From this he concluded that the cyst is a production of the host. Some cysts contain 2 or 3 myxosporidia filled with spores, and with a residue of a very few granulations of protoplasm.

Myxosporidium not described.

Spore.—Free; "without a proper membrane"[2]; length, 7 μ.

Habitat.—Encysted in the branchial lamellæ of *Mugil auratus* and of *M. capito* (gray mullets). Rare; found only twice in 300 Mugils.

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[1] Remak here erroneously refers to his fig. 5*a* instead of fig. 7A.

[2] From other similar expressions by the same author I interpret this to mean: "No pansporoblast membrane."

Relative to its generic relations Perugia says:

This form might be referred to the genus *Myxobolus*, from which it seems to me to differ only by a little. The different hosts and the form of the spores only might cause it to be regarded as a distinct species.

40 Myxobolus sp. incert. Pl. 14, fig. 7.

(Psorosperm of *Nais proboscidea*, Lieberkühn in Bütschli, 1882, Bronn's Thier-Reich, I, p. 590, pl. 38, fig. 23; *ib.*, Thélohan, 1890, Annal. de Microgr., II, p. 193; *ib.* Pfeiffer, 1890, Virchow's Archiv. f. pathol. Anat. u. Physiol., CXXII, p. 557; *ib.* Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739.)

No description. Its symmetry shows it to be a *Myxobolus*. Observed by Lieberkühn, and communicated by him to Bütschli; published only by the latter.[1]

Habitat.—Nais proboscidea (a worm).

41 Myxobolus sp. incert. Pl. 15, figs. 1–6.

Psorosperms of *Esox lucius*, Lieberkühn, 1855, Mém. Cour. et Mém. Sav. Étrang. Acad. Roy. Belg., XXVI, p. 37, pl. 10, figs. 10–12, pl. 11, figs. 1–4; ? *ib.* Bütschli 1882, Bronn's Thier-Reich, I, pl. 38, fig. 11.

Cyst.—Size 8 mm. (0·31 inch) by 4·25 mm. (0·17 inch); contents "granular matter" alone, spores alone, or both "granular matter" and spores, in variable proportion.

Myxosporidium unknown.

Spore.—Oval or circular, tailed or untailed; the 2 kinds often mixed without order in the same cyst.

Habitat.—Cysts of branchiæ of *Lucius lucius* L. (pike).

It is hard to know what to do with this form. In spite of his assertion that tailed and untailed forms occur in the same cyst, Lieberkühn appears to figure only untailed forms. In view of this, and provisionally until some other observer shall confirm this observation, I prefer to recognize this as a "form" distinct from the tailed one having approximately the same habitat. (See also p. 256.)

42 Myxobolus oviformis Thélohan, 1892. Pl. 14, fig. 8.

("Myxosporidian spore (*M. mülleri* Bütschli?)" of *Cyprinus carpio* and of *Gobio fluviatilis*,[2] Thélohan, 1890, Annal. de Microgr., II, pp. 200, 204, 209, 210, 211, 213, pl. 1, figs. 8–11; spore of *C. carpio*, Thélohan, 1890, Compt. Rend. Acad. Sci. Paris, CIX, p. 921).

Myxobolus oviformis Thélohan, Bull. Soc. philomat. Paris, IV, p. 177; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 414; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst and myxosporidium not mentioned.

Spore.—Flattened-ovoid, with notably attenuate anterior extremity; length, 10 to 12 μ; breadth, 8μ; capsules relatively large (6μ); nuclei *ad plur.*, 3; vacuole, present.

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[1] Braun's language is slightly ambiguous: "Eine ältere Notiz, von Lieberkühn, erwähnt" the occurrence of *Myxosporidia* in invertebrates.

[2] An ambiguous expression of Lieberkühn's (Bull. Acad. Roy. Belg., 1854, XXI, pt. 2, pp. 22–23) may refer to an observation of a species upon the branchiæ of this fish.

Habitat.—Common on fins (where the spores exist in great numbers in the subcutaneous tissue) of *Gobio gobio* L. (gudgeon); branchiæ of same fish, of *Cyprinus carpio* L. (carp), and of *Alburnus alburnus* L.

43. Myxobolus ? cf. oviformis.

Psorosperms of *Cyprinus carpio*, Balbiani, 1883, Journ. de Microgr., VII, pp. 199–201; *ib.*, Balbiani, 1884, Léçons sur les Sporozoaires, pp. 128, 130, 131.

Cyst and myxosporidium not mentioned.

Spore.—Length 18 μ; breadth 12 μ.

Habitat.—On *Cyprinus carpio* L. (carp).

The dimensions differ so markedly from those of *M. oviformis* that on the present evidence I have not felt justified in fusing the 2 forms. It is, however, worthy of note that the ratio between the dimensions is the same as that in *M. oviformis*, and also that "18" may not impossibly be an error for 8. M. Thélohan writes that he has never found in the carp spores measuring 18 by 12 μ, and suggests that these dimensions may be an error.

44. Myxobolus sp. incert. Pl. 15, fig. 7.

Cyprinus brama, "psorosperms," etc., of—	Gobio fluviatilis [error] myxosporidian spore of—	Date.	Authority; reference.
Cf.	....	1841	Müller, Müller's Archiv., pp. 491–2.
×	....	1854	Lieberkühn, Müller's Archiv., p. 368, pl. 14, figs. 7, 8.
×	....	1879	Leuckart, Die Parasiten des Menschen, p. 248, fig. 99*b*.
	×	1882	Bütschli, Bronn's Thier-Reich, I, p. 600.
	×	1882	Lieberkühn in Bütschli, Bronn's Thier-Reich, I, pl. 38, fig. 18*a-c*.
×	....	1886	Leuckart, The Parasites of Man, 2 ed., p. 197, fig. 99B.
×	....	1887	Koch, Encyklop. d. gesammt. Thierheilkde u. Thierzucht, IV, p. 94, fig. 668, 2, 3.

Bütschli's reference to *Gobio fluviatilis* is certainly an error. His figs. 18*b* and 18*c* (loaned him by Lieberkühn) are respectively copies of Lieberkühn's figs. 7 and 8. That they are not merely independent figures of specifically identical material can be seen from the identity of the figure of the ever-varying amœboid (fig. 8, Lieberkühn; fig. 18*c*, Bütschli; see pl. 15, fig. 7*c*). The question is, moreover, additionally settled by Prof. Bütschli's statement that—

Concerning the subsequent fate of the spore, only two observers, Lieberkühn and Balbiani, have so far expressed opinions. They agree that the spore-shell finally separates, the protoplasmic contents emerging as a small active amœboid body (18*b*, *o*).

Thus the 2 figures in question were copied. Further, Lieberkühn mentions a "psorosperm" from the body cavity of *Gobio fluviatilis* (see p. 243), and describes in detail his observations in that form upon the separation of the valves and the exit of the amœboid posterior mass. He makes no mention, however, of any forms upon the branchiæ of *Gobio fluviatilis.* The fact that Bütschli cites its habitat as the branchiæ, with his statement that in this matter he is quoting, establishes the conclusion that his reference to *Gobio fluviatilis* was due to an erroneous correlation between Lieberkühn's text and Lieberkühn's figures. Finally, Bütschli's fig. 18*a* appears to be the transverse view of 18*b*.

Concerning the relation between this form and *M. sp.* 45, M. Thélohan (letter to author, 1893) says:

It is impossible to say whether this figure should be approximated to my *Myxobolus* of the bream.

No description.

Habitat.—Branchiæ of *Abramis brama* L. (bream).

45. Myxobolus sp. incert.

Myxobolus of bream, Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 178.

Cyst and myxosporidium not mentioned.

Spore.—Length, 8 μ; breadth, 6 to 7 μ.

Habitat.—Branchiæ of *Abramis brama* (bream).

Remarks.—Differs from *M. mülleri* only in the smaller size of the spores. See also remarks on the preceding species.

46. Myxobolus mülleri Bütschli, 1882. Pls. 16, 17.

(Myxosporidian spores of *Squalius cephalus*, of *Barbus fluviatilis*, and of other fresh-water Cyprinoids, Bütschli, 1881, Ztschr. f. wiss. Zool., XXXV, p. 630, footnote, pp. 630–8, 646–8, pl. 31, figs. 1–24.)

Myxobolus mülleri, Bronn's Thier-Reich, I, pp. 595–7, pl. 38, figs. 6–10; *ib.* Lankester, 1885, Encycl. Britan., 9 ed., XIX, p. 855, fig. XVII, 40, 41; *ib.*, Leunis, 1886, Synopsis d. Thierkde, II, pp. 1137–8, figs. 1118–9; *ib.*, Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 166, 167, 178; *ib.*, Gurley, 1893, Bull. U. S. Fish. Com. for 1891, XI, p. 414; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Synonymy.—Bütschli (1881) says the *Myxosporidia* investigated by him came principally from the Cyprinoids, but that he could not give the species of host exactly, as he investigated large numbers of excised branchiæ. In part, however, these latter were derived from *Squalius cephalus* and from *Barbus fluviatilis.* He further states that he was unable to recognize any specific distinctions between the spores of the series he examined. Bütschli's type figures of 1882 are copies of his figures of 1881. Parenthetically, also Lankester's and Leunis's are copies of these. Of those who have studied the pathogenic muscle-form of *Barbus barbus* (=*fluviatilis*), all admit its close similarity to, and some assert its identity with, *M. mülleri* (see p. 225). Further, Pfeiffer states that in the Rhine basin, in which the epidemic produced by the muscle-form is very extensive, the branchiæ are free from *Myxosporidia*, a nonassociation that would seem to favor the idea of specific distinctness. So far, then, no direct comparison has been made between the spores inhabiting the branchiæ of *B. barbus* and those inhabiting the muscles of the same fish. In the meantime it is probable that *Leuciscus* (*squalius*) *cephalus* L. should be regarded as, so to speak, the type host of *M. mülleri.*

Cyst.[1]—Exclusively confined to the branchial lamellæ, appearing by reflected light as white pustules, usually elongate-oval, 2 to 3 mm. long; with greater development distending the flat branchial lamellæ. On closer examination of the freshest possible branchiæ, the cysts are seen to be neither extra-, nor intra-, but sub-epithelial, the blood vessels of the mucosa running over their surfaces. Their seat is thus the submucous connective tissue layer which immediately surrounds the supporting central cartilaginous rod of the lamella, and which underlies each and separates both of the layers of mucous membrane, which latter form the opposite faces of the lamella and in which run, superficially, the afferent and efferent blood vessels and the capillaries of the mucosa. One can easily convince himself of this situation of the myxosporidium by external observation. One then remarks that the transverse-running capillaries superficially girdle the myxosporidium. A transverse section through the mass thus shows the supporting central cartilaginous rod girdled by the myxosporidium, and the latter in its turn surrounded by the vascular layer of the mucosa. If the myxosporidium attain a greater growth, it naturally distends the lamellæ more and more, and, since the transverse capillaries girdle the myxosporidium ring-wise and oppose an obstacle to its expansion, the latter structure bulges out, sac-like, in the intervals between them, its whole outline being thus multilobate. From some further observations on very large myxosporidia, Bütschli believes that finally, through the continued growth of the myxosporidium, the restraining capillaries become ruptured, which explains the blood extravasations observed by him in the superficial portions of large myxosporidia, the girdling capillaries in these cases being absent.

Membrane: By careful manipulation the myxosporidium can sometimes be removed intact from its seat in the branchiæ. In both of the two successful instances, Bütschli observed a distinct membrane which possessed special interest in differing from the type usual among the unicellular organisms and particularly from that found in the Gregarines. It is of a plasmatic nature, being composed of clear, very finely granular protoplasm, in which numerous small nuclei are imbedded. Neither acetic acid nor staining reactions show any evidence of cell outlines. The finely granular nuclei possess a distinct dark membrane, show a somewhat irregular outline, and stain intensely with alum carmine. It is difficult to determine with certainty whether this membrane is a production of the myxosporidium or of the tissues of the host. As opposing the former view (a view which, however, Bütschli considers as in no wise excluded) is the fact that the nuclei of the membrane are somewhat larger than those found in the endoplasm.

[1] The description is Bütschli's. He calls it the myxosporidium, but it appears from his description to be the cyst (which, however, is probably only a later stage of growth of the imbedded myxosporidium). Pfeiffer erroneously states that these observations were made upon *Perca fluviatilis* (Die Protozoen als Krankheitserreger, 2 ed., 1891, p. 130).

Myxosporidium.—Myxosporidium usually showing no clear differentiation of ectoplasm and endoplasm except in thin sections, where certain portions exhibit very plainly a tolerably thick, granule-free exterior zone, possessing a great interest on account of its very distinct fine radiate striation. Endoplasm thickly studded with very small but distinct nuclei which in thin sections are, even in the fresh state, rather plainly visible as faint roundish corpuscles, in which dilute acetic acid differentiates a dark somewhat granulated membrane, a small dark nucleolus, and, sometimes quite clearly, fine nuclear threads radiating from the nucleolus to the membrane. This structure, together with their intense affinity for stains, permits no doubt as to their nuclear nature.

Spore formation.[1]—This species never shows a paired spore-development, or a development within a pansporoblast (?; see below), the spores being directly imbedded in the endoplasm. These spores, however, show indications of a similarity in their development to the other *Myxosporidia* in their origin from a trisegmented ("trinucleate") plasma-globule, 2 of whose segments develop the capsules and the third the sporoplasm.

Development of spore.[2]—In the myxosporidium, inclosed in a delicate membrane, a number of mature spores are seen, many things pointing to their origin from the protoplasm. They always contain 3 pale, almost spherical, but somewhat angular bodies. The membrane frequently shows an excavation and an opening at one end. At this end the 2 protocysts are situated, the protosporoplasm being remote therefrom. Further observation shows the protosporoplasm to develop into the sporoplasm of the mature spore and the two protocysts to give origin to the capsules. The latter structures develop within the protocysts, the filament appearing first in the extruded condition, apparently forming a prolongation of the capsular wall.

Subsequently, in the light of his observations on the development of *Myxidium lieberkühnii*, Bütschli inclined to interpret thus: That the 3 spheres (viz, the 2 protocysts and the protosporoplasm) represent not plasma-spheres but nuclei, the latter being, on this supposition, imbedded in a plasma mass which he had failed to see, probably on account of strong swelling and great transparency.

The observations of Balbiani and of Thélohan, however, render it almost certain that Bütschli's observations were accurate and that his subsequent interpretation was erroneous (see also pp. 82, 223). Upon this view the present species would seem to develop pansporoblasts, each with a single spore.

Spore.—Lenticular-oval, anterior end sharpened, showing quite plainly a shallow funnel-shaped depression; posterior end rounded off; dimensions 10 to 12 μ by 9 to 11 μ. On vertical view, contour rather variable,

[1] Bütschli, 1882, Bronn's Thier-Reich, I, p. 597.

[2] The description is Bütschli's (Ztschr. f. wiss. Zool., 1881, XXXV, pp. 646–8).

often almost circular, anterior end only slightly attenuated, border of suture exhibiting folds or crimpings varying in number from 7 to 9.

Shell: Substance dark and somewhat glittering, possessing a marked resistance to chemical reagents; warmed with concentrated sulphuric acid the valves fall apart; stronger heating effects their complete destruction. Valves 2, superior and inferior, with a tolerably thick ridge or welt along the border (line of junction), visible very plainly as a ridge on transverse view.

Capsule: Wall tolerably thick, glittering, inclosing a cavity occupied by the coiled filament which appears paler than the wall; showing, with the normal extrusion of the filaments, a very noticeable diminution of volume, whence the conclusion that (as with the thread-cells proper) such extrusion is the result of the pressure of the stretched elastic capsular walls. The capsules are destroyed by gently warming with concentrated sulphuric acid. Filaments extruded under the influence of potassium hydrate solution, glycerin, and especially concentrated sulphuric acid; also by mechanical pressure. The extrusion produced by the last means is frequently abnormal and very irregular, the filament being ejected in a more or less spiral form, or only incompletely, or sometimes through a rupture in the capsular wall, either into the shell cavity, or through the shell, or, in the last case, more probably between the (by the pressure) partially loosened valves. Bütschli adds a few interesting remarks to the effect that the capsules, so constant in the *Myxosporidia*, doubtless have some important and yet to be discovered function.

Sporoplasm: Mostly very delicate, cloudy, granulated, nearly filling the posterior portion of the shell cavity, projecting forward in the median line and on the outer side of the capsules; this projection could not be traced all the way around the capsules. Containing a variable number of granules. Vacuole,[1] frequently quite plainly visible even in the fresh state as a circular or oval clear spot. It becomes more prominent, however, after the addition of dilute acetic acid or iodine solution and then shows a dark, somewhat granulated membrane and a number of rather pale granules strewn through the contents, resisting all stains,[2] according to Bütschli sometimes invisible, a result that he attributes to great condensation of the protoplasm. Some spores appeared to possess 2 vacuoles, but upon this point Bütschli was not certain.

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[1]This is Bütschli's description of his "nucleus."

[2]A circumstance explained (but erroneously) by Bütschli as being due to a failure of the stain to permeate the shell. He says the nonstaining can not be taken as a contraindication of the nuclear nature of the structure in question, as the protoplasm also resists the stain. From my own experience I should say that would depend on the kind of stain used, plasmatic stains generally being, nuclear stains generally not being, retained.

"Granules."—Bütschli summarizes his results thus:

There are very constantly found in the protoplasm 2, or sometimes more, strongly refractile glittering granules of a roundish form. They are usually, though by no means always, situated tolerably symmetrically, just at the posterior ends of the polar capsules. No decided regularity obtains either as regards the number or position of the granules, as they are sometimes placed farther forward between the capsules, and sometimes are strewn entirely irregularly through the plasma.

I have also observed, with longer preservation of the spore in water, an appearance which was not clearly intelligible, but which I will briefly describe. In spores so preserved one sees after some time nothing more of the 2 dark granules usually present, but on the other hand one sees on each polar capsule posteriorly a dark punctule which occupies nearly the same position as the above-mentioned granule. It gives the impression as though the dark granule had fused with the capsular membrane and had developed into the punctule. I must, however, regard the interpretation mentioned as a mere conjecture.

Effects.—Invades the connective tissue and ovules of *Phoxinus phoxinus* (Thélohan, 1892).

Habitat.—Branchiæ of various cyprinoids, particularly *Leuciscus* (*Squalius*) *cephalus* L.; *Barbus barbus* L. (barbel), both *fide* Bütschli. Fins of *L. cephalus*; kidney and ovary of *Phoxinus phoxinus* L., and on *Crenilabrus melops* at Roscoff (Thélohan).

47. Myxobolus? sp. incert.

Psorosperm (second species) of *Platystoma fasciatum* Müller, 1841, Müller's Archiv., p. 489.

Cyst and myxosporidium unknown.

Spore.—Oval, untailed; size equals that of *M. sp.* 61.

Habitat.—On branchial arches (especially at their angles where the mucous membrane is soft) of *Pseudoplatystoma fasciatum.*

48. Myxobolus bicostatus Gurley, 1893. Pl. 19, fig. 1.

(Myxosporidian spore of *Tinca vulgaris*, Lieberkühn in Bütschli, 1882, Bronn's Thier-Reich, I, pl. 38, fig. 19.)

Myxobolus bicostatus, Bull. U. S. Fish Com. for 1891, XI, p. 414; *ib.* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

No description.

Habitat.—Branchiæ of *Tinca tinca* L. (=*vulgaris*), tench.

This species is distinguished from *M. ellipsoides* by its larger capsular index (0·50 as against 0·33 in *M. ellipsoides*) and by the 2 oblique ribs on the shell.

49. Myxobolus ellipsoides, Thélohan, 1892. Pl. 13, figs. 3, 4[1]; pls. 18, 20; pl. 19, figs. 2–8; pl. 21, figs. 1, *3d*, 5, (? 2, *3a–c*, *e*; ?? 4; ? pl. 22, figs. 1–3).

Tench "psorosperms" of, spores of, etc.	Pike, [Error] "psorosperms" of.	ellipsoides.	Date.	Authority; reference.
×	....	....	1863	Balbiani, Compt. Rend. Acad. Sci. Paris, LVII, p. 160.
×	....	....	1864	Balbiani, Gaz. Méd., Paris, XIX, p. 146.
×	....	....	1874	Moreau, Compt. Rend. Assoc. franc. Avanc. Sci., 2e (Lyons) Sess., p. 814.
×	....	....	1883	Balbiani, Journ. de Microgr., VII, pp. 199, 201–2, 272–4, 276–9, figs. 40, 61–3, 65*a* (see p. 211).
×	....	....	1884	Balbiani, Léçons sur les Sporozoaires, pp. 127–8, 130, 137–40, 142–6, 148, figs. 36, 42–44, 46*a*; pl. 3, fig. 9; pl. 4, figs. 1–3 (*pars;* see p. 211).
×	....	....	1886	Railliet, Élém. Zool. Méd. et Agric. Paris, pp. 167–8, fig. 72.
×	....	....	1887	Pfeiffer, Ztschr. f. Hygiene, III, p. 475, fig. 2 *e, f, g*.
×	×	....	1888	Pfeiffer, Ztschr. f. Hygiene, IV, pp. 409, 417–20, fig. 15 *a–c*.
×	....	....	1889	Henneguy, Dict. Encyclop. d. Sci. Méd., p. 775, figs. 2 *a–h*.
×	....	....	1889	Thélohan, Compt. Rend. Acad. Sci. Paris, CIX, pp. 920–1.
×	....	....	1890	Thélohan, Annal. de Microgr., II, pp. 198, 200–4, 207, 209, 210, pl. 1, figs. 2, 3, 12–16.
×	....	....	1890	Thélohan, Compt. Rend. Acad. Sci. Paris, CXI, p. 695.
×	....	....	1890	Pfeiffer, Arch. f. pathol. Anat. u. Physiol., CXXII, pp. 558–9, 563.
×	....	....	1890	Pfeiffer, Die Protozoen als Krankheitserreger, 1 ed., pp. 44, 47, 48, figs. 14, 16 (part; all ?).
×	....	....	1891	Pfeiffer, Die Protozoen als Krankheitserreger, 2 ed., pp. 130, 133–4, figs. 54, 56 (part; all ?).
	....	Myxobolus.	1892	Thélohan, Bull. Soc. philomat. Paris, IV, p. 177.
	....	...do	1893	Gurley, Bull. U. S. Fish Com. for 1891, XI, p. 414.
	....	...do	1893	Braun, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 739.
	....	...do	1894	Braun, Centralbl. f. Bakt. u. Parasitenkde, XVI, p. 87.

Synonymy.—The number of known forms habitant on *Tinca tinca* is large and their relations *inter se* are dubious. By the separation of *M. piriformis*, Thélohan has made a decided advance in the direction of clearness. By its lanceolate shape, single capsule, and large capsular index it is distinguished clearly from *M. ellipsoides* and from *M. brachycystis.* It is probable that some of Pfeiffer's degenerated forms should receive a somewhat similar interpretation. His figures are, however, such that in the absence of more definite statements they can hardly be placed. One of them (pl. 21, fig. *3d*) would seem to belong to this species. The others are entirely indeterminate.

Cyst.—Thélohan (1890, p. 203) saw cysts enlarge, become submucous, distending the mucous membrane, which subsequently ruptured, permitting the cyst to shell out and fall into the water, where it burst exactly as with the subcutaneous cysts of *Gasterosteus aculeatus.* Cysts are found in the comparatively exposed parts, e. g., the subcutaneous and intermuscular connective tissue and in the subepithelial tissue of the branchiæ, being absent in the internal organs (air-bladder, etc.).

Myxosporidium.[2]—(*a*) In the air bladder: Two forms occur in the air-bladder of the tench; the first very similar to that found in the

[1] See p. 211, footnote 1, and the explanations of the plates.

[2] Thélohan, Annal. de Microgr., 1890, II, pp. 201–2.

urinary bladder of *Lucius lucius*, consisting of small free masses lining the internal surface of the organ, the second consisting of drawn-out, chain-like masses in the midst of the tissues of the organ. The second he believes to be merely a more advanced stage of the first. When the parasite is only slightly developed its presence is recognizable only by small opaque streaks in the otherwise transparent bladder, on opening which the myxosporidium is found upon its internal surface. In other cases small white prominences are found, presenting a transition between the large mammillated masses described by Balbiani, and which can attain 10 mm. in thickness. Sections show the myxosporidium intimately united to the epithelium. The latter soon becomes broken up and the plasmic chains insinuate themselves between the fibers of the connective tissue.

By serial sections one can follow progressively the march of the parasite into the tissues. These last allow of separation and stretching of the fasciæ, such change being progressive and slow. Soon, however, under the continuous pressure produced by the growth of the invading mass, the fibers arrive at the limit of extensibility and finally rupture. Thus are formed irregular spaces, in the middle of which one finds the débris of the tissue of the organ, surrounded by the myxosporidia. During this time spores are formed. They finally almost entirely replace the protoplasm. In other parts of the same mass earlier and intermediate stages can be seen. In the air bladder, as in the kidney, the distinction between the ectoplasm and endoplasm is little evident and, beyond the fact of the absence of nuclei from the ectoplasm, it is difficult to find characters to separate these layers.

(*b*) Of the external surface, Balbiani[1] gives, as the results of his investigations, the following account of the development:

Of all freshwater fishes the tench is most frequently affected with *Myxosporidia* and at all seasons. This, together with the transparency of the fins of the young, renders it especially favorable for investigation. Balbiani frequently observed upon the fins, mingled with developed psorosperms, small amœboid bodies of very variable size. These move like the most agile amœbæ (e. g., *A. diffluens*), 9 changes of form occurring in less than 15 minutes; temperature had great influence, heat accelerating, cold retarding. The pseudopodia were large and obtuse, the mass appearing lobed, as in *A. diffluens*. Unless obscured by fat globules (numerous in the later stages), the nucleus is plainly visible, particularly at the time of the exit of the mass from the spore. It is the nucleus of which Bütschli has proven the existence in the interior of the psorosperm (cf. p. 208). There is no contractile vacuole, and from this point of view these bodies differ from the ordinary amœbæ.

While thus wandering over the fins, the small amœboid bodies absorb nutriment, grow, show more or fewer fatty globules, tend to take a rounded oval, or sometimes irregular form with expansions and lobes, and to surround themselves with a thin envelope easily visible in water. As the water penetrates the fin tissue, the amœboid movements become more and more slow and finally cease. Independently of its thin proper membrane, the small mass is encysted in the same manner as other foreign bodies, by the connective tissue of the host.

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[1] Journ. de Microgr., 1883, VII, pp. 272–4.

Spore formation.—With the growth the number of nuclei increases by successive divisions[1] (many of which were seen to occur). Subsequently each nucleus condenses around it some of the myxoplasm, thus forming the pansporoblasts. These grow, become elliptic, and the rudiments of the capsules appear in them, at first as very pale, then as brilliant bodies. The mode of their development was not entirely satisfactorily ascertained. They usually develop 2 in each pansporoblast, some of these sporoblasts containing 3 granular globules, 2 small and 1 large, which probably develop respectively into the capsules and the sporoplasm. Also incompletely developed spores were seen inclosing elements believed to be capsules in process of development. These were: (1) Two spherical vesicles containing each a small central globule placed in the substance of the spore remote from the poles. (2) Two small similar vesicles placed one beside the other at one pole. (3) Two pyriform vesicles with a small central globule, sometimes remote from each other, sometimes approximated to each other and situated at one extremity of the spore. These vesicles were no doubt the small organs with spiral filaments. Their origin could not be clearly determined.

Spore.—Flattened-ellipsoid, rather elongate, the two ends similar; length 12 to 15 μ; breadth 9 to 11 μ; length of capsules 4 μ; nuclei of capsulogenous membrane persisting to maturity of spore; vacuole present; nuclei originating by continued division from a primitive one, not more than 4; when of this number, 2 are situated before and 2 behind the vacuole (Thélohan, pp. 209–210).

Degenerate forms [of this species ?] from the gall bladder may have 3 capsules or none, and the bivalve character of the shell may be absent (Pfeiffer).

Ribbons: Balbiani[2] has made some curious but dubious observations, arriving at conclusions which by no means accord with the general consensus of opinion. He describes an elastic, ribbon-like process (the *ribbon*) as existing along the border of each valve of the shell, stating that at the time of maturity of the spore (the only period at which such ribbons are visible, as at other periods they are closely appressed to the valves) they become unrolled and recurved, such action resulting in the splitting apart of the valves and the consequent release of the amœboid sporoplasm. The ribbons divide at their distal extremity into 2 or 3 *ribbonettes*. These elastic structures he regards as comparable to the cruciform elastic filaments (*elaters*) of the *Equisetum* spore, remarking that in the *Myxosporidia* they serve a different function, their action here being valve-separation and not spore-dispersal. He further says that these elastic ribbons have another function, viz, to maintain contact of 2 spores during what he regards as a state of

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[1] From Balbiani's language it is plain that he did not recognize the vacuolic nature of Bütschli's "nucleus." Still he must have seen nuclei (and not vacuoles) in the later myxosporidium stages, as he states that he repeatedly observed them to divide. Probably Thélohan's observation of karyokinetic division (Compt. Rend. Acad. Sci. Paris, 1890, CXI, p. 693) was upon *M. ellipsoides*, though it is not distinctly so stated. Among other figures he saw a spindle with an absolutely typical equatorial plate.

[2] Journ. de Microgr., 1883, VII, pp. 276–7: Léçons sur les Sporozoaires, 1884, pp. 142–4.

conjugation. And still further, in some individuals the filaments instead of lying along the borders of the valves, extend themselves in the direction of the axis of the body, and, reuniting themselves for a variable distance, constitute the simple or double caudal prolongation that Müller and other observers describe as a specific character of certain psorosperms. (See also p. 207.)

Concerning these, Bütschli[1] states that he could find no evidence whatever of the existence of such ribbons, either in the whole spore or in the separated valves. He seems to think that such ribbons are an illusion due to an abnormal extrusion of the capsular filaments.

Thélohan's observations seem to throw some light upon this discrepancy. This observer[2] says that he has never seen them except in the present species. They are frequently absent, yet the spores split open perfectly. Having found all possible transitions between the ribboned spores and spores evidently monstrous and abnormal, he regards the ribbons as structures, accidental rather than fundamental and necessary to the development of the spore.

Habitat.—Thélohan gives this as the branchiæ, air bladder, liver, intestine, and spleen (last *fide* letter to author, 1893) of *Tinca tinca* L. (tench). Balbiani says the *Myxosporidia* are always confined to the short anterior portion of the air bladder.

Speaking collectively of a poorly delineated and very probably multi. specific group of forms, Pfeiffer says that perfectly developed forms occur on the branchiæ and in the air bladder, this stage of development being possibly connected with an abundance of oxygen. In the gall bladder incompletely developed forms occur, with 3, 1, or no capsules; also entirely undeveloped forms, destitute of a bivalve shell, comparable to the *Microsporidia* or to the pseudo-navicellæ found in *Lumbricus*. Transition forms to the *Coccidia* also occur. Possibly (from Pfeiffer's figure) *M. ellipsoides* may also occur in the air bladder or gall bladder.

Effects.—The *Myxosporidia* do not confine themselves to existing cavities. Thus, in the kidney of *Tinca tinca*, Thélohan (1890, p. 200) has seen the tissue of the organ invaded while the tubes remained free (see also the above description of changes produced in the structure of the air bladder by the myxosporidium found in that organ).

50. Myxobolus ? sp. incert. Pl. 22, fig. 4.

Psorosperms of *Cyprinus leuciscus*, Müller, 1841, Müller's Archiv., p. 486; *ib.*, Dujardin, 1845, Hist. Nat. des Helminthes, p. 644; *ib.*, Leuckart, 1852, Archiv. f. physiol. Heilkde, XI, p. 436, fig. 21*c*, *d*; *ib.*, Robin, 1853, Hist. Nat. des Végét. Parasites, p. 299.

Synonymy.—This is little more than a collection of references to spores found on "*Cyprinus leuciscus*." Robin's mention is, however, certainly the same as Müller's.

Cyst and myxosporidium unknown.

[1] Ztschr. f. wiss. Zool., 1881, XXXV, p. 633; Bronn's Thier-Reich, 1882, I, p. 598.

[2] Compt Rend. Acad. Sci. Paris, 1889, CIX, pp. 920-1.

Spore.—Resembling *Chloromyxum dujardini;* 11 μ (0·0051‴) long and 7 μ (0·0034‴) broad.

Habitat.—On *Leuciscus* (*Squalius*) *grislagine* L. (= *Cyprinus leuciscus*). Tumors less common than on *Leuciscus rutilus.*

It seems strange that Müller should approximate this form to the "sharp corpuscles of *C. rutilus*,"[1] as Leuckart's figure resembles much more closely the elliptic form figured by Müller (Müller's figs. *f*, *g*; pl. 28, figs. 5*f*, *g*).

51. Myxobolus sp. incert. Pl. 22, figs. 5, 6; pls. 23–25.

Barbel "psorosperms," etc., of—	mülleri.*	Date.	Authority; reference.
×	....	1885	Mégnin, Bull. Soc. Zool. France, X, pp. 351–2 (fig.); Compt. Rend. hebdom. Soc. Biol. Paris, II, pp. 446–7.
×	....	1886	Railliet, Bull. et Mém. Soc. Centrale Méd. Veter. Paris, IV, pp. 134–7.
....	Myxobolus† (*pars*).	1889	Ludwig, Jahresber. rhein. Fisch.-Ver. Bonn, 1888, pp. 27–36.
×	....	1890	Railliet, Bull. Soc. Central. d'Aquicult. Paris, II, pp. 117–20.
×	....	1890	Pfeiffer, Virchow's Archiv. f. pathol. Anat. u. Physiol., CXXII, pp. 552, 557–8, pl. 12, figs. A2, C1–8.
×	....	1890	Die Protozoen als Krankheitserreger, 1 ed., pp. 28–9, 55, 67, fig. 10, plate, figs. IV, V.
×	....	1891	Pfeiffer, Die Protozoen als Krankheitserreger, 2 ed., pp. 100, 105–10, 130, figs. 43*b*, 45, 57.
×	....	1892	Thélohan, Bull. Soc. philomat. Paris, IV, pp. 168, 178.
×	....	1892	Henneguy and Thélohan, Annal. de Micrógr., IV, p. 619.
×	....	1893	Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, V, pp. 267–70.
×	....	1893	Pfeiffer, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 118–130, plate, figs. 13–15, 16 (*pars*).
×	....	1893	Sticker, Archiv f. Animal. Nahrungsmittelkde Wien, VIII, p. 124.
Myxobolus.	....	1893	Railliet, Traité de Zool. Méd. et Agric., pp. 158–159.

* *Non* Bütschli.

† Ludwig's figures seem as though they might be generalized composites based upon several of Bütschli's. They may thus perhaps be *not* independent figures of the spore habitant in the skin of *B. barbus*, but have been considered to represent that form in view of its supposed identity with *M. mülleri*.

Synonymy.—Both Mégnin and Ludwig, the former with doubt, the latter apparently without hesitation, regard this form as identical with *M. mülleri.* While admitting their superior advantages (of direct observation of material) I still feel considerable doubt as to the identity of these 2 forms, and have therefore provisionally classed them separately, as, while I do not consider that there is sufficient ground for a positive assertion of the distinctness of the two forms, there is certainly sufficient to justify a hesitation as to their fusion.

Mégnin says the present species is probably the same as that described by Robin and Balbiani as infesting the tench and carp. Now as to this: (1) I am not aware that Robin ever observed such a form, and (2) the spore habitant on the tench (*M. ellipsoides*) is, as shown by Thélohan,[2] unquestionably distinct from that habitant on the carp (*M. oviformis*).

[1] "Bei *C. leuciscus* glichen sie ganz den spitzen Körperchen des *C. rutilus.*"

[2] Annal. de Micrógr., 1890, II, p. 210.

Further, Mégnin's figures would not by themselves induce me to fuse the two forms.

Besides, after considerable study of Ludwig's description, I am unable to decide how much of it represents his own observations and how much is copy of Bütschli's description of *M. mülleri*. It seems to be part original and part copy, but how much of each it is impossible to determine. It would seem as though Ludwig first determined in his own mind the specific identity of the present form (*M. sp.* 51) with *M. mülleri* and then applied to the former (*M. sp.* 51) Bütschli's description of *M. mülleri*, at the same time incorporating therewith certain observations, *e. g.*, the dimensions of the spore which must be his own (made upon *M. sp.* 51) inasmuch as they are not, to my knowledge, to be found in any previous description of *M. mülleri*. My reason for this view of the subject is Ludwig's statement that—

I can only confirm Bütschli's results upon the finer structure of *Myxobolus*.

Further, his figures bear some indication of being semidiagrammatic generalized composites of several of Bütschli's figures of *M. mülleri*. And still further his description (except the few additions) is Bütschli's. This course has rendered it impossible for me to distinguish how much of the composite description represents Ludwig's actual observations on *M. sp.* 51 and how much of it merely pertains to *M. mülleri* generally, and is regarded as applying to *M. sp.* 51, by virtue of its supposed identity with *M. mülleri*. Under these circumstances I have credited to *M. sp.* 51 only the minimum (viz, the residual after subtracting from the composite, Bütschli's description of *M. mülleri*); as, though this residual may be incomplete for *M. sp.* 51, it is all that can be positively asserted to belong to that species.

Pfeiffer's figures (pl. 25, figs. 5, 6) approximate the present form much more closely to *M. ellipsoides* than to *M. mülleri*.

Finally, Thélohan says that the present species—

Presents a great resemblance to *M. mülleri;* perhaps it should, however, be considered as specifically distinct.

Cyst.—Membrane thin, probably formed by host. Contents clear living protoplasm, in which are imbedded very fine dark granules, very small nuclei corresponding to those of true cells, and spores (Ludwig).

Composed of an irregularly concentric-fibered layer inclosing a second double-contoured layer, which latter surrounds the cyst cavity filled with spores. The large white, stout-walled, walnut-sized, or smaller muscle cysts are situated near the skin or pleura; 30, 40, or more myxosporidia occur near together, surrounded by a loose web formed by the host. Each myxosporidium is to be regarded as an individual, and the multicamerate tubes result from the common encapsuling by the host of many such individuals of nearly equal age, which individuals subsequently, he thinks (from sarcosporidian analogy, etc.) fuse, the process recalling the so-called conjugation of the large free-living intestinal Gregarines (Pfeiffer).

Myxosporidium.[1]—Pfeiffer has seen the exit of the sporoplasm. He did not have the opportunity to cultivate the spores *via* the overhanging drop, but says such cultivation would be easy and would show the stage at which infection occurs. He did not actually see the myxosporidium penetrate the muscle cell, but he has found within that cell all growth-stages of the myxosporidium. The elongate myxosporidia often show, in their center, pansporoblasts containing well-developed spores, while at the ends these structures are smaller and contain only 1, 2, 4, or more nuclei. This proves that, as in the *Sarcosporidia* (also with the tubes of *Sygnathus* and, *fide* Thélohan, with those of *Cottus scorpio*), growth takes place at the ends of the tubes. Have these younger developmental stages originated from germs from the interior of the large tube, do they proceed from residual germs of the first multiple infection, or do they develop from newly immigrated germs? A positive answer can not yet be given, but in the barbel Pfeiffer regards the second mode (viz, a supplementary outgrowth from the germs which penetrated *en masse* in the first infection) as the more probable. In the myxosporidium tubes germs migrate from the center to the circumference, where they find better food conditions and through progressive division become new pansporoblasts (*Sporenkugeln*). The center of the cyst is also empty in the cysts of the sheep, those of the tench's air bladder, and that of the kangaroo's intestine. When the myxosporidia have attained a certain size, they are found free in the interstices of the muscular fiber. When crowded, they fuse to an irregular mass; only at the edges are some unfused myxosporidia to be seen. Hæmatoidin crystals are found in the myxosporidium.

Spore formation.—This appears in the smallest circular cysts with 16 to 20 germs; also in uniloculate elongate cysts thickly filled with 100 to 200 germs. In places large granule cells are imbedded in the muscular fiber. At another (?later) stage the dancing granules have vanished and the contents of the cells have separated with 10 to 20 or more pale globules one-third the size of the ripe germs. Also some fibrillæ show in their interior well-developed spores, with capsules and nuclei, single or in rank and file (? accident; ? pressure on cover-glass). The possibility of these must be admitted, yet the contents of the capsules appeared to have been voided.

Spore.—Lenticular or oval; length 12 μ, breadth 10 μ, thickness 6 μ (Ludwig); bivalve, shell cavity containing sporoplasm and 2 capsules, the latter extruding filaments under the influence of potassium hydrate (Mégnin); by glycerin (Pfeiffer).

Have the *Myxosporidia* resting spores? Mega-, and micro-spores (differing only in size) occur; also defective spores with 1 capsule, with caudiform appendages, or with a subrotund form (Pfeiffer).

Habitat.—Encysted and free in muscles, mostly of belly and sides of body (never elsewhere, the liver, spleen, ovary, eggs, and gills being

[1] Description, Pfeiffer's (*loc. cit.*, 2 ed., 1891, p. 106).

free) of *Barbus barbus* L. (barbel) from the Rhine, Mosel, and Saar, the barbels of the Elbe and Weser territory being free from them (Pfeiffer). Also once in heart cavity (Ludwig). In barbels from the Marne, probably also from the Aisne and Seine (Railliet). Balbiani failed to find "adult psorosperms" in the viscera in Mégnin's material (Mégnin).

Liver, kidney, spleen, connective tissue of various organs; found in ovary by Balbiani.[1] In one case the myxosporidia and spores were lodged in a sort of cavity in the connective tissue of the intestinal wall 10 cm. from the anus. They produced a very conspicuous thickening, almost completely obliterating the lumen.

Pathology.—Tumors:[2] A badly infected barbel showed about 40 tumors; fully 10 per cent of all the muscular fibers were filled with spores. This condition must have resulted from auto-infection. The tumors may soften to an irregular stinking abscess containing spores, wandering cells, and the large bacilli (Pfeiffer; see below under *Ulcers*).

Tumors, usually 10 to 15, ranging in size from a nut to a hen's egg, with a very resistant wall 1 to 1·5 mm. thick; hemispherical or slightly elongate; sometimes uniting into patches 17 to 20 mm. long by 7 or 8 mm. broad in fishes of 2·5 kilos (about 5 pounds) weight. Scales over tumor raised, easily detachable, finally falling off. Not all tumors open, some fishes dying before the ulcer stage.

Some fishes die without external tumors, these being found located in the viscera (Meuse; Railliet). Uusually of walnut size; sometimes, however, 50 mm. long and 20 mm. thick, single or multiple, usually on belly or sides; filled with a yellow or caseous purulent mass (Mosel, Saar; *fide* Ludwig).

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[1] *Fide* Thélohan (Annal. de Microgr., 1890, II, p. 200; Compt. Rend. hebdom. Soc. Biol. Paris, 1893, V, p. 268) who refers to Balbiani's *Leçons sur ler Sporozoaires.* The only page of the last work to which the reference could apply is p. 147, and as M. Thélohan says (letter to author, 1893), Balbiani is there not at all explicit.

[2] The following notes of four cases are from Ludwig. The fish were taken alive from the Mosel above Trier, died en route, and were examined the next day:

1. ♂ 30 cm. long; on left side just above ventral fin a tumor 50 mm. long, 40 mm. broad, and 30 mm. thick, extending above lateral line; skin and omentum in neighborhood of tumor normal.

2. ♀ 47 cm. long; two tumors: (*a*) on right side above ventral fin, under trunk muscles (which latter were, around the tumor, reddened), 45 mm. long, 35 mm. broad, and 15 mm. thick; covered by normal skin. Tumor so extended into body cavity as to have driven the omentum hernia-like before it. (*b*) On left side in front of pelvic bone, length 50 mm., breadth 15 mm.; already opened; orifice 10 mm. in diameter with an irregular strongly reddened border, surrounded by reddened skin. Cavity of ulcer filled with bloody mucus, which, apart from the admixture of blood, agreed with the tumor contents.

3. ♀ 44 cm. long; on left side at level of lateral line, between ventral and anal fins, a tumor 25 mm. long, 12 mm. broad, and 12 mm. thick; heart cavity filled with same substance as tumor contents.

4. ♂ 30 cm. long; in front of left ventral fin a tumor 35 mm. long, 25 mm. broad, and 25 mm. thick, projecting but little externally, but greatly into abdominal cavity.

Opening of the tumors: The active agents in the puriform transformation and opening of the tumor are the bacilli first observed by Pfeiffer in the ulcer contents. These are only found in the myxosporidian-infected muscles, never in other organs. The presence of these microbes either prevents connective tissue proliferation entirely, or prevents it from becoming complete, the tissue undergoing gangrene (a digestion-liquefaction, so to speak), which soon results in the destruction of the overlying tissues.

Subsequently the bacilli were studied by Thélohan (see synonymy, 1893) who observed two kinds of them:

1. Bacilli: Large, motile, as long as the spores, showing with hæmatoxylin 4 or 5 red granules, and a short flagellum; frequently several cohere by their surfaces; also long separated threads occur (Pfeiffer, 1891, p. 105).

Length 6 μ; sometimes isolated, sometimes in linear colonies, no motion seen; rapidly liquefying gelatin upon which it gives large, slightly yellowish-white colonies; in rabbits provoking a small, very limited abscess; staining easily with methylen blue, gentian violet, fuchsin, etc. (Thélohan, 1893).

2. Cocci: More rarely, sometimes with last, sometimes alone, another species consisting of Cocci isolated or united under the form of Streptococci or Diplococci occurs.

Ulcers: The tumors subsequently soften and burst, forming deep crateriform bloody-bordered ulcers filled with a yellowish purulent mass consisting of spores and of cell detritus. Among the latter large bacilli crawl.

Cell infection: The primary seat of infection is the interior of the muscle cell. Myxosporidia are found within well-preserved (distinctly transverse-striate) or markedly atrophied muscular fibrillæ; also between healthy fibrillæ. Atrophied muscle-cells are seen containing long rows of well-developed spores, which, on account of the absence of filaments within the capsules, Pfeiffer inclines to believe have reached their present position by a general immigration. In places the fibrillæ are beaded. such muscle bead-strings being ordinarily heaped near together in the neighborhood of the hard cysts. Around the cysts the muscular tissue is infiltrated with blood, the infiltration, where superficial, being visible through the skin. Near the ulcers the muscular substance is broken up, loosened, fatty-degenerated, and contains blood-colored tubes with numerous myxosporidia not yet encapsuled and also well-developed spores.

Thélohan[1] says:

In the ovary they are very frequently encountered. M. Balbiani has studied them in the ovary of the barbel and he has seen that the psorospermic matter does not confine itself to traveling *via* the connective tissue, but often invades the young ovules.

Pathological anatomy.[2]—The presence of the parasite in the primitive muscle fiber seems to lead rapidly to degeneration. On examining

[1] Annal. de Microgr., 1890, II, p. 200.

[2] Description Thélohan's (Compt. Rend. hebdom. Soc. Biol. Paris, 1893, V, pp. 267–270).

fragments in the fresh state, fibers are seen, which, in places, have preserved their normal aspect and their striation, and at other points more or less considerable spaces, where the muscular substance is filled with a vitreous refringent mass, around and in the intervals of which lie fatty droplets, yellowish granules, and spores. The degeneration invades gradually the muscular substance of the primitive fibers, and one finds it in parts of these elements, where the parasite appears not to have penetrated. On the contrary, the neighboring, noninfested, primitive fibers seem exempt from that alteration, and one frequently observes a degenerated fiber surrounded by healthy ones.

The fiber thus degenerated and broken up, is soon invaded by phagocytal cells coming, some from the sarcolemma, others from the connective tissue. This latter, at the diseased points, is the seat of a very marked irritative proliferation.

It is necessary to distinguish, in the degenerated fiber, the parts where spores are found in great number, and those where these elements are few or absent, the degenerative process in the latter case having originated from the presence of the parasite at a different point.

In this latter case the cells which have penetrated into the degenerated tissue multiply rapidly; in proportion as their number augments, one sees the muscular débris diminish; very soon they have completely disappeared, the place of the fiber being finally occupied by connective tissue. While these phenomena occur, the irritation is propagated, the connective-tissue proliferation extends itself, and a sclerosis of the neighboring muscle region, with atrophy of the primitive fibers, is produced.

At the points where the degenerated fiber incloses a great number of spores, the formation of connective tissue is at first limited to a thickening of the perimysium. There are thus formed connective-tissue bridges, separating the spaces occupied by the spores, and which correspond to disappeared primitive fibers. These facts are seen especially clearly on transverse sections. Little by little these bridges increase in thickness, at the same time their tissue becomes more dense; they thus form around each space a fibrous shell, which tends to contract more and more. There seems to be here a true encystment of the parasite, such as is produced around foreign bodies introduced into the tissues.

Symptoms.—Barbels attacked are less lively than usual and have much difficulty in ascending streams; surface of body, dull, grayish yellow, oily, slippery (Meuse; Railliet).

Less lively than usual, easily caught in the hand, breasting the current with difficulty, avoiding rapid water (their usual haunt), taken in great numbers in bow-nets. Some affirm, others deny, that the sick fish will not bite at the hook. Diseased fish are of all sizes. Those seriously affected are of a weight much below that indicated by their external appearance, the body being in fact more or less dilated. On this account the fishermen often estimate the weight at nearly double the actual (Railliet.)

According to Vet. Surg. Hanzo, the affected fishes float on the surface as though poisoned with *Cocculus indicus*.

Epidemics.—In the Meuse it has manifested itself with the characters of a veritable epidemic during three consecutive years, from 1883 to 1885, inclusive. It became progressively more aggravated, reaching its maximum of intensity towards the middle of 1885. On certain days of that year M. Ladague had interred nearly 100 kilograms of barbels; the Meuse was covered with dead fish. The disease subsided little by little, and actually appeared to become extinct, but it could almost be said that the combat closed for want of combatants.

In the district of Ardennes it was remarked only in the Meuse itself; all the affluents have always been spared. The maximum intensity, according to Railliet, was reached about the middle of 1884. On certain days, at Mézières alone, as many as 100 kilos (about 200 pounds) were interred. Some years later the disease had disappeared from that region, but raged down stream at Monthermé and Givet.

In the neighborhood of Nancy the barbels die in great numbers (Mégnin).

In the Aisne Railliet was informed of ravages of the disease occurring near Rethel. The disease, he thinks, extended to the Aisne and the Marne from the Moselle *via* the canals.

In the Marne a considerable number of barbels floated dead or unable to escape, down the lower Marne. The disease appears to have begun (at least in the neighborhood of Charenton) about June 15; thence it progressively increased, attaining its maximum at the time of emptying of the St. Maurice Canal. It persisted till the end of July, at which date Railliet's information ceased.

In the Seine it did not extend above the Port a l'Angláis dam. The Grenelle fishermen, Railliet was informed, had seen a great number of sick barbels. The Seine thus appears invaded, without doubt consecutively, from the Marne.

In the Rhine and its tributaries, the Saar and Mosel, according to Ludwig, it seems to have appeared at least several decades ago without, however, ever having attained the magnitude that it has reached in làte years in the Mosel. The disease has there been observed since the end of 1870 and has so increased that, especially in the warm summer months, the dying and dead fish from the upper Mosel and Saar pass Trier by the hundreds, and at Zell (on the Mosel) it is reported that they spread a carrion-like odor. According to Pfeiffer, in the Saar and Mosel during the summer of 1890 no very extensive mortality occurred.

Contributory causes.—As regards age as a predisposing factor, Railliet observes that in the Meuse the young barbels are attacked as well as the old, the weights of dead fish varying from 22 grams to 6 or 7 kilograms.

In the 3 German streams Treplin[1] believes 3 series of cases to be distinguishable: (1) Mostly small fish (up to 100 grams), still well nourished, with only individual, or without recognizable, indurated patches, and which present in the abdominal region, at most, 1 hard tumor. (2) Somewhat larger fish (up to 200 grams), which almost always show in several places on their sides hard, somewhat swollen, patches; also tumors similar to those on the smaller fishes, mostly on the abdominal region. These fishes already begin to emaciate. (3) Fishes of and above the preceding weights, showing on the sides, belly, or back large ulcers, mostly lying immediately under the skin. A part of the same is already broken up; borders foul and red; interior containing a yellow pus. The fishes have emaciated greatly, and die.

Season, Railliet thinks, appears to have no influence, fish being seen dead in midwinter as well as in June, July, and August.

Pollution of streams Railliet considers a minor factor, saying:

> The diversion into the Meuse of manufactory refuse is often blamed for the existence of this condition of affairs, but the investigations of M. Ladague tend to incriminate rather the erection of dams at certain points on the river, these structures diminishing the rapidity of current, in the midst of which the barbel ordinarily lives.

Treplin[1] believed that the young barbels receive the germ from refuse deposits of industrial establishments (breweries, malt houses, tanneries, distilleries, etc.) on the headwater of the Saar and Mosel; and, further, that these germs enter by the alimentary canal, passing thence into the rest of the body, and first make their exit therefrom (*via* the ulcers) in the second or third year. Herr Hanzo,[2] on the contrary, considers the cloth and paper mills as chiefly responsible, as these establishments handle old rags which are, he says, saturated with infective material.

Of the views of Treplin and Hanzo, Ludwig considers that of Treplin to have the greater degree of probability. Both, however, he remarks, consist only of opinions and probabilities, and further leave out of sight other sources of contamination. While no sufficient evidence exists for holding pollution of water by different industrial establishments responsible for barbel myxosporidiosis, an indirect connection between such water pollution and the disease is by no means to be entirely rejected. It is very easily possible that such pollution may favor myxosporidian increase and development, and especially that it may, by injuriously affecting the general life conditions, diminish the normal resistive power of the fish, thus rendering infection more easy. This view explains the fact (*fide* the fishermen) that the barbels at Bonn recover, while they die in the Saar and Mosel, in which latter streams pollution must, on account of the smaller volume of water, affect the fish more injuriously.

M. Braun[3] places less stress upon fouling of the water, as once

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[1] In Ludwig, Jahresber. rhein. Fisch.-Vereins, Bonn, 1888, p. 34.

[2] In Ludwig, *loc. cit.*, pp. 34, 35.

[3] Review of Ludwig in Centralbl. f. Bakt. u. Parasitenkde, 1889, v, p. 420.

healthy whitefish sickened from introduction into water in which a whitefish affected with myxosporidiosis had died, and as the same disease is not rare upon *Coregonus* from lakes Peipus and Ladoga.

Exciting causes.—This may be safely assumed to be the presence and development of the myxosporidia. Pfeiffer,[1] from numerous examinations, states that these latter are always present in barbels from the Rhine, Mosel, and Saar, becoming pathogenic only at irregular intervals, probably when other causes so diminish fish vitality that the reactive encapsuling of the parasite is no longer possible. The latter then obtains the supremacy, and through the accompanying bacteria rapid death of the fish may result.

Mégnin's opinion is as follows:

> *Mode of infection.*—One now understands how the fish become infected; the psorosperms which escape from the ulcers are ingested with the water during deglutition or respiration; under the form of an amœboid they enter the circulatory current, then arrive in the subcutaneous cellular tissue, which is their seat of election, where they undergo their last transformations.

Upon this subject Ludwig remarks that—

> The greater frequency of occurrence upon the branchiæ suggests that infection occurs less through the alimentary canal than through the respiratory tract. The lymph paths of the connective tissue appear to represent the principal channels by which the parasite spreads through the body, but nothing certain is known.[2]

The infection of previously healthy fishes is brought about, Pfeiffer remarks, through the extensive fouling of the water by the numerous fish corpses, and the durable construction of the spores. Infection may then take place *via* the stomach, gills, or wounds. The last are of frequent occurrence in the spring at the time of breaking up of the ice.

Remedies proposed.—"How, now, to arrest the epidemic? It is difficult. I see no other method than to collect all the dead or sick fishes and destroy them by fire" (Mégnin).

Ludwig thinks that our ignorance of the complete life-history of the parasite, and especially of the way in which it secures a lodgment in the fish, precludes rational radical measures and permits us only to adopt certain prophylactic makeshifts. With reference to myxosporidiosis, as also for a number of other reasons, the waters, especially the Saar and Mosel, should be maintained in the highest state of purity, and to that end all pollution of the rivers mentioned, by communities or industrial establishments, should be interdicted. That most dangerous contamination of the water, by the *Myxosporidia* from the ulcers, cannot, of course, be stopped entirely, but it is evident that it will be less if all fishermen are impressed with the importance of destroying[3] all diseased and dead fish, instead of throwing them back into the water. Such destruction must be so effected as to prevent the reëntry of the germs into the water.

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[1] Die Protozoen als Krankheitserreger, 1890, 1 ed., p. 67; 2 ed., 1891, p. 110.

[2] No actual observations are cited in support of this lymph-path theory.

[3] Pfeiffer (*loc. cit.*, 1 ed., 1890, p. 37) quotes Ludwig as recommending that they be *buried.*

Railliet (loc. cit., 1890) further says that every one up to the present appears to be in accord as to the means of combating the disease. It is, above all, expedient to collect the diseased fish and to bury them at a certain depth and at a great distance from the water course. This is what was done on the Meuse and one has just seen that this course succeeded sufficiently well. Thus at the end of some years the disease appears to have left no traces. Thus Railliet saw taken, even at Mézières, 3 barbels, the smallest of which weighed 1·5 kilos or 3 pounds.

Pfeiffer[1] says that prophylaxis must obviously be directed to the careful removal of all fishes dead of the disease. They should be burned or buried with caustic alkali. By this means, perhaps, the extermination of the barbel may yet be prevented.

The only attempts at cure are cited by Railliet, who says that M. Ladague succeeded by opening the tumors in greatly prolonging the life of the fish, and sometimes in curing it. If, on the contrary, the disease is allowed to take its course the tumors increase rapidly and the fish soon dies.

52. Myxobolus ? sp. incert. Pl. 26, fig. 1.

> Psorosperms of *Cyprinus erythrophthalmus*, Remak, 1852, Müller's Archiv., pp. 144, 149, pl. 5, fig. 9B.

Spore.—Tailed and untailed were seen.

Habitat.—From pigment follicles on wall of splenic artery of *Leuciscus* (*Scardinius*) *erythrophthalmus* L.

Remarks.—As the relation between this form and *Chloromyxum dujardini* is at present doubtful, the present form is provisionally left separate.

53. Myxobolus sp. incert. Pl. 26, fig. 2.

> Globules of *Cyprinus phoxinus* Rayer, 1843, Rayer's Archiv. de Méd. comp., I, pp. 58-9, pl. 9, fig. 13.

Cysts.—In the single specimen observed, 2 in number, yellowish white, the size of a pin's head; contents, a mass of ovoid spores. Ether rendered the cyst contents more transparent, ammonia more cloudy.

Myxosporidium and spore unknown.

Habitat.—Encysted on left side of head of *Phoxinus phoxinus* L., from the Seule River. Disease apparently rare.

54. Myxobolus oblongus Gurley, 1893. Pl. 26, figs. 3-6.

> (Psorosperms of *Catostomus tuberculatus* (Le Sueur), Müller, 1841, Müller's Archiv., pp. 487–90, pl. 16, figs. 7–9; *ib.*, Müller, 1843, Rayer's Archiv. de Méd. comp., I, p. 229, pl. 9, figs. 7–9; *ib.*, Robin, 1853, Hist. Nat. d. Végét. Parasites, p. 301, pl. 14, figs. 9, 10.)
>
> *Myxobolus oblongus*, Bull. U. S. Fish Com. for 1891, XI, p. 414; *ib.* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Myxosporidium unknown.

Cyst.—Round or elliptic, not over 1 mm. in diameter; membrane

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[1] Die Protozoen als Krankheitserreger, 2 ed., 1891, p. 110.

resistant; contents whitish, consisting of spores, with more or less granular detritus.

Spore.—Outline spatular, approaching roundish-oblong; untailed; length 14 to 17 μ, breadth 8·5 μ, thickness 5 to 6 μ.

Shell substance thin, almost perfectly transparent, insoluble in cold and moderately warm concentrated sulphuric acid, quickly destroyed when heated with the concentrated acid to near its boiling point; insoluble in concentrated solution of caustic potash, cold or hot. Valves separating in sulphuric acid (cold, concentrated), equally convex, the spore on transverse view appearing symmetrical on both (superior and inferior) sides of the wide ridge. Greatest convexity of valves well forward (at about the junction of the anterior with the second fourth of the length;) ridge index nearly $\frac{1}{3}$.

Capsules 2, pyriform, of equal size, containing a coiled filament visible (in iodine water) through the capsular walls; capsules drawn out anteriorly into the ducts, orifice visible. Methyl-green stains the capsular walls bright green; the filaments, sporoplasm, and shell not at all. Under this treatment there are differentiated in the uniformly bright green capsular walls several dark green granules. Sometimes only 2 are seen, and these are then often situated approximately in the long axis of the capsules. Other specimens are seen with 4 or 5, which are usually arranged without marked regularity, generally, however, being collected near the center. Their nature is problematical. Their presence, position, and numerical range appear to be constant.

Sporoplasm: The outline was not accurately traced, but the results, obtained by staining, suggest that upon the superior surface it may perhaps extend to the anterior end of the shell; upon the inferior surface it only reaches the posterior ends of the capsules. Upon this view of the relations, the capsules would indent the *inferior* surface of the sporoplasm. A similar condition appears to have been observed in other species (pl. 34, fig. 3*d*). It is obvious that between the greater (but partial) anterior projection of the sporoplasm upon the superior surface in *M. macrurus*, and its complete anterior extension upon one surface in the present species, various transitions might occur, and I believe that this greater anterior projection affords, even in the absence of valvular inequality, a criterion for the discrimination of the superior from the inferior surface, the greater projection being always superior and the capsules always more or less inferior.

Nuclei: Besides the deeply methyl-green staining bodies in the capsular walls, 3 series of bodies, which have a constant position and stain with both carmine and gentian violet, occur. Those forming the first series have every appearance of being, and I believe are, nuclei. The second and third series are much more dubious, for if all the granule-like particles which stain with gentian violet are to be regarded as nuclei, the number of the latter must be reckoned as 1 or 2 score. I have, therefore, merely described the appearances presented by the specimens, and will direct attention to the possibility of sporoplasmic degeneration having taken place.[1]

Series 1: Consisting constantly of 2 deeply-staining globules (best shown by carmine), always found in the median tongue-like process of the sporoplasm, usually disposed submedianly, one behind the other, though not infrequently obliquely or even transversely directed; often seen closely approximated, sometimes flattened on their adjacent sides.

Series 2: Forming 2 curved lines whose direction and position coincide in a general way both with the concave anterior margins of the sporoplasm, and also with the adjacent postero-inner border of the capsule; best stained by carmine. Each line is resolved by high powers into several deeply-stained dots; its outer end approaches so closely the usual position of the pericornual nucleus that I suspect that this latter structure may form the last dot. Further, with one pair of such lines distinctly in focus, a second pair (parallel and slightly anterior to the first) can sometimes be seen. That this pair exists on another focus-plane becomes evident by change of focus, when it comes into distinct view, the first pair at the same time receding into obscurity. Finally, at the anterior median cornu a distinct deeply-stained granule is also sometimes seen.

Series 3: These chromatophile bodies are best shown by gentian violet. This reagent differentiated, besides the lightly tinted shell, three kinds of substances which stain, respectively, not at all, medium, and very dark. There is never any difficulty in distinguishing these from one another; that is, there are no transitions between the tints. The medium-stained portion is the general protoplasm. Without pronouncing such to be their nature, I may say that the dark-, and nonstaining portions behave toward gentian violet precisely as would nucleolar and nuclear substances, respectively. Moreover, the order of succession (from the center of the space outward) is always deepest-staining, nonstaining, medium-staining, the nonstaining portions forming circular, oval, or slightly irregular spaces, which are delimited by a sharp, clearly defined border from the surrounding medium-stained protoplasm on the one hand, and from the inclosed deeply stained granules on the other.

As regards their location, though they often seem to, and apparently sometimes do, honeycomb the protoplasmic portion of the spore, they nevertheless show a decided tendency toward peripheral aggregation. In most cases there can be distinguished in the posterior two-thirds of the spores 2 zones, a more deeply stained tongue-shaped median, and a markedly lighter band-like circumferential portion. The latter is, by preference, the seat of the third series of chromatophile bodies. The

[1] The fishes had been kept for years in rather weak alcohol and their condition of preservation was by no means perfect. Further, the results of staining with gentian violet were by no means constant, only a single slide serving as a basis for the description given. The action of carmine was less variable.

anterior end of each series appears usually to be (is?) formed by one of the pericornual nuclei. Sometimes these latter are the only ones to be seen. Almost always they are the largest. Starting anteriorly with these two, an increase may be traced up to 6 (3 on each side[1]), the 3 pairs being often subsymmetrically arranged. In cases of deficiency it is the posterior ones that are absent. These facts would seem to suggest a possible origin of the series from the two large pericornual nuclei.

Besides the structures already described, others more or less similar may be seen, especially anteriorly and in the higher (presumably also in the lower) focus-planes. Some of these show the same combination (deeply stained granules in unstained areas) as those already mentioned, but often no surrounding unstained areas were visible.

Vacuole: I could not detect this structure, but do not wish, on the strength of the material available, to positively assert its absence.

Habitat, etc.—Encysted immediately beneath the skin, on the external (scaleless) surface of the head, never elsewhere except twice in skin of body immediately behind head of *Erimyzon sucetta oblongus* (=*Catostomus tuberculatus* Le Sueur, *fide* Jordan and Drayton[2]), chub sucker. Apparently a scaly surface constitutes an almost impassable barrier for this species.

Observed on fish collected as follows:

U. S. Nat. Mus. Cat. No. 20105. Tributaries Fox River, Mississippi. Collector, Prof. S. F. Baird. Tumors very numerous on 2 specimens. Fish adults.

U. S. Nat. Mus. Cat. No. 20523. Kinston, North Carolina. J. W. Milner, collector. A single tumor on 1 fish; the latter rather young.

This species was not found in the following:

U. S. Nat. Mus. Cat. No. 20254. Near Piermont (?Pierpont) New York. Collector Prof. S. F. Baird. Fish half-grown.

U. S. Nat. Mus. Cat. No. 25573. Columbia, South Carolina, March 21, 1880. Collector, Col. Marshall McDonald.

The striking contrasts between the very great number of cysts present on the fish from Mississippi and their extreme rarity upon those found at the other localities is interesting. Data are, however, wanting for the proper appreciation of relative potency of geographic location, temperature, season, and age of the fish.

Remarks.—This species is, I believe, identical with the one described by Müller.[3] Although he states the branchiæ to be the principal seat of this species, I have only found it imbedded under the skin covering the head. The cysts found on the branchiæ, besides being distinguished

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[1] I have not seen more than 3 nucleiform bodies (deep-stained granules in the midst of a non-stained area) on a side, though the number of deep-stained granules may be greater, 2 being sometimes found in one unstained space.

[2] Bull. 12, U. S. Nat. Mus., pp. 100, 145; var. *oblongus*, *fide* Prof. B. W. Evermann.

[3] Müller's description in brief is:

Cysts conspicuous, elongate, 2 to 4 mm. long, imbedded principally under mucous membrane of branchial lamellæ, also in that of the branchial chamber and in skin of head of *Catostomus tuberculatus* from North American rivers. Cysts found in all of the 3 fish examined, being in one case numerous.

by their *much* smaller average size, contain a quite distinct species (*M. globosus*) which is much smaller, subcircular, and with a much larger capsular index.

55. **Myxobolus lintoni** Gurley, 1893. Pl. 26, figs. 7, 8; pl. 27.

(Psorosperms of *Cyprinodon variegatus*, Linton, 1891, Bull. U. S. Fish Com. for 1889, IX, pp. 99–102, pl. 35, figs. 1–16; *ib.* Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIII, p. 97.)

Myxobolus lintoni, Bull. U. S. Fish Com. for 1891, XI, p. 414; *ib.* of *Cypsinodon* [error] *variegatus* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cysts.—Apparently no closed cysts. Fungoid masses of an irregular shape, varying in size from 4 by 2·5 mm., to 10 by 4 mm., projecting as much as 3 mm. above general surface of skin.

Myxosporidium unknown.

Spore.—Shape and size very uniform; biconvex-lenticular, outline broadly rounded-elliptic, length 13·9 μ, breadth 11 μ, thickness about 8 μ. Shell thick, showing under action of osmic and sulphuric acids a low longitudinal ridge, resisting the action of concentrated sulphuric acid and of potassium hydrate solution and a 10 days' maceration in sea water; staining brown with iodine and deeply when treated with methyl green and eosin; collapsing under action of glycerin. Capsules 2, situated and converging anteriorly, pyriform, transparent, refractile, not staining deeply with methyl green and eosin, showing, with osmic acid, a minute pore at anterior end; containing filaments which are extruded under the influence of sulphuric acid; filaments when extruded nearly straight, undulate, or more or less closely spiral, of the same thickness throughout, distal ends tenuate. Sporoplasm showing, on addition of acetic acid or after 8 days' immersion in sea water, a "nuclear vesicle"; in many specimens showing the "smaller supplemental refractile bodies" represented in pl. 27, fig. 2. Spore associated with calcareous particles of irregular shapes (fig. 14).

The above is Prof. Linton's description, condensed and rearranged. To it I am able to add, partly by way of correction, the following data:

Spore.—Shell composed of 2 valves, superior and inferior; easily and rapidly separating in sulphuric acid (cold, concentrated); ridge present. Capsules extruding the filaments (alcoholic specimens) in a loose spiral or straight, under the action of iodine water. Sporoplasm showing, with iodine, a rather large vacuole with clearly defined borders. Nuclei, at the most, 4, 2 of which are the pericornual.

These 2 specimens were also from the Atlantic, at Woods Holl, Mass.; collected by Mr. V. N. Edwards, August 1, 1892.

Habitat.—Imbedded in the subcutaneous tissue of *Cyprinodon variegatus* (short minnow), taken in the Atlantic at Woods Holl, on August 20, 1889; also August 1, 1892.

Effects.—The skin of the host overlying these tumors is more or less cracked and broken, and the scales scattering.

56. Myxobolus sp. incert. Pl. 28, fig. 4.

Cyst and myxosporidium unknown.

Spore.—Broadly elliptic; length, 14 μ; breadth, 10 μ; thickness, 5 μ; shell bivalve; valves equally convex; ridge index about 0·25. Capsules 2, equal; capsular index not quite 0·50. Sporoplasm showing a clear, round space, without doubt the vacuole.

Habitat.—Body cavity of *Carassius carassius* L. (goldfish), from Germany.

Remarks.—For this species I am indebted to Dr. C. W. Stiles, who mounted the spores in Leipsic. The exact locality whence the host came is unknown. The specimen was mounted unstained in Farrant's solution. For this reason the vacuole could not be stained or the nuclei be determined.

57. Myxobolus ? obesus Gurley, 1893. Pl. 28, fig. 7.

(Psorosperm of the "Ablette," Balbiani, 1883, Journ. de Microgr., VII, p. 203, fig. 43; *ib.* Balbiani, 1884, Léçons sur les Sporozoaires, p. 133, fig. 39.)

Myxobolus obesus, Bull. U. S. Fish Com. for 1891, XI, p. 415; *ib.* of *Alburnus lucidus*[1] Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

No description.

Habitat.—On *Alburnus alburnus* L.

58. Myxobolus cycloides Gurley, 1893. Pl. 28, fig. 5.

(Psorosperms of *Cyprinus rutilus*, Müller, 1841, Müller's Archiv., pp. 481, 486, pl. 16, fig. 4*d–g*; *ib.*,[2] Creplin, 1842, Wiegmann's Archiv. f. Naturgesch., I, p. 63 (footnote); *ib.*, Müller, 1843, Rayer's Archiv. de. Méd comp., I, p. 226, pl. 9, fig. 4*d–g*; *ib.*, Rayer, 1843, *ibid.*, p. 269; *ib.*, (*pars*) Robin, 1853, Hist. Nat. Végét. Parasites, p. 299, pl. 14, fig. 6.)

Myxobolus cycloides, Bull. U. S. Fish Com. for 1891, XI, p. 415; *ib.*, Braun, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.—Not described. Creplin states that the membrane is very delicate and that it is "dissolved" by water.

Myxosporidium unknown.

Spore.—Subcircular-ovate or broadly rounded-elliptic, resembling *M. circularis;* length, 12 μ (0·0054′′′).

Habitat.—Encysted, most frequently on inner surface of opercle and particularly on the pseudobranchiæ (*Nebenkiemen*) of *Leuciscus rutilus* from German rivers. Disease of very frequent occurrence, principally in May and June. Creplin's specimens were taken May 8, 1835, and January 31, 1839.

59. Myxobolus sp. incert.

Myxosporidian spore of *Gardon*, Thélohan, 1889, Compt. Rend. Acad. Sci. Paris, CIX, p. 921.

Spore.—Vacuole present; maximum number of nuclei, 3.

Habitat.—On the "*Gardon.*" At present this form is entirely indeterminate, as M. Thélohan informs me (letter, 1893) that *Gardon* is applied indiscriminately to both *Leuciscus rutilus* and *L. erythrophthalmus.*

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[1] The question between the two specific names is merely that of the advisability of the use of a specific name identical with the generic.

[2] Creplin compares his form to Müller's, fig. 4*d*.

60. Myxobolus spheralis Gurley, 1893.

(Psorosperms of *Coregonus fera*, Claparède, 1874, in Lunel's Hist. Nat. d. poissons du bassin du Léman, pp. 113–14.)

Myxobolus spheralis, Bull. U. S. Fish Com. for 1891, XI, p. 415; *Myxobolus sphæralis* [error] Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.—Diameter, 0·25 to 0·33 mm.

Myxosporidium unknown.

Spore.—Very different from those contained in the cysts of the muscles of the same fish, untailed, perfectly spherical, 9 μ in diameter, containing a single spherical, very strongly refringent "nucleus" and some small granules. Some cysts contain spores with less refringent nuclei and with very numerous small granules. This difference is perhaps only one of age.

Habitat.—Cysts imbedded by thousands in the mucosa of the branchiæ of *Coregonus fera* Jur. Their abundance gives to the branchiæ a grayish color apparent at the first glance.

Remarks.—Claparède remarks that it might naturally be supposed that a generic bond exists between the small cysts of the branchiæ and the large cysts of the muscles, but observation was unable to justify this hypothesis.

61. Myxobolus sp. incert. Pl. 28, fig. 6.

Psorosperms of *Lucioperca sandra*, Müller, 1841, Müller's Archiv., pp. 480–6, pl. 16, figs. 3*a–l*; *ib.*, Müller, 1843, Rayer's Archiv. de Méd. comp., I, pp. 222–6, pl. 9, fig. 3*a–l*; *ib.*, Dujardin, 1845, Hist. Nat. d. Helminthes, p. 644; *ib.*, Robin, 1853, Hist. Nat. d. Végét. Parasites, p. 295, pl. 15, fig. 5.

Cysts.—Flat white vesicles or pustules, 1·09 to 2·18 mm. (½ to 1‴) in diameter, usually few and discrete; contents a small quantity of granular matter, mostly, however, consisting of the spores.

Myxosporidium unknown.

Spore.—Almost exactly round, untailed or very rarely (once in 200 to 300 times) tailed, the tailed forms occurring in the same cyst and resembling especially *M. schizurus*, from which species, however, they differ in having the tail no longer or only a little longer than the body; with double-contoured border, thickness equal to one-half the breadth; ridge present; capsules 2, of equal size, converging and appearing as though united by a knot at their anterior extremities (fig. 6*a*). Among multitudes of typical specimens, Müller says an occasional one is seen containing 3 bodies, the third being placed behind and between the other two. Spore frequently showing a dark punctule just behind the posterior end of each capsule which sometimes simulates an oblique line extending from the border to the capsules; at others, a slight projection of the shell.

Development.—Traced (naturally enough, but erroneously[1]) by Müller, as follows: (1) Spores occur in which the capsules are no longer at the

[1] It must be remembered that Müller was not aware of the existence of the myxosporidium. Recently Mingazzini has attempted to revive this view of the office of the capsules (see p. 87).

anterior end, but in the middle, and have their axes parallel (fig. *3h*). (2) Numerous mother vesicles [pansporoblasts] are seen containing 2 spores standing on edge, in contact, with their longitudinal planes parallel; such spores show capsules in their interior in the usual place. (3) Rare cases occur (fig. *6e*) where the mother vesicles contain 3 such spores; these correspond to the rare cases in which the contents of the spore consist of 3 parts. He concludes that the capsules are the germs of new spores.

Habitat.—Encysted in skin of the external or internal surface of the opercles, in the rays of the branchial membrane, on upper surface of head or on the fins of *Stizostedion lucioperca* (=*Lucioperca sandra*), pike perch, from German rivers and from the Don. Disease very frequent, mostly in May and June. Müller found it in from 20 to 25 per cent of the young fishes examined. They were taken during the first of the winter.

62. **Myxobolus globosus** Gurley, 1893. Pl. 28, figs. 1–3.

Bull. U. S. Fish. Com. for 1891, XI, p. 415; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cysts.—Varying from very minute to a maximum of 0·5 mm., elongate-elliptic or rod-shaped, apparently (judging from ease of rupture) with a very thin membrane; color, whitish; contents, spores.

Myxosporidium unknown.

Spore.—Globose, subcircular in outline, untailed; length, 7 or 8 μ; breadth, 6 or 7μ; thickness, 5μ. Shell substance thin, very transparent, composed of 2 valves (superior and inferior in position), which present a heavy ridge whose width nearly equals one-third of the thickness of the spore. Valves equally and very convex on their external surfaces, appearing symmetrical on either side of the ridge. Capsules, 2, of equal size, rather strongly diverging; capsular index somewhat more than 0·50. Nuclei 3 or 4, viz: the 2 pericornual and 1 or 2 others, the latter the usual and presumably the fully developed condition (see p. 92). Vacuole present. Owing to the great convexity of the sporoplasm surface and the great thickness of its substance, it is not so clearly outlined as usual.

Habitat.—Encysted on the branchial lamellæ of *Erimyzon sucetta oblongus* Lac. (=*Catostomus tuberculatus* Le Sueur[1]), chub sucker.

This species was found upon fishes from the first 3 localities; on those from the fourth none were detected.

The following is the record of fishes examined:

U. S. Nat. Mus. No.	Locality.	Date.	Collector.
20523	Kinston, N. C		J. W. Milner.
25573	Columbia, S. C	Mar. 21, 1880	Marshall McDonald.
20105	Tributaries Fox River, Mississippi		S. F. Baird.
20254	Near Piermont (? Pierpont), N. Y		S. F. Baird.

[1] Fide Jordan & Drayton, Bull. 12, U. S. Nat. Mus., pp. 100, 145; var. *oblongus, fide* Prof. B. W. Evermann.

63. **Myxobolus transovalis** Gurley, 1893. Pl. 29, fig. 1.

Bull. U. S. Fish Com. for 1891, XI, p. 415; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.—Existence not evident, the spore-mass appearing to be held together by a small soft gelatinous or mucoid mass which has no attachment to the subjacent connective tissue, as it invariably comes away with the scale. It forms a thin discoidal mass situated in the center of the concave under surface of the scale. When at its thickest it elevates the scale slightly, and this elevation is the principal guide to its detection. In addition its color when coagulated is a slightly deeper yellow than that of the surrounding tissues. It is exceedingly difficult, in fact nearly impossible, to detect its presence in the fresh state.

Myxosporidium unknown.

Spore.—Length, 6 μ; breadth, 8 μ; shell thin; substance almost perfectly transparent, insoluble in concentrated sulphuric acid, bivalve; the valves superior and inferior in position, equally ventricose, with a narrow ridge; valves separating easily when placed in cold concentrated sulphuric acid, also sometimes in strong glycerin, or when the mass is rolled under the cover slip.

Capsules: Two, of equal size, containing a coiled filament extruded under the influence of glycerin and of sulphuric acid; capsular index about 0·50.

Sporoplasm: The great convexity of the sporoplasm renders it difficult of determination whether the deeper iodine-stained portions represent merely greater thickness or a vacuole. Sometimes the latter view was suggested by the rather sharp outline of such deeper-stained areas. Hydrochloric acid alcohol carmine stains 2 (very rarely 1 only) comparatively large (1 to 1·5 μ in diameter) nuclei, which are always and plainly situated in the sporoplasm with a site by preference along or near one of its concave anterior borders; pericornual nuclei apparently absent.

Habitat.—Under scales on external surface (mostly on posterior half) of *Phoxinus* (*Clinostomus*) *funduloides* Girard, taken in 4-mile Run (tributary of Potomac River), near Carlins, Va., June 29, 1892; collector, the author. Among fishes collected from the same locality, August 29, 1892, no diseased specimens were found.

64. **Myxobolus ? merlucii** Perugia, 1891. Pl. 29, figs. 2–7.

Myxosporidium merlucii Perugia, 1891, Boll. Scientif., Pavia, XIII, pp. 22, 24, figs. 9–14; *Myxobolus merluccii* [error], Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 166, 178; *M. merlucii*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 415; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Myxosporidium.—Occurring under various forms; no differentiation of ectoderm; no pansporoblast membrane. The spores are expelled at their maturity from the myxosporidium. Perugia adds:

I have also seen form 2 contiguous vacuoles which do not present the slightest trace of capsules, but only a few granulations.

Spore.—Always 2, oval, with 2 capsules situated "at the superior border in the transverse diameter." Perugia did not see the extrusion of the filaments under the action of reagents. He adds that he has convinced himself of the accuracy of Thélohan's opinion as to the vacuolic nature of Bütschli's "nucleus" and also of that of Thélohan's observations upon the nuclei of the spore.

Habitat.—Gall-bladder of *Merlucius merlucius* (= *esculentus*, = *vulgaris*), hake, collected August 13, 1890.

Remarks (see also p. 275).—This is a rather peculiar species, and the generic reference is provisional. As indicated elsewhere, gall-bladder species of *Myxobolus* are so rare that this habitat is a caution-mark as to the generic reference of imperfectly described forms. The present generic reference is made provisionally and very doubtfully upon Perugia's assertion of the presence of an iodinophile vacuole. Finally, attention may be directed to Perugia's figure 9 (pl. 29, fig. 2), which differs entirely from the others.

65. Myxobolus ? sp. incert.

Psorosperms of *Gobio fluviatilis* Lieberkühn, Müller's Archiv., pp. 353–4; *ib.*, Lieberkühn, 1854, Bull. Acad. Roy. Belg., XXI, pt. 2, pp. 21–2; ? myxosporidian of kidney of *G. fluviatilis* Thélohan, 1890, Annal. de Microgr., II, p. 198; *ib.*, of *Gobius* [error] Pfeiffer, 1890, Die Protozoen als Krankheitserreger, 1 ed., p. 49; *ib.*, Pfeiffer, 1891, *ibid*, 2 ed., p. 134.

Cyst.—Nearly spherical, about 0.22 mm. in diameter; contents, "psorosperms," empty shells of the same, "free nuclei" of the same, and amœboid bodies with amœboid movements.

Myxosporidium.—The above and below mentioned amœboid bodies in all probability represent the earliest stages.

Spore.—Untailed. Lieberkühn repeatedly saw spores contract to an hour-glass shape and extrude an amœboid body, which formed blunt processes, and moved slowly over the field, the movements continuing for a long time; amœboid bodies diaphanous, destitute of granules and of apparent structure, usually invisible within the spore, but sometimes plainly seen; size, that of a colorless blood corpuscle.

Habitat.—In the kidney and encysted in body cavity between the kidney and the air-bladder of *Gobio gobio* L.

Remarks.—The habitat and the "encysted" condition of this form imply *Myxobolus* affinities.

66. Myxobolus ? sp. incert.

Psorosperms of *Perca fluviatilis*, Müller, 1841, pp. 481, 490; *ib.* Robin, 1853, Hist. Nat. des Végét. Parasites, p. 296; *ib.* Lieberkühn, 1854, Müller's Archiv., p. 365; *ib.* Bessels, 1867, Tagebl. d. 41 Versamml. d. deutsch, Naturf. u. Aerzte, pp. 71–72.

Cyst mentioned but not described by Lieberkühn; myxosporidium unknown.

Spore.—Untailed. Bessels observed the extrusion of the filaments as a result of 8 hours' immersion in glycerin.

Habitat.—In May and June encysted in the skin of *Perca fluviatilis* (yellow perch) in German rivers and in the Irtisch (Müller). Scales (Lieberkühn; Bessels). Disease not common.

Remarks.—Bessels's form seems probably referable here, as he speaks of having observed the longitudinal splitting into 2 symmetrical halves of an ellipsoid form.

67. **Myxobolus sp. incert.** Pl. 29, fig. 8.

Psorosperms of *Leuciscus rutilus*, v. d. Borne, 1886, Handb. d. Fischzucht u. Fischerei, p. 211, fig. 215.

No description.

Habitat.—On *Leuciscus rutilus* L.

68. **Myxobolus ?? zschokkei** Gurley, 1893. Pl. 31, fig. 1.

(Psorosperms of *Coregonus fera*, Zschokke, 1884, Archiv. de Biol., v, pp. 234–5, pl. 10, fig. 16; *ib.*, Linton, 1891, Bull. U. S. Fish Com. for 1889, IX, p. 101.)

Myxobolus ?? zschokkei, Bull. U. S. Fish Com. for 1891, XI, p. 416.

Cyst.—Oval, white, size varying from that of a small pea to that of a large nut; multiple, sometimes as many as 30 on one fish, the largest usually situated in dorsal muscles; cyst membrane thick, very resistant, without apparent structure; contents a milky fluid, occasionally a caseous mass, coagulable by alcohol.

Myxosporidium unknown.

Spore.—I quote in substance Zschokke's description:

Body lenticular or oval, a little wider in front than behind; often bearing in front a blunt prolongation; posteriorly one distinguishes 2 "tails" (*queues*), 6 to 8 times longer than the body, attenuating posteriorly, curved and undulating; the number of 2 "tails" is constant; at the pole opposite to the "tails" are 2 oval, transparent anteriorly-converging vesicles; one sometimes sees, however, an extremely fine canal extending from the posterior end of each vesicle to the base of the corresponding "tail"; the vesicles then probably play here also the role of receptacles for the "tails." Round refractile globules are also seen at the bases of the vesicles; the remainder of the body is filled by a homogeneous plasmic mass, which frequently contracts to the center of the body cavity, forming a clearly distinct round or oval mass.

Habitat.—Encysted in the subcutaneous and superficial intermuscular tissue of *Coregonus fera.* Observed during April and May. Disease stated by fishermen to be of very frequent occurrence.

Effects.—The skin is irregularly swollen and the scales fall easily. As to myxosporidiosis of *Coregonus*, see also p. 233.

This form is a very puzzling one. As appears from the above description and from the figure (pl. 31, fig. 1), the 2 structures, called by Zschokke "tails" (*queues*), are seen at one end, and at the opposite end are 2 structures (the "vesicles" of the above description) approximating to the position of and presenting somewhat the appearance usual to the capsules, and Zschokke considers them to be the capsules. They converge, as do the capsules of most species, toward the end of the spore, at or near which they are situated, and they diverge in the opposite direction. From these facts one would be inclined to pronounce this end (viz, the one at which these "vesicles" are placed and toward which they converge) the anterior, and the opposite one (the one from which the "tails" proceed) as the posterior. Zschokke, however, states that he has often seen a fine canal running from the (on the above supposition) *posterior* end of each capsule to the base of the "tail," and expresses his belief that, in this species as in those observed by Balbiani, the function of the "vesicles" is to contain the "tails." Both he and, subsequently, Linton[1] perceived the anomaly which, upon his view, is presented by this species, but neither of them discusses it at length. It is almost as difficult to reverse the position of the spore and consider the "tails" as corresponding to the filaments which in other species are extruded from the capsules, as this view would necessitate the admissions that the capsules are placed at and converge toward the posterior end of the body, and that the filaments are extruded from their posterior ends, a state of things occurring in no other known species.[2] I may add that the filiform aspect of the so-called "tails" is quite different from that shown by the stout tails of other species, while it closely resembles that of the capsular filaments.

69. Myxobolus cf. creplini. Pl. 30.

Myxosporidian spore of *Esox lucius*, Weltner, 1892, Sitzungs-Ber. Ges. Naturf. Freunde Berlin, 1892, pp. 28–36, figs. 1–16.

The fish was a spawner, weight estimated at 1 kilo; it showed a mass of milk-white eggs whose contents consisted of myxosporidian spores, a granular mass, and a few yolk granules. The material was first examined by Hilgendorf, who recognized the myxosporidian spores.

Spore dimorphous, untailed and tailed forms occurring. Anterior end more or less bluntly rounded. Posterior end showing great differences, as a rule gradually drawn out without any boundary into the thin tail. More rarely the alternation is sudden and the tail is then delimited from the body. With some spores there is found at the place of transition of the body into the tail a wing-like expansion, which lies at the border of the spore. The untailed spores have the posterior end rounded, much blunter than the anterior; otherwise they are formed entirely like the tailed. The tailed spores are of a fusiform shape.

Relation of untailed to tailed: It might readily be believed that the tailed develop from the untailed by the appearance of a short stump, which would subsequently grow in length and breadth; thus the body-length of the 2 forms is about the same, the whole length of the tailed consequently exceeding that of the untailed only by the length of the tail. Also the maximum width is about the same for both spore-forms.

Shell consisting of 2 thick almost always unequally arched[3] valves which can gape apart anteriorly for more than half their length; by

[1] Bull. U. S. Fish Com. for 1889 (1891), p. 101.

[2] *M. diplurus* has (if Bütschli's figure be correct, pl. 36, fig. 4) the capsules *posteriorly* placed, but their convergence and divergence is not evident, and nothing is known about the capsular filaments.

[3] Weltner refers to his figs. 8 to 11, in which the inequality of valve-convexity might perhaps be the result of the oblique positions of the spores.

pressure on the cover-glass they can be separated almost completely. They remain, however, connected at the posterior end; ridge present.

On longitudinal ("end") view the valves are seen to unite with each other, either by direct fusion and without appreciable line of demarcation, or to be soldered by the thick interiorly projecting welt-like ridge (in optical section, circular).

Weltner believes that the tail structure (in this species) always consists of a superior and an inferior half, each half being a process of the corresponding valve. For, in the very few cases in which the valves diverged posteriorly (remaining connected anteriorly), he saw this quite plainly; with some shells the tail-halves were shorter; with others longer; also inequality of length is very frequent in the same spore, and one valve-process may be very long and the other very short. Other spores have only one valve sharply drawn out, the other showing no trace of a tail. Tail thinner than that of *M. psorospermicus* (Lieberkühn's figures in Bütschli).

The spores in which the tail is double may lie in 3 positions:[1] (1) Most frequently the tails are plainly visible only on a transverse (or at least an oblique) view. The tail-halves (which on vertical view cover each other) then diverge. (2) With other spores things are different; here the tail-halves appear side by side, on vertical view. (3) The third position is that in which the tails cross (in the manner of a crossbill's beak) both on vertical and transverse views.

Capsules: 2, fusiform, length 5·1 to 5·9 μ; their posterior end bluntly rounded off and often obliquely truncated.[2] The separated capsules are rounded pyriform. Capsules mostly parallel-appressed, mutually flattened. In spores whose capsules lie separated from each other the granulated sporoplasm is seen between them. Longitudinal ("end") views show the capsules to be imbedded in the sporoplasm. Weltner only once certainly observed the sporoplasmic covering to extend as far forward as the apex of the capsules. The latter is always clear and glistening when containing the filament; dull when empty. The capsule of the present form differs from that of *M. psorospermicus* (Lieberkühn's figures in Bütschli) in shape; also here the capsular index is smaller. In *M. schizurus* the shape and position of the capsule is also different.

Filament: Not visible (under a power of 1,000 diameters) through the capsular wall; only a dark shadow being seen. Exit produced by glacial acetic acid; also (spores in alcohol), by pressure on the cover glass; the last method produced the extrusion of many filaments; extruded filaments often quite straight; length, 47·9 μ.

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[1] It seems to me that all this is produced merely by a slight lateral shifting of the valves and by the flexibility of the tail. At any rate all these aspects are so produced in *M. cf. linearis* (see p. 254).

[2] A similar apparent marked truncation is an optical illusion in *M. macrurus*.

Sporoplasm: In the preparation this had run to a mass with plainly visible coarser and finer granules. Sporoplasm traceable only to the root of the tail, where its lateral borders converge sharply; in the untailed forms it is rounded off posteriorly.

No nucleus was discovered; bodies staining with hæmatoxylin, borax-carmine, bismarck brown, gentian violet and *Kernschwarz* were resolved by a Leitz $\frac{1}{20}$ immersion into coarse granule-heaps, having little similarity to nuclei.

Microscopic technique.—Material received fresh; the pathologic material was placed in glycerin and water (equal parts) and fixed with some drops of saturated sublimate solution; 14 days later it was transferred to 50 per cent, and subsequently to 70 per cent alcohol. In alcohol the eggs remained soft. In this form the material was catalogued as *Protozoa* No. 1661 in the collection of the *Königliches Museum für Naturkunde.* Bismarck brown stains the capsules only; borax carmine, only the sporoplasm.

Habitat.—Ovary of *Lucius lucius* (pike) collected at the beginning of February, 1892.

Remarks.—Of Müller's forms, the present species resembles most, but is not identical with, *M. schizurus.* This species also bears a great similarity to Lieberkühn's figures (in Bütschli) of *M. psorospermicus*, but here too, specific differences exist. On the contrary, he believes the present form to be identical with *M. creplini*, as the shape and size of the two agree well; it is, however, to be noted that the thickness is seldom as great as that of the last-named species.

70. Myxobolus brevis Thélohan, 1892.

(Cf. tailed psorosperms of kidney of *Gasterosteus aculeatus*, Lieberkühn, 1854, Müller's Archiv., 1854, p. 357 (see p. 185); myxosporidian spores of *G. aculeatus* and *G. pungitius* (*pars*) Thélohan, 1890, Annal. de Microgr., II, pp. 198–200, 209, pl. 1, fig. 1; *ib.* (*pars*) Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, II, p. 604.)

Henneguya brevis Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 177.
Myxobolus brevis, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 416.
Henneguya brevis, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739.
Myxobolus brevis, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst and myxosporidium not mentioned.

Spore.—Small; length, 15 μ; breadth, 5 to 6 μ; anterior portion more swollen; tail very short, caudal index hardly 0·50.

Habitat.—Renal tubules and ovary of *Gasterosteus aculeatus* (stickleback); renal tubules and ovary of *Pygosteus pungitius* (9-spined stickleback); all *fide* Thélohan, letter, 1893.

Effects.—The following from Thélohan probably refers to this species:

At the moment of the expulsion it is not rare to see the normal spawning replaced by the expulsion of a small mass of gluey and viscous matter in which the microscopist easily recognizes psorosperms, aborted eggs, etc.

71. Myxobolus medius Thélohan, 1892. Pl. 31, figs. 2–4.

(Cf. tailed psorosperms of kidney of *Gasterosteus aculeatus* Lieberkühn, 1854, Müller's Archiv., 1854, p. 357 (see p. 185); myxosporidian spores of *G. aculeatus* and of *G. pungitius*, Thélohan, 1890, Annal. de Microgr., II, pp. 198–200, 209, 211, pl. 1, figs. 1, 18 (last *fide* Thélohan, letter); *ib.* Thélohan, 1890, Compt. Rend. hebdom. Soc. Biol. Paris, II, p. 604.)

Henneguya media Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 176.

Myxobolus medius Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 416.

Henneguya media Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739.

Myxobolus medius Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst none; myxosporidium unknown.

Spore formation.—Pansporoblast apparently monosporogenetic (see pl. 31, fig. 4, reproduction of Thélohan's fig. 18).

Spore.—Fusiform; length, 20 to 22 μ (Thélohan, 1892); total length, 24 to 30 μ (*ibid.*, 1890); shell striate; tail present, resembling especially that of *M. psorospermicus*, curved close against the body during development, straightening only after rupture of the pansporoblast membrane; nuclei unknown; vacuole present.

Habitat.—Renal tubules and ovary of *Gasterosteus aculeatus* L. (stickleback); renal tubules and ovary of *Pygosteus pungitius* (9-spined stickleback).

Effects.—The following probably apply to this species, to *M. brevis*, and to *Chloromyxum elegans:*

Upon the kidney, Thélohan's observations are as follows:

The organ is often almost entirely invaded. Upon section one sees nearly all the tubes completely obstructed by psorospermic matter. The canaliculus invaded is dilated and attains relatively enormous proportions, the entire kidney being consequently enormously augmented in volume, and its function evidently must be almost completely abolished. A remarkable fact of this invasion of the renal canaliculi by the *Myxosporidia* is the small amount of disorder that they occasion. Beyond the dilatation of the tubes one observes only a little augmentation of volume of the nuclei of the epithelium. The cells are otherwise respected, and I have never seen the protoplasm of the myxosporidium invade them or insinuate itself between them. This is due without doubt to the dilatability of the renal tubules.

The following upon the ovary probably applies both to *M. medius* and to *M. brevis:*

Upon sections of this organ one sees the connective tissue invaded by the plasmic masses, which separate its fasciæ; certain invaded ovules have completely lost their normal aspect and present in their interior more or less confluent islets of psorospermic matter.

72. Myxobolus creplini Gurley, 1893. Pl. 32, figs. 1, 2.

(Psorosperms of *Acerina vulgaris*, Creplin, 1842, Wiegm. Archiv. f. Naturgesch., 1842, I, pp. 61–3, pl. 1, figs. A–E; *ib.*, Rayer, 1843, Rayer's Archiv. de Méd. Comp, I, pp. 268–9; *ib.*, Dujardin, 1845, Hist. Nat. d. Helminthes, p. 644; "tailed" psorosperm of *Acerina* Leydig, 1851, Müller's Archiv., p. 222; psorosperm of *Acerina vulgaris* Leuckart, 1852, Archiv. f. physiolog. Heilkde, XI, p. 436, fig. 21*e*; *ib.*, Robin, 1853, Hist. Nat. de Végét. Parasites, pp. 312–14; spore of *Acerina vulgaris*, Weltner, 1892, Sitzgs-Ber. Ges. Naturf. Freunde, Berlin, 1892, pp. 29–31, 34).

Myxobolus creplini, Bull. U. S. Fish. Com. for 1891, XI, p. 418; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst not described; myxosporidium unknown.

Spore.—Perfectly transparent, colorless, much larger than any of Müller's species, body elongate, strongly ventricose-elliptic, 17·3μ long by 5·8μ broad; shell bivalve, of firm texture, enabling the spore to retain its shape on drying, splitting open after several days' immersion in water, the resulting median fissure extending nearly to the root of the tail; tail present, simple, diminishing in thickness from origin to its fine pointed extremity, about as long as or a little longer than the body (in 1 specimen 2½ times that length), often more or less deflected from the line of the antero-posterior axis of the body; contents of body cavity perfectly clear, granule-free, showing no trace of structure other than the capsules; capsules 2 (on transverse view only 1) of equal size, pale yellow, subcylindrical, situated at the anterior pole, diverging posteriorly or adnate to each other along their inner borders; in a single specimen beginning as a single cylindrical tube (½ the length of the capsules), which divided posteriorly into the 2 capsules; the latter diverging from their origin to their blind posterior extremities (fig. *d*). Capsules become strongly wrinkled on drying.

Habitat.—On *Acerina cernua* L.; collected March 14, 1837.

73. Myxobolus strongylurus Gurley, 1893. Pl. 31, fig. 5.

(Psorosperms of *Synodontis schal*, Müller, 1841, Müller's Archiv., pp. 480–1, pl. 16, fig. 2; *ib.*, Müller, 1843, Rayer's Archiv. de Méd. Comp., I, pp. 222, 227, pl. 9, fig. 2; *ib.*, Robin, 1853, Hist. Nat. de Végét. Parasites, p. 295, pl. 14, fig. 4.)

Myxobolus strongylurus, Bull. U. S. Fish Com. for 1891, XI, p. 417; *Myxobolus strongylura* [error], Braun, 1894, Centralbl. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.—Over 2·18 mm. (1‴) in length.

Myxosporidium unknown.

Spore.—Body blunter anteriorly than in *M. schizurus;* length without tail 9μ (0·0040‴); breadth, 5·4μ; tail always undivided, very peculiar in being constantly oblique in the longitudinal plane, appearing straight when seen in transverse view; capsules, 2, of equal size. Spore sometimes showing at posterior end of capsule a dark punctule which occasionally causes a slight projection of the shell at this part.

Habitat.—Encysted in skin of cephalic region of *Synodontis schal* from the Nile.

74. Myxobolus monurus Gurley, 1893. Pl. 32, figs. 3, 4.

(Psorosperms of *Aphredoderus sayanus* Ryder, 1880, Amer. Nat., XIV, pp. 211–2, figs. 1, 2; parasite of *Aphredoderus savanus*[1] [error] Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 177.)

Myxobolus monurus, Bull. U. S. Fish Com. for 1891, XI, p. 416; *ib.* of *Aphrododerus* [error] *sayanus* Braun, 1894, Centralbl. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.—Lenticular, large, bulging, white, opaque, numerous (about 20 in the only fish seen), imbedded in the subcutaneous muscles, arranged as a rule in pairs on the opposite side of the body of the fish; membrane very thin; contents, a thick, white, creamy mass, containing multitudes of spores and of excessively minute round granules.

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[1] "The parasite described by J. Ryder in *Aphredoderus savanus* constitutes probably a fourth species" [of Thélohan's genus *Henneguya*].

Myxosporidium unknown.

Spore.—Body lenticular or slightly obovate; tail present (rarely absent), thick at origin, attenuating gradually, more or less curved, between 2 and 3 times as long as the body, undivided; capsules, 2, of equal size, subparallel, on longitudinal view seen to be eccentric.

Habitat.—Encysted in subcutaneous intermuscular tissue of *Aphredoderus sayanus* Gilliams (pike perch), taken near Woodbury, N. J.

75. Myxobolus macrurus Gurley, 1893. Pl. 32, fig. 5; pl. 33, figs. 1–4.

(*Myxosporidia* of *Hybognathus nuchalis*, Evermann, 1892, Bull. U. S. Fish Com. for 1891, XI, p. 76).

Myxobolus macrurus, Bull. U. S. Fish Com. for 1891, XI, p. 416; *ib.* of *Hypognathus* [error] *nuchalis*, Braun, 1894, Centralbl. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.—Multiple (usually 15 to 20 or more), the size of a pin-head, sometimes separated, more frequently in contact, forming elongated masses 6 mm. by 2, or less, imbedded in the subcutaneous connective tissue; almost invariably situated upon some portion of the head. Out of a multitude of cysts upon more than 80 fish, I have seen but one exception, a cyst situated at the base of the pectoral fin, a few millimeters behind the head. The great majority of the cysts are concentrated in 2 lines along the 2 halves of the inferior maxilla between the bone and the skin.

Myxosporidium unknown.

Spore.—Tailed; body rounded-oblong, 10 or 11μ long, 6 to 8μ broad, 4μ thick. Shell substance thin, colorless, perfectly transparent, very resistant to the strongest acids and alkalies, not stained by any of the reagents tried. Valves 2, superior and inferior, unequally convex. Superior valve with a very convex outer surface, to which corresponds internally a surface deeply concaved for the reception of the larger portion of the capsules and sporoplasm. Inferior valve outwardly convex-flattish, with a shallow line of depression across the middle portion of its external surface, to which corresponds on the internal surface a broad, gentle ridge, marking the space between the capsules and the sporoplasm. Ridge forming the anterior continuation of the tail, at the anterior extremity of the spore, projecting slightly in transverse view (optical section), as a blunt, nasute process.

Tail substance somewhat less transparent than that of the shell, completely dissolved by sulphuric acid (cold, concentrated) almost (usually entirely) invisible in balsam, the species then appearing untailed. Tail very long when complete (30 to 40 μ or less), the very attenuate posterior portion easily (and consequently frequently) broken off, the tail then appearing short, thick, and blunt. Tail consisting of a single long, posteriorly-directed median piece, and of two short, anteriorly-directed lateral pieces. Median piece, usually straight, frequently, however, more or less deflected to the right or left, or upward or downward, thick at its origin, attenuating gradually thence to the acuate posterior extremity, destitute of apparent structure,[1] very liable to break off, the fracture always taking place evenly and never producing a ragged end. Lateral pieces 2, strongly curved, extending forward on either side from the anterior end of the median piece, applied closely to the rounded posterior portion of the shell about as far forward as the junction of the posterior and middle thirds of its outer margin; thickest at their origin, becoming very thin toward their anterior extremities. They have a slight expansion over the superior and inferior surfaces of the shell, thus tending to form a slightly cup-shaped receptacle for it. It is probable that they really extend forward along upon the surface and over the sides of the ridges, which structures appear as though continuous with them.

Capsules: 2, pyriform, somewhat diverging posteriorly, attenuated at the anterior end into the ducts which converge forward toward the median line, on either side of which they open. Capsular wall staining readily with and retaining tenaciously bismarck brown and fuchsin; rendered transparent by iodine water and by strong ammonia water. The filaments are thus seen lying coiled within the capsule. They appear not to stain with reagents which stain the walls, the capsule usually showing a lighter central and a darker circumferential portion. Relative to the occasional presence on or near the capsule of a dark "granule," see p. 220. The capsules are always surrounded by a clear space, the *pericystic*. This space never shows a double contour, never stains, and presents no appearance suggestive of an outer membrane. It is apparently a natural and presumably (by exclusion and analogy) a fluid-filled space. It does not stain with iodine, agreeing in this respect with the space (with which it is continuous) everywhere lining the inner surface of the shell, and differing in the same respect from the vacuolic space.

Sporoplasm: Inferior surface convex in all directions, showing a rounded postero-lateral margin,[2] extending from about the middle point of the lateral border of the spore on one side to the corresponding point on the opposite side. From these two points (infero-lateral cornua) the 2 antero-lateral borders curve inward and forward with a sharp anteriorly directed concavity to the median line where the sporoplasm is drawn out to a point (the infero-median cornu) which forms also the inferior extremity of a ridge shortly to be described as the supero-inferior intercornual ridge. The infero-median cornu is situated about at the level of the middle point of the antero-posterior diameter of the shell cavity. Lateral surface, extending forward for some distance

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[1] Iodine (aqueous solution with potassium iodide) produces a decided beading of the median piece, transverse lines of division appearing, constituting a decided pseudo-segmentation. My attention was directed to this phenomenon by Dr. Stiles.

[2] Common, of course, to it and to the superior surface, being the line of intersection of the longitudinal plane with the interior surface of the shell.

convexly, both antero-posteriorly and supero-inferiorly, the cross-section of the sporoplasm at this point being unequally biconvex-lenticutar. Anteriorly, however, each lateral surface is probably excavated for the lodgment of the posterior end of the capsule of the same side. The cross-section of the sporoplasm at the level of the infero-median cornu is a biconcavo-convex isosceles triangle. Superior surface convex in all directions with its postero-lateral margin coincident with the same margin of the inferior surface; differing from that surface mainly in the slighter concavity of the antero-lateral margins (and the consequently less mucronate shape of the supero-lateral cornua) and in the greater extension forward both of the supero-median and of the supero-lateral cornua. The supero-inferior intercornual ridge mentioned above curves (in the vertical plane) from the supero-median cornu downward and backward through the interior of the shell cavity to terminate in the infero-median cornu.

Micro-chemistry.—Hydrochloric acid alcohol carmine stains the nuclei better than other reagents. Iodine (aqueous solution with potassium iodide) stains the vacuole dark brown; stain removed by alcohol; staining most intense at first, the vacuole staining more rapidly than the sporoplasm. This reagent causes the separation of the tail from the body, and a beaded appearance of the tail. As, however, I have not detected this condition in other examination media, I suspect that it is not the normal structure. Finally iodine renders the capsular walls transparent and the filaments visible. Sulphuric acid (cold, concentrated) dissolves the tail (the shell remaining unaffected) and causes the valves to gape open, and finally to separate. Gently warmed, no further effect is produced. Heated to the boiling point, the valve substance is destroyed (dissolved?). Ammonia water renders the capsular walls transparent and the filaments visible. Balsam renders the tail invisible, the shell remaining visible.

Habitat.—Encysted on head of *Hybognathus nuchalis* Ag. (identification by Prof. B. W. Evermann), collected November 24, 1891, in the Neches River, 14 miles east of Palestine, Texas, by Prof. B. W. Evermann, U. S. Fish Commission. Water temperature 9·4° C. (49·5° F.). Disease very frequent.

Effects.—Although the tumors form quite extensive patches, the effect upon the fish could hardly, I think, be serious. That the movements of the jaw are not materially impaired is shown by the excellent nutrition of the fish. Indeed the present species seems rather a subcommensal than a true parasite. Thélohan[1] reports that he saw a cyst shell out of its place in the tissue of the fish and fall into the water. Everything implies that a similar process takes place here, as superficial pitted scars were seen upon several specimens. These show no trace of long-continued ulceration, being very free from the puckerings

[1] Annal. de Microgr., 1890, II, pp. 203–4.

thus caused. Moreover they conform very closely to the shape of the cysts. This is especially well shown where a cyst situated in the center of a group has shelled out, the surrounding cysts, preserving the shape of the cavity.

In this species, under influence of cold, concentrated sulphuric acid (which dissolves the tail) the valves separate, the divergence appearing always to begin at the posterior end. The appearances seem to favor the view that such divergence was the result of the previous solution of the tail, the 2 lateral pieces of which would thus act as a splint. As, however, examination of untailed species (in which I suspected the lateral pieces might exist without the median) failed to show evidence of the existence of the lateral pieces or even of the constancy of the initial posterior divergence, this function of the tail must be regarded as dubious. In any case, at least, one other causal factor must be involved in valve separation, as iodine, which produces separation of the tail, does not produce separation of the valves. I suspected that this might be exosmotic pressure from within, and attempted to produce valve separation by the action of strong glycerin used after iodine had detached the tail, but the results were indecisive.

This species is particularly interesting as exhibiting decided supero-inferior asymmetry, the superior valve being conspicuously more convex, and the supero-median cornu projecting farther forward. It is also important to note that the tail is not a shell process, but is, on the contrary, an independent structure with distinct optical and chemical characters.

76. Myxobolus sp. incert.

Psorosperms of *Coregonus fera*, Claparède, 1874, in Lunel's Hist. nat. des poissons d. bassin du Léman, p. 114.

Cyst.—A single one seen, 1 mm. in diameter; contents entirely different from those of the other branchial cysts, approximating to, without being perfectly identical with, those of the cysts of the muscles of the same fish.

Myxosporidium unknown.

Spore.—Distinguishable from those of the muscle cysts by their shorter and usually single tail, which, however, in a great number of individuals was bifurcate at the extremity.

Habitat.—Branchial arches of *Coregonus fera.*

77. Myxobolus cf. linearis. Pl. 33, figs. 5–8.

Cysts of base of dorsal fin of *Ameiurus melas*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 417.

Cyst.—Subspherical, about 1 mm. in diameter, 7 in number in a row at the bases of the spines of the second dorsal fin.

Myxosporidium unknown.

Spore.—Body lanceolate; length of body, 19 μ; breadth, 5 or 6 μ; thickness, about 3 μ.

Shell consisting of 2 valves, superior and inferior in position; ridge present, forming continuation of tail. The tail in this species is a shell process, consisting of 2 halves, a superior and an inferior, each connected with and forming a solid process of the corresponding valve. Length of tail, 38 μ. Valves separating very slowly in sulphuric acid (cold, concentrated), the gradual lateral shifting of one valve over another beginning within a few minutes and continuing for 20 or 30. Coincidently the two tail halves diverge, serving well as indices of the amount of lateral shifting of the valves. Iodine fails to loosen the connection of the tail (or of either half) with the valves.

Capsules long, narrow, parallel-appressed; capsular index about 0·40; walls rendered transparent and filaments visible by iodine water.

Sporoplasm showing the usual anterior extension of the superomedian cornu. The other cornua are also recognizable. Vacuole present, subcircular in outline, usually placed toward the anterior end of the sporoplasm. As regards nuclei, hydrochloric acid alcohol carmine always stains as many as and usually 2, rarely 3; position inconstant, one or both being either before or behind the vacuole. In addition, there are constantly present, at or close to the extreme posterior end of the sporoplasm, 2 deeply stained dots, which are too minute to show any structural details.

Habitat.—7 or 8 cysts at bases of the spines of the second dorsal fin of *Ameiurus melas* Raf. (bullhead) from Storm Lake, Iowa, collected August 23, 1890, by Prof. Seth E. Meek, to whose kindness I am indebted for the specimen.

This species can only be compared with the next. The following summarizes Müller's scanty diagnosis of that form:

Body very narrow, 3 to 4 times as long as broad; capsules parallel-appressed; tail simple, occasionally double.

The present species answers to all of these characters, but they are too few to warrant the fusion of the two forms, although their identity may be strongly suspected. If established, their identity would constitute a very interesting fact, both in zoological and in geographical distribution, for we should then have a species found (so far) confined in its zoological range within the *Siluridæ* and with a very wide geographical distribution.[1]

[1] For the geographical distribution (in South America) of *R. sebæ* and of *P. fasciatum*, see Eigenmann & Eigenmann, Revision So. Amer. Nematognathi (Occas. Papers Calif. Acad. Sci., San Franc., 1890), pp. 123, 209. Considering the names used by Müller, the date of his writing, etc., it seems rather probable that his localities were those known to Cuvier and Valenciennes (1840), viz, for *R. sebæ*, Surinam, Cayenne, Rio Janeiro, Buenos Ayres, and for *P. fasciatum*, Surinam.

78. Myxobolus linearis Gurley, 1893. Pl. 36, fig. 2.

(Psorosperm of *Pimelodus sebæ* and of *Platystoma fasciatum*, Müller, 1841, Müller's Archiv., p. 489, pl. 16, fig. 10; *ib.*, Müller, 1843, Rayer's Arch. de Méd. comp., pp. 228–229, pl. 9, fig. 10; *ib.*, Robin, 1853, Hist. Nat. d. Végét. Parasites, p. 300, pl. 14, fig. 11.)

Myxobolus linearis, Bull. U. S. Fish Com. for 1891, XI, p. 417; *ib.* of *Pimelodes* [error] etc., Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst not described; myxosporidium unknown.

Spore.—Body very narrow; length, 3 to 4 times breadth; capsules parallel-appressed, in contact along their entire length; tail simple, occasionally double.

Habitat.—Cysts in membrane lining branchial cavity of *Rhamdia sebæ* Cuv. & Val.; cysts on branchial lamellæ of *Pseudoplatystoma fasciatum* L., from South American rivers.

79. Myxobolus schizurus Gurley, 1893. Pl. 36, fig. 1.

(Psorosperms of *Esox lucius*, Müller, 1841, Müller's Archiv., pp. 477–478, pl. 16, fig. 1; *ib.*, Müller, 1843, Rayer's Archiv. de Méd. Comp., I, pp. 219–222, pl. 9, fig. 1; *ib.*, Dujardin, 1845, Hist. Nat. des Helminthes, pp. 643, 644; *ib.*, Robin, 1853, Hist. Nat. des Végét. Parasites, p. 292, pl. 14, figs. 2, 3; *ib.*, Lieberkühn, 1854, Müller's Archiv., p. 5; ? *ib.*, Thélohan, 1890, Compt. Rend. hebdom Soc. Biol. Paris, II, p. 604; *ib.*, Weltner, 1892, Sitzgsber. Ges. Naturf. Freunde Berlin, pp. 29-35.)

Myxobolus schizurus, Bull. U. S. Fish Com. for 1891, XI, p. 417; *Myxobolus schiozurus* [error] Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.[1]—Whitish, 0·44 to 1·09 mm. ($\frac{1}{5}$–$\frac{1}{2}'''$) in diameter, membrane delicate, contents white, unaffected by water, consisting of finely granular matter and spores, the latter motionless.

Myxosporidium unknown.

Spore.—Body oval, double contoured, resembling and about the same size as the oval blood corpuscle of the fish; length 12 μ (0·0054'''), breadth 6 μ (7 μ Robin; 0·0026'''), thickness about one-half the breadth; border flattened-rotund, marked by a ridge which extends forwards on either side of the shell, projecting slightly in front; tail stout at origin, attenuating gradually, 3 to 4 times length of the body, not articulated, very frequently (probably as a rule) bifurcate at the tip, or for more or less of its length. Untailed forms very rare; capsules 2, of equal size, always diverging posteriorly; remainder of shell cavity filled with a transparent, rarely granular substance, differentiated by refraction from the shell substance.

Habitat.—Encysted in the orbit (never found elsewhere) in the cellular tissue of the eye-muscles, in the sclerotic, and between the last and the choroid of young *Lucius lucius* L. (pike) in May and June. Found in only about 10 per cent of the fish examined. Müller failed to find this disease in the North American pikes examined.

[1] These cysts are not to be confounded with similar white entozoan cysts. The latter are of more frequent occurrence in the orbit than the myxosporidian cysts. They are smaller in size (about 0·50 to 0·65 mm.) and have thick walls. Under the microscope the entozoan can be seen moving with transverse wrinklings of its cyst.

80. Myxobolus psorospermicus Thélohan, 1892. Pl. 34.

(Psorosperms of *Perca fluviatilis*, Bütschli, 1882, Bronn's Thier-Reich, I, pl. 38, fig. 16; *ib.*, Balbiani, 1883, Journ. de Microgr., VII, pp. 201, 203, fig. 42; psorosperms of *Esox lucius, ibid.*, pp. 201–2, fig. 41; *ib.*, Balbiani, 1884, Leçons sur les Sporozoaires, p. 132, fig. 37; psorosperms of *Perca fluviatilis, ibid.*, p. 133, fig. 38; *ib.*, Lankester, 1885, Ency. Britan., 9 ed., XIX, p. 855, fig. XVII, 43, 44; *ib.*, Thélohan, 1889, Compt. Rend. Acad. Sci. Paris, CIX, p. 604; *ib.*, Thélohan, 1890, Annal. de Microgr., II, pp. 202, 207, 211, figs. 5–7; *ib.*, Thélohan, 1890, Compt. Rend. hebdom. Soc. Biol. Paris, II, p. 604; tailed psorosperms of pike, *ibid.*; psorosperms of *Perca fluviatilis*, Pfeiffer, 1890, Die Protozoen als Krankheitserreger, 1 ed., p. 43; *ib.*, Pfeiffer, 1891, *ibid.*, 2 ed., p. 130.)

Henneguya psorospermica, [1] Bull. Soc. philomat. Paris, IV, pp. 167, 176.

Myxobolus psorospermica Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 418.

Henneguya psorospermica Braun, 1893, Centralbl. Bakt. u. Parasitenkde, XIV, p. 739.

Myxobolus psorospermica, Braun, 1894, Centralbl. Bakt. u. Parasitenkde, XV, p. 87.

Cyst and myxosporidium not described.

Spore.—Anterior extremity obtuse; length, 35 to 40 μ (Thélohan, 1892; 36 μ, Balbiani for spore of *Lucius;* 30 μ, Thélohan, 1890, for spore of *Perca*); breadth, 4 μ (Thélohan, 1890). Tail curved close against the body during development, becoming straight only after the rupture of the pansporoblast membrane; caudal index, 1. Capsules, 6 to 8 μ in length. Maximum number of nuclei, 3; vacuole present (Thélohan, 1890).

Habitat.—Branchiæ of *Lucius lucius* L. (pike) and of *Perca fluviatilis* (yellow perch).

Remarks.—In view of Thélohan's positive statement as to the identity of the forms habitant on the branchiæ of *L. lucius* and *P. fluviatilis*, I believe we are justified in referring all the forms figured to one species, although fig. 34 (pl. 4) differs somewhat from the rest.

81. Myxobolus kolesnikovi Gurley, 1893. Pl. 35.

(Psorosperms of *Coregonus*, Kolesnikoff, 1886, Vet. Vestnik Kharkoff, V, pp. 242–248, plate, figs. 1–3.)

Myxobolus kolesnikovi of *Coregonus fera* [error],[2] Bull. U. S. Fish Com. for 1891, XI, p. 417.

Cyst.—Numerous, sometimes as many as 80, length 10 to 30 mm., breadth 7 to 20 mm., spherical or oval, bean-shaped, yellowish-white, surface of cyst-wall smooth and shining, membrane of the thickness of a cigarette paper, rupturing by the slightest pressure of the forceps. Contents thick, yellowish-white, creamy, consisting of spores and an oily substance.

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[1] "One finds on the branchiæ of the pike and of the perch a myxosporidian absolutely identical in the two cases and which it is certainly necessary to consider as constituting but a single species" (Thélohan.)

The words "Psorospermies de J. Müller" were evidently attached to this species inadvertently. Müller knew no species on the branchiæ of *L. lucius*. In this fish he observed them only in the orbit.

[2] Kolesnikoff does not mention any species.

Myxosporidium.—The following may refer to this stage. To me it is rather obscure:

Between the tailed spores were found in great numbers protoplasmic bodies of the size of a blood corpuscle or smaller, which were round and contained "semen" (?spores). The protoplasm of these bodies was seminal (?sporigenous). The nucleus was sharply defined and contained several semina (?granules).

Spore.—Round or oval with a sharp anterior end; shell double-contoured; substance homogeneous, texture reminding one of chitin, unaffected by acids and by alkaline hydrates; capsules 2, anteriorly placed; filaments gradually extruded under the influence of gentle heating. By means of staining with fuchsin or methylen blue performed after warming, there appeared in the spore a sharply defined "nucleus". Tail single or double, consisting of a substance similar to the shell, thick at its origin, attenuating gradually to its free extremity; shape similar to that of the tail of *M. psorospermicus* as figured by Bütschli.[1]

Micro-chemistry.—Fuchsin and methylen blue stain the spores and the extruded capsular filaments, but not the shell or the tail.

Habitat.—Cysts irregularly distributed in the interstitial connective tissue of the thoracic and intercostal muscles of *Coregonus.* Loosely united to the surrounding muscular tissue by spongy connective tissue and easily separable therefrom by its rupture.

As to the relation of this species to the next, see next page.

82. Myxobolus sp. incert.

Psorosperms of muscles of *Coregonus fera,* Claparède, 1874, in Lunel's Hist. nat. d. poissons du bassin du Léman, p. 113.

Cyst.—Five in number, varying in size from that of a filbert to that of a small walnut. Characters constant. Contents, a milky fluid or (from resorption of the more liquid portions) a caseous mass. This fluid or semifluid mass consists of psorosperms in great number, with a granular protoplasm between them.

Myxosporidium.—This granular protoplasm is without doubt the remains of the amœba at the expense of whose protoplasm, and within which, the psorosperms were formed. The protoplasm in fact contains "vacuoles" (pansporoblasts) which in the beginning are destitute of proper walls, but which form the point of departure for psorosperm production. The examination of one fragment of protoplasm is sufficient to show all transitions between the simple vacuoles (pansporoblasts) and the vesicles containing the 2 oval corpuscles [capsules] characteristic of the psorosperm, and a third corpuscle, whence will be derived the "blastema" (sporoplasm) which fills the posterior part of the body of the psorosperm. It is only a step from these vesicles to the imperfectly developed psorosperms disseminated through the protoplasm. These last already show all essential traits of the fully developed psorosperm

[1] Bronn's Thier-Reich, 1882, I, pl. 38, fig. 16.

except that the 2 tails are still short and distant from each other at their origin. Besides they show an extreme transparency, their degree of refringency being very inferior to that of the psorosperm, thus easily escaping search in the midst of the very similarly refringent protoplasm.

Spore.—Characters constant; body lenticular; length, 8 to 10 μ; tail not merely bifurcate, but double from the base, this feature, however, being only recognizable in a portion of the profile, as when the spore is seen from the face one tail exactly covers the other; capsules 2, ovoid.

Habitat.—Encysted in the muscles of *Coregonus fera.*

Remarks.—Very probably this form should be correlated with the preceding; but as Kolesnikoff has given no measurements and Claparède no figures, it is thought advisable to refrain from fusing them.

83. Myxobolus? diplurus Gurley, 1893. Pl. 36, fig. 4.

(Psorosperms from kidney of *Lola vulgaris*, Bütschli, 1882, Bronn's Thier-Reich, I, pl. 38, fig. 21; *ib.*, Lankester, 1885, Encycl. Britan., 9 ed., XIX, p. 855, fig. XVII, 42.)

Myxobolus diplurus, Bull. U. S. Fish Com. for 1891, XI, p. 418; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

No description. If Bütschli's figures are to be depended upon, this species is at once distinguished from all others of the genus by the *posterior* position of the capsules.

Habitat.—Kidney of *Lota lota* L. (ling).

Fam. CHLOROMYXIDÆ Gurley, 1893.

("Chloromyxées," *et* "Myxidiées" (*pars*), Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 176; Chloromyxea [Thél.] Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739.)

Chloromyxidæ, Bull. U. S. Fish Com. for 1891, XI, pp. 412, 418; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Definition.—Phænocystes destitute of antero-posterior, but possessing bilateral symmetry;[1] capsules in 1 group at the anterior end; a bivalve shell, the plane of junction of whose valves is perpendicular to the longitudinal;[2] no vacuole; type genus *Chloromyxum.*

Vacuole.—Thélohan[3] is authority for the statement that this structure is absent from the sporoplasm of the *Chloromyxidæ* as here constituted. My observations on *C.* (*S.*) *ohlmacheri* confirm this.

Pigment.—Leydig (see p. 260) notes in the myxosporidium of *C. leydigii* a yellowish coloration which he attributed to bile-staining.

Mingazzini[4] also mentions this coloration, but does not comment upon its origin.

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[1] Imperfect from unilateral position of sporoplasm in *Ceratomyxa.*

[2] An examination of *C.* (*S.*) *ohlmacheri* has confirmed the opinion hazarded in a former paper (Bull. U. S. Fish Com. for 1891, XI, p. 412), that in the *Chloromyxidæ* the valve-junction plane is the vertical.

[3] Bull. Soc. philomat. Paris, 1892, IV, p. 173.

[4] Boll. Soc. Nat. Napoli, 1890, IV, p. 160.

Finally Thélohan's observations on *Ceratomyxa sphærulosa* (pp. 76, 277) indicate that perhaps a proper pigment (and not merely an extraneous one, as hæmatoidin) may exist in this genus.

VI. CHLOROMYXUM Mingazzini, 1890.

Etymology not given.

Boll. Soc. Nat. Napoli, IV, p. 160; *ib.*, Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 176; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, pp. 411, 412, 418; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Definition.—Chloromyxidæ with subspherical or ovate spores, whose breadth does not much exceed the length; valves hemispherical; sporoplasm bilaterally and symmetrically situated; type *C. leydigii.*

Synonymy.—By reference to table on page 115, it will be seen that *Sphærospora* and *Myxosoma* differ in none of the characters there given, the genera at present resting solely upon spore-form. This is entirely insufficient to warrant the retention of both genera, especially as any reason which would justify the generic separation of the ovate from the subspherical bicapsulate spores, would equally justify a similar separation of the ovate from the subspherical quadricapsulate spores. From *Chloromyxum* the *Sphærospora-Myxosoma* section has indeed the additional character of 2 capsules as opposed to 4 in *Chloromyxum* proper. I have already given (p. 115) my reasons for regarding the *number* of the capsules as a character secondary in importance to their *grouping* and *position*. *Sphærospora* (including *Myxosoma*) is therefore here accorded subgeneric rank.

CHLOROMYXUM, *sens. strict.*

Definition.—Quadricapsulate Chloromyxa; type *C. leydigii.*

93. Chloromyxum incisum Gurley, 1893.[1] Pl. 37, fig. 1.

(Psorosperms of *Raja batis*, Leydig, Müller's Archiv., 1851, pp. 225-6, 234, pl. 8, fig. 4*a–f*.)

Chloromyxum incisum, Bull. U. S. Fish Com. for 1891, XI, p. 419; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst unknown.

Myxosporidium.—Biliary-yellow, mostly roundish or somewhat elongate, 29 to 88 μ (·0135–·0405‴) in diameter, without or with 1 to 4 pansporoblasts (*Tochterblase*), most of which last contain spores. As in the spore of *Squatina squatina* (*M. leydigii*), the sporoblasts increase at the expense of the other portions of the cell contents until they nearly fill the cell (fig. 1*e, f*).

Spore.—Sharply cuneate-ovate, *posterior border radiate-incised* (causing it to resemble a radiate-ribbed Lamellibranch shell); capsules 4, situate anteriorly, converging.

Habitat.—Free in gall bladder of *Raja batis* L. (skate); present in great numbers.

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[1] Concerning the relation between this species and the next, see the latter, under *Synonymy.*

94. Chloromyxum leydigii Mingazzini, 1890. Pl. 37, figs. 2–7; pl. 38; pl. 39, figs. 1–3.

Squatina angelus, "psorosperms" of.	Spinax vulgaris "psorosperms" of.	Torpedo narke, "psorosperms" of.	Scyllium canicula, "psorosperms" of.	leydigii.	plagiostomi.	Date.	Authority; reference.
× [1]	× [2]	× [3]	× [4]	....	....	1851	Leydig, Müller's Archiv., pp. 224–5, 233–4, pl. 8, figs. 1–3, 5.
....	....	....	....	....	....	1852	Leuckart, Archiv. f. physiol. Heilkde, XI, p. 435, plate, fig. 22.[5]
....	....	....	....	Chloromyxum.	....	1890	Mingazzini, Boll. Soc. Nat. Napoli, IV, pp. 160–4.
....	....	....	....	....	Myxosporidium.	1891	Perugia, Boll. Scientif., Pavia, XIII, p. 23, figs. 1–6.
....	....	....	....	Chloromyxum.	Myxosporidium.	1892	Thélohan, Bull. Soc. philomat. Paris, IV, pp. 166, 169, 170, 173, 176.
....	....	....	....	Chloromyxum.	....	1893	Gurley, Bull. U. S. Fish Com. for 1891, XI, pp. 418–19.
....	....	....	....	Chloromyxum.	....	1893	Braun, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 738–9.
....	....	....	....	Chloromyxum.	....	1894	Braun, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

[1] Leydig's description is as follows (p. 233, pl. 8, fig. 1*a–f*): *Myxosporidium* (developmental stages). (1) Roundish myxosporidia (*Mutterblase*), 29μ to 118μ (·0135 to ·0540′′′) with a thin membrane and yellowish semifluid contents, containing a mass of yellow granules concentrated toward the center, leaving a granule-free border (fig. 1*a*). (2) Other myxosporidia of the same size contain, in addition, several transparent pansporoblasts (*Tochterblase*), whose number varies with the size of the myxosporidium, the smaller having but 1, the largest as many as 6. (3) Other myxosporidia show spores in the sporoblasts, always 1 in each (fig. 1*c*, *d*). (4) In the later stages the sporoblasts become very large, nearly filling the myxosporidium, and separated from its membrane only by a zone which represents a greatly diminished state of the granular mass. Yellow color due to the absorption of bile pigment. That the pansporoblast membrane is impervious to this pigment is shown by the unstained condition of the latter. *Spore*: Sharp-contoured, untailed, acute cuneate-oval, anterior extremity pointed. Capsules 4, situated at the anterior end. Free spores also occur. *Habitat:* Free in gall-bladder of *Squatina angelus*.

[2] The form found in gall-bladder of *Acanthias* (*Spinax*) *vulgaris* is (*fide* Perugia) referable to this species. Leydig's description is as follows (pp. 224–5, 233, pl. 8, fig. 2): *Myxosporidium:* Visible to naked eye, similar to that of *Squatina angelus* except that the appearance is more varied; round, vermiform, and retort-shaped forms occurring; frequently 2 or 3 round forms are united resembling a segmenting ovum; no movements or pansporoblasts seen. *Habitat:* Free in gall-bladder of *Spinax vulgaris*.

[3] Leydig's description (pp. 225, 233, pl. 8, fig. 3): *Myxosporidium* (developmental stages). (1) Large (29 to 118μ; ·0135 to ·0540′′′) yellow club-shaped protoplasmic masses of same general character as in *Squatina angelus*; pansporoblasts absent from this stage. (2) The large yellow masses contain much smaller (15μ; ·00675′′′) colorless vesicles with granular contents, the latter mostly heaped together. (3) A transparent pansporoblast is visible through the finely granular contents. On addition of sodium hydrate, spores become visible in it. Numerous free spores are also seen. *Habitat:* Free in gall-bladder of *Torpedo narke*.

[4] Leydig's description (pp. 225, 234, pl. 8, fig. 5): *Myxosporidium:* Size 29μ to 147μ (·0135 to ·0675′′′); shape, roundish, elongated, retort-shaped, or vermiform with clubbed ends. Many show only membrane and contents; others show well-developed pansporoblasts, sometimes as many as 12, each containing 1 spore. *Habitat:* Free in gall-bladder of *Scyllium canicula*.

[5] On the page cited, Leuckart virtually says that his figure is "after Leydig," and a comparison with figs. $2a_1$, $2a_2$ (plate 39) shows it to be a generalized composite from them.

Concerning the synonymy, Mingazzini says:

All those examined by me in the various species of the *Plagiostomi* (*Torpedo, Scyllium, Squatina, Trygon, Raja, Mustelus, Pristiurus,* etc.) belong to the same species.

There is, however, in Mingazzini's paper almost nothing to show that he studied the spore at all. Only a single sentence refers to the structure of the spore, viz, "Its theca shows an oblique striation in two contrary directions." Moreover, he unfortunately fails to indicate the species of fishes which he examined.[1]

Perugia, however, has given a list of the species of fishes he examined, which includes 2 species investigated by Leydig. He says:

While Leydig had observed that certain spores were striated and others not, Mingazzini says that the striæ are common to all, and is of opinion that there is question of but a single species, an opinion which I believe to be correct.

In describing *Chloromyxum leydigii*, Thélohan[2] says it has

Great striæ upon the shell, which, in passing round the posterior part of the spore, give it a toothed appearance.

It is thus evident that he includes with the present species *C. incisum*. As there is nothing, however, anywhere in the literature to show that he himself ever studied the spores of *C. incisum*, it is very probable that this statement is only intended as representing the consensus of opinion, that is, Mingazzini's and Perugia's views.

As regards Mingazzini's, we have (1) no evidence that he ever examined the gall bladder of *Raja batis*, and (2) only the very loose statement given above (which practically amounts to nothing), so that his opinion that there is but one species is a mere dictum, and even that does not necessarily, as far as the record shows, refer distinctly to this case.

Further, although Perugia notes the discrepancy between Leydig's and Mingazzini's observations and ranges himself with Mingazzini, it appears that he did not examine the gall bladder of *Raja batis*, and the general statement that "the striæ are common to all" seems to me too vague to warrant the fusion of 2 such distinct spore-forms as those here separated as *Chloromyxum leydigii* and *C. incisum*. Until distinct and detailed comparisons between the spores habitant in the gall bladder of *Raja batis* and those habitant in the gall bladders of the other Plagiostomes shall have been made and properly recorded, the specific identity of the 2 forms can not be admitted.

Myxosporidium.[3]—Examined in the bile they have the form of true plasmodes, consisting of a diversely ramified, yellow globular protoplasm, movements exceedingly slow. A few minutes after being placed on the slide they suddenly undergo modification, throwing out an external layer of colorless refracting protoplasm, which (especially at the extremities of the individual) suddenly protrudes filiform thin pseudopodia, which soon become more robust. They also modify their

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[1] In this connection the following judicious criticism of Perugia's upon Mingazzini's work may be quoted: "He had an opportunity to make interesting observations, but he might well have set them forth in greater detail in his paper, especially as regards the various phases of formation of the spore, which he affirms he observed taking place in the vacuoles designated by Leydig as daughter-cells" [pansporoblasts].

[2] Bull. Soc. philomat. Paris, 1892, IV, p. 176.

[3] Description, Mingazzini's.

form, becoming globular or more or less ellipsoidal. It is important to note that in some individuals the entire protoplasm is transformed, changing from globular and yellow to spongy and colorless, the several globules disappearing almost in an instant, changing directly into clear protoplasm, not growing smaller, as might be thought. This shows how rapidly the protoplasm may change its constitution. Nucleus not found either in fresh material or in that treated by hydrochloric or acetic acid. Anilin stains only show here and there deeper colored granules, which, however, could not have the signification of nuclei.

Relative to the nuclei, Thélohan, however, says:

> In the myxosporidium of *Chloromyxum leydigii*, as in the other forms, I have been able to prove the presence of numerous nuclei; they are, indeed, of rather small size, but nevertheless are easily recognized in sections, and if, as is probable, Mingazzini did not observe them, he did not have recourse to this method.

"*Gregarinoid forms.*"—In some gall bladders of the plagiostomes, Mingazzini found in summer also other forms of a very different figure, which were often united to the myxomycetous forms. These forms were uniformly cylindric-elongate, with one end obtusely rounded and the other drawn out to a sharp point in the form of a long tail four or five times as long as the body, sometimes multiple. Size varying greatly; no very small ones seen; large ones equaling the size of adult myxosporidians. Movements rather rapid, always taking place blunt end foremost. Protoplasm hyaline, or showing round hyaline globules arranged in regular longitudinal rows. Many contain a subcentral nucleus. Anteriorly the protoplasm contains rather numerous small, strongly refracting granules. This form thus resembles a monocystid Gregarine, but possesses peculiarities which differentiate it therefrom. For, first, an external membrane is wanting, as shown by negative microscopic investigation and by the protrusion (in individuals kept for many hours on the slide) from the blunt end of thin pseudopodia, which bear a great resemblance to those emitted under the same conditions by the *Myxosporidia;* and, second, no known monocystid possesses such a whip-like tail. Besides these forms others occur, which, while resembling in figure the preceding, have their protoplasm more or less charged with yellow granules resembling those of the adult *Myxosporidia.* Between these and the *Myxosporidia* are found other forms departing for the most part by more profound alterations of form from the first ones. Further, the more advanced gregarinoid forms, which possess refracting hyaline globules, take on the character of more adult forms, transforming their hyaline globules into yellow globules. From what precedes we thus see that *the gregarinoid forms are phases in the development of the myxosporidia of the plagiostomes* [italics his own].

Commenting upon this view, after noting that Mingazzini remarked that these views of the development of the *Myxosporidia* (i. e., *via* the "gregarinoid forms") did not accord with those held by Lieberkühn and Balbiani, Perugia[1] says that his own observation of the exit of the

[1] Boll. Scientif., Pavia, 1890, XII, pp. 138, 139.

amœboid sporoplasm from the spore (see below) causes him to support the opinions of Lieberkühn and Balbiani. Unfortunately, however, he adds the following:

Finally, also, the observations of Thélohan upon the failure of the filaments in the capsules of many spores is not favorable to the mode of view of Mingazzini.

Here again we have the *ribbonettes and the capsular filaments* confounded, another instructive warning against the application of the same name to two entirely different structures (see also p. 87).

Perugia further remarks (p. 138) that if the "gregarinoid forms" be regarded as larval stages the adult forms represent a retrogression, inasmuch as the "gregarinoids" with a nucleus and the protoplasm regularly disposed, need only a cuticle to be monocystids, while the adult stages, destitute of a nucleus and with the protoplasm never regularly disposed, are much farther removed therefrom. Perugia was, however, unable to find any such "gregarinoid forms."

Kruse, however, says:

Very interesting is an observation of Mingazzini's, which the author can confirm. In the gall bladder of the Selachians are found, besides typical *Myxosporidia*, long-drawn-out, tailed bodies, which move in Gregarine fashion, but which, on the other hand, are connected by manifold transitions with the amœboid forms.

Spore formation.—Rapidity of spore formation is truly extraordinary, most of the individuals having spores formed or in course of formation in less than 15 minutes. At undetermined points in the endoplasm (in the middle or near the periphery) appear round vacuoles of clear protoplasm, which, like the ectoplasm, originate by a rapid transformation of the yellow protoplasm. This vacuole presently acquires an enveloping membrane, and within it is formed the spore. Its theca shows an oblique striation in two directions. Spores may arise in individuals whose protoplasm is little modified, i. e., almost entirely composed of yellow granules, the spores being then inclosed in a membrane, round in form, formed from the yellow protoplasm, and containing also a colorless refracting liquid; or the spores may form in colorless protoplasm, in this case without the enveloping membrane, the spores issuing free and floating in the bile. Where, as sometimes happens in the first case, spores form at the periphery, they form, in growing, a sort of crown around the individual, and the spore is not set free until the enveloping membrane is well formed (Mingazzini).

Normally the pansporoblast shows at some portion of its circumference a distinctly semilunar aggregation of protoplasmic granules. Under the influence of reagents (e. g., osmic and sulphuric acids) the pansporoblast membrane bursts, discharging its contents, and remaining as a hyaline empty sac (Perugia).

Spore.—Untailed; cuneate-ovate; capsules 4. Perugia saw the exit of the sporoplasm from a spore of the gall bladder of *T. narke*. The large striæ on the shell render the posterior border of the shell in contour dentate (Thélohan, 1892; see also p. 261).

Table of hosts.

Leydig.*	Mingazzini.†	Perugia.	Latest synonymy by Dr. Theodore Gill.	Common names.
	Mustelus		Galeus sp	
		Mustelus lævis	Galeus mustelus	Smooth dogfish.
Scyllium canicula.			Scylliorhinus canicula L	Large-spotted dogfish.
	Scyllium		Scylliorhinus sp	
		Scyllium stellare	Scylliorhinus stellaris	
	Pristiurus		Pristiurus melanostomus Bon	
Spinax vulgaris		Acanthias vulgaris.	Squalus acanthias L	Spiny dogfish.
Squatina angelus			Squatina squatina L	Angel-fish.
	Squatina		Squatina sp	
Torpedo narke		Torpedo narce	Torpedo torpedo Gmel	Electric ray.
	Torpedo		Torpedo sp	
		Torpedo marmorata.	Torpedo marmorata	
[Raja batis ‡]				
	Raja		Raja sp	Skate.
		Raja clavata	Raja clavata	Thornback.
	Trygon		Dasyatis sp	Stingray.
		Myliobatis aquila	Cephalentherus aquila	Eagle ray.

* By an evident misprint (*rinvenne* instead of *rinvenni*; "he found" instead of "I found") Perugia (Boll. Scientif., Pavia, 1890, XII, p. 136) states that Leydig, instead of Perugia himself, found this form in the series of hosts examined by Perugia.

† Mingazzini gives nothing but the generic name of the host. As there is nothing to indicate the identity of the species of hosts with those examined by the other authors, they are noted separately.

‡ This species I regard as distinct (see p. 261).

95. Chloromyxum fluviatile Thélohan, 1892. Pl. 39, fig. 4.

Bull. Soc. philomat. Paris, IV, pp. 173, 176, fig. 2; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 418; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 738, 739; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst none.

Myxosporidium.—The ectoplasm emits lobed pseudopodiæ. Endoplasm, when young, colorless; when older, yellow; color appearing not to be located in special spheres.

Spore formation.—Number of spores formed in each myxosporidium indefinite.

Spore.—Nearly regularly spherical; size about 5 to 7 μ; shell bivalve; bearing small, often difficultly visible, spines; ridge present; capsules 4; sporoplasm nonvacuolate.

Habitat.—Gall bladder of *Leuciscus* (*Squalius*) *cephalus* L.

This species is apparently rather rare; seen only twice; it is nearly related to *C. leydigii* (Thélohan).

96. Chloromyxum mucronatum Gurley, 1893. Pl. 39, figs. 5, 6.

(Psorosperm of *Gadus lota* Lieberkühn, 1854, Müller's Archiv., pp. 352–3, 368, pl. 14, figs. 5, 6; *ib.*, Lieberkühn, 1854, Bull. Acad. Roy. Belg., XXI, pt. 2, p. 22, name only; *ib.*, Leuckart, 1879, Parasiten des Menschen, 2 ed., p. 248, fig. 99*a*; *ib.*, Bütschli, 1882, Bronn's Thier-Reich, I, pl. 38, fig. 17; *ib.*, Balbiani, 1883, Journ. de Microgr., VII, pp. 201, 203, fig. 45; *ib.*, Balbiani, 1884, Léçons sur les Sporozoaires, pp. 130, 133, fig. 41;[1] *ib.*, Leuckart, 1886, Parasites of Man, 2 ed., p. 197, fig. 99*a*; *ib.*, Koch, 1887, Encyklop. d. gesammt. Thierheilkde u. Thierzucht, IV, p. 94, fig. 668, 3.)

Chloromyxum mucronatum, Bull. U. S. Fish. Com. for 1891, XI, p. 419; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

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[1] See also below, under *C. elegans* (p. 266).

Myxosporidium.—The largest attaining 75 μ ($\frac{1}{30}'''$ Lieberkühn), the smallest the size of a blood corpuscle; spherical or ellipsoidal, more rarely irregular, membraneless, containing irregularly scattered fat-like globules.

Spore formation.—Many myxosporidia appear destitute of fat granules, but show a large number of structureless gelatinous globules; other myxosporidia show partly the same globules, partly similar ones of the same size containing 4 capsules whose apices are approximated. Many globules show only faint indications of such capsules. Sometimes 2 such globules occur inclosed within a common structureless membrane. Besides these, developed psorosperms occur, both individually and in heaps, held together by a mucoid substance.

Spore.—Sharp-contoured, subglobular, mucronate anteriorly; length *ad max.*, 8 μ; capsules 4, converging anteriorly.

Habitat.—Free in urinary bladder of *Lota lota* L. (ling). Found in about 20 per cent of the fishes examined.

Remarks.—Lieberkühn emphasizes the striking resemblance between this species and those described by Leydig from the gall-bladder of the Plagiostomes (*Chloromyxum leydigii* and *C. incisum*). He notes, however, that *C. mucronatum* differs from Leydig's forms in the absence of a membrane around the myxosporidium, and in the absence of the pansporoblastic vesicles (Leydig's *Tochterblase*). From later researches it is easy to interpret Lieberkühn's results in harmony with those of Leydig, as the vesicle stage of the pansporoblast is merely a later stage of the gelatinous globules of the above description (see pp. 81, 286).

SUBGEN. SPHÆROSPORA Thélohan, 1892.

Etymology not given.

Bull. Soc. philomat. Paris, IV, p. 175; *Myxosoma* et *Mixosoma*[1], *ibid.*, p. 175; subgen. (including *Myxosoma* and *Mixosoma*) of *Chloromyxum*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, pp. 411–412, 418–419; *Sphærospora* et *Myxosoma*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *ib.*, Braun, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Definition.—Bicapsulate Chloromyxa; type *Chloromyxum* (*S.*) *elegans*.

Species.—The study which, through the kindness of Dr. Ohlmacher, I was able to make of *C.* (*S.*) *ohlmacheri* enabled me to recognize 2 other species in the literature which should be referred to this subgenus. The first is Balbiani's spore of *Acerina cernua*, which I have named *Myxobolus perlatus*. The median anterior and posterior mucronate projections and the median line shown in Balbiani's figures, can be respectively interpreted only as the ends and the intervening portion of the ridge. In other words, the valve-junction plane is vertical. The appearances are identical with those shown by *C. ohlmacheri*. The second is Bütschli's spore of the ovary of *Lota lota*. Though Bütschli's figures represent it as bicapsulate it should be compared with *C. mucronatum*.

[1] Type *Myxosoma dujardini*.

88. Chloromyxum (Sphærospora) elegans Thélohan, 1892. Pl. 40, fig. 1.

(Myxosporidian spores of *Gasterosteus aculeatus* and *G. pungitius* (*pars*), Thélohan, 1890, Annal. de Microgr., II, pp. 193, 200, 203, 209, pl. 1, fig. 1.)
Sphærospora elegans, Bull. Soc. philomat. Paris, IV, pp. 167, 175.
Chloromyxum elegans, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 419.
Sphærospora elegans, Braun, 1893, Centralbl. Bakt. u. Parasitenkde, XIV, p. 739.
Chloromyxum elegans, Braun, 1894, Centralbl. Bakt. u. Parasitenkde, XV, p. 87.

Synonymy.—In 1890 Thélohan described the present species and *M. medius* as spores occurring in the renal tubules of *G. aculeatus* and *P. pungitius.* He remarked that the 2 entirely different forms of spore are found in close association, occurring not only in the same kidney, but side by side in the same tube of the kidney. Their relation to each other could not be determined, as he was unable to trace them back to the myxosporidium.

M. Thélohan writes me (1893) that:

In putting an interrogation point in regard to the presence of *Sphærospora elegans* in the kidney of *Lota lota,* I had in mind Balbiani's fig. 41. The spores which that figure represents are indeed a little less regularly spherical than those of *Sphærospora* and present a more pronouncedly attenuated extremity. Not having observed *Myxosporidia* in the Lotas that I have been able to examine, I do not know whether these fish contain exactly the same species as *G. aculeatus.* The figures of Lieberkühn (Müller's Archiv., 1854, pl. 11, figs. 5, 6) certainly do not belong to *Sphærospora.* They, in fact, present 4 polar capsules, and are rather near *Chloromyxum fluviatile.* Still they form, I believe, a distinct species.

A close study of these figures has led me to doubt seriously whether Balbiani's fig. 41 can be correlated with *Chloromyxum* (*Sphærospora*) *elegans.* The whole question hinges upon the number of capsules in Balbiani's spore. The close similarity between his figure and Lieberkühn's fig. 6, the fact that quadricapsulate forms have frequently been figured by the authors as bicapsulate, and finally the close approximation in habitat (kidney and urinary bladder of same fish [1]), all point toward the synonymy given above.

Cyst none; myxosporidium unknown.

Spore.—Round, nearly spherical, untailed, 8 to 10 μ (Thélohan, 1892; 9 to 12 μ, *ibid.*, 1890). Ridge present, terminating in a slight projection at each end of the spore.

Habitat.—Almost constantly present in the renal tubules of *Gasterosteus aculeatus* (stickleback) and those of *Pygosteus pungitius* (9-spined stickleback); ? also in kidney of *Lota lota* [2] (ling); "accidentally" present in kidney of *Phoxinus phoxinus* L., ovary of *G. aculeatus* and that of *P. pungitius* (all *fide* Thélohan; the last two in a letter to the author, 1893).

Effects.—See p. 248.

[1] Balbiani does not give the seat. Thélohan cites it as the kidney (*fide* specimens in Collége de France?).

[2] The form habitant here I have referred to *Chloromyxum mucronatum* (see that species, and the paragraph above in this one).

89. Chloromyxum (Sphærospora) ohlmacheri Gurley, 1893. Pl. 40, fig. 8; pl. 41, figs. 1–3.

(*Myxosporidia* of *Bufo lentiginosus* Shaw, Ohlmacher, 1893, Journ. Amer. Med. Assoc., XX, pp. 561–7, plate, figs. 1–4.)

Chloromyxum ohlmacheri, in Whinery, N. Y. Med. Journ., LVIII, pp. 660-662, figure.

Cyst unknown.

Myxosporidium.—No myxosporidium could be detected. From this Ohlmacher concludes that:

It is probable that, in this case, the parasite did not reach its adult condition in its batrachian host, but here only passed one stage of its existence, that is, the spore stage.

Spore.—Transversely elliptic, about 6 μ long and 8 μ broad. Shell bivalve, valve-junction plane perpendicular to the longer axis of the spore; staining with gentian violet (Gram's method); exhibiting a well-defined undulate-parallel longitudinal striation, the optical expression of the spiral-coil structure of the shell. Ridge present, marking the line of junction of the valves. No loosened band (apparently springing, like a loosened barrel hoop, from the uniting edges of the spore-valves), such as Lutz describes, could be demonstrated.

Relative to the arrangement of the spore contents, Ohlmacher says:

On the side of the pole corpuscles opposite the plasmatic body the vacuole occurred. This space was unstained in specimens in which the excess of stain had been washed out; but in overstained spores the vacuole retained the dye, though not so strongly as the pole corpuscles and the plasmatic body.

Interpreted in connection with the orientation of the spore, this may be construed to mean that the contents of the shell cavity consist (from before backward), first, of a clear, nonstaining space (part of the pericystic space, and of course not to be confounded with *the* vacuole, which is intra-sporoplasmic); next, the capsules, and last (and most posterior), the sporoplasm.[1]

Capsules: Lying side by side, 2, occasionally only 1, a condition explicable, at least in part, Ohlmacher thinks, as spore mutilation in the technique; length, 3 to 3·5 μ; staining bright red, but showing no evidence of structure with Pfitzner's alcoholic safranin. Relative to their position, Ohlmacher remarks that—

The situation of these polar corpuscles on the side of the spore is peculiar, and in this respect our myxosporidia differ from those thus far described.

As shown below, this view is due to a nonorientation of the spore.

In safranin preparations the bright red capsules were frequently observed outside of the spores in the tissue of the kidney. Whether these extra-sporal capsules had migrated during life or had been displaced by the technique, it is, Ohlmacher says, impossible to assert positively. He continues:

I am of the opinion, however, that the migration of the pole corpuscles is a natural phenomenon in these organisms, and that it has as much or more weight in the life

[1] Subsequent examination of the spore confirmed this orientation.

history than the migration of the plasmatic mass usually described. The presence of many empty capsules[1] in the sections would lend weight to this view of the expulsion of the contents of the spore, and in fig. 4*a* I have represented a capsule[1] with a single pole corpuscle, which appeared to be in the act of escaping through a rent in the capsule.

Filaments best seen in sections, stained with Babes's anilin-water safranin where they stain prominently yellow; length varying considerably, many occurring curled up at the end as though only partly unwound, measuring when fully projected 6 to 8 times the spore-breadth, extending far into the surrounding tissues; sometimes dimly visible through capsular wall; extruded parallel to the shorter (antero-posterior) diameter of the spore.

Sporoplasm varying considerably in size and shape, and sometimes filling all the extra-capsular portion of the shell cavity; in this condition presenting no evidence of segmentation. In other cases less extensive, being sometimes very small and shrunken,[2] the sporoplasm then frequently showing a well-defined segmentation, the line of division extending through its middle [i. e., coinciding with the vertical plane]. Each sporoplasm-half envelops, in the form of a well-defined crescent, the corresponding capsule. Nonvacuolate (letter to author, 1893).

The sporoplasm stains with Pfitzner's alcoholic safranin a light pinkish hue, appearing under a Leitz $\frac{1}{12}$ in anilin-stained sections, delicately granular; no other structure discernible. Nucleus and evidence of nuclear contents invariably absent. Ohlmacher adds:

I could not even demonstrate the micrococci-like particles in the plasmatic body, as have been described by Lutz, or the safranophile particles of Bütschli.

Micro-chemistry: Ohlmacher finds the sporoplasm constantly cyanophilous, the capsules constantly erythrophilous. This occurs with carbolic fuchsin and carbolic iodine green (Russell's method); the capsules staining a brilliant red, the sporoplasm light green. The tint of the sporoplasm (consequently also the degree of dichromophilism) varies from violet to a well-defined green. This difference depends in large part on the developmental stage of the sporoplasm. Where large and unsegmented and occupying a large part of the shell cavity the green stain was less clearly defined; where more condensed and divided into the 2 crescents closely applied to the capsules, the green was well marked. A striking differentiation is produced by Pfitzner's alcoholic safranin, followed by aqueous methyl blue, rapid washing in alcohol, and clearing in xylol. The Biondi-Heidenhain triple stain and Watasé's cyanin-chromatrop failed, a result attributed to nonpenetration of the shell by the stain. On the other hand, the success of fuchsin-iodine-green and safranin-methyl-blue seems, Ohlmacher says, to be due solely to their more powerful staining properties, which permit them to penetrate the somewhat resistant shell.

This dichromophilism of the capsule and sporoplasm Ohlmacher com-

[1] By this term he means the spore-shell.

[2] Due, I think, to absolute alcohol fixation.

pares with the observations of Auerbach and others,[1] but without affirming Auerbach's interpretation of dichromophilism as indicative of nuclear bisexuality.

Habitat.—Host: *Bufo lentiginosus* Shaw (a toad). The single specimen was a large female, sent with a lot of frogs (which latter showed no unusual mortality) from the country to the laboratory early in September. A gradual increase in size took place in the toad and finally became particularly noticeable, but this was unconsciously ascribed to development of ova. About November 15 the specimen was noticed lying on its back, apparently dead, showing on careful examination, however, a faint flutter of the pleural wall over the heart, but no respiration.

Dr. Ohlmacher has kindly informed me (letter, 1893) that the locality whence all the specimens were obtained is Sycamore, De Kalb County, Illinois. Three more specimens of *B. lentiginosus* collected there July, 1893, showed the same myxosporidian species, but not in such numbers. All of the toads thus far examined have been females. (Later the same condition was found in the males.)

Seat: Almost invariably present in larger or smaller groups in the lumen of the urinary tubules; never within the epithelial cells, which latter never show the nuclear metamorphosis occurring with the intracellular *Sporozoa*; occasionally found in sections among the blood corpuscles in the large blood vessels, it being here impossible to say that it might not have been due to displacement during the technique; never found in the glomeruli; occurring sparingly in the collapsed folds of the urinary bladder, always on the bladder surface, never imbedded in the bladder wall; also free in the urine.

Microscopic technique.—Fixation by absolute alcohol or Flemming; imbedding in xylol-paraffin; affixing by the water-albumen method; staining with various anilins.

Mode of infection.—As to the origin of the myxosporidian infection, it can only be conjectured, Ohlmacher says, that it must have occurred by way of the cloaca to the bladder, and from here the parasites ascended the urinary passages. It is probable that in this case the parasite did not reach its adult condition in its batrachian host, but here only passed one stage of its development, the spore stage.

Pathology.—Abdomen containing a large quantity of straw-colored, serous fluid derived from the abdominal cavity and the subcutaneous lymph sinuses; to this fluid the distension was in large part due. The organs showed nothing unusual, except that the urinary bladder was

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[1] Ohlmacher gives reference as follows: Auerbach, Ueber einen sexuellen Gegensatz in der chromophile der Keimsubstanzen; Sitzgsber. k. preuss. Akad. d. Wissensch. Berlin, June 25, 1891, pp. 713–750; Adamkiewicz, Untersuchung ü. d. Krebs u. d. Princip. seiner Behandlung, Wien u. Leipzig, 1893; Noeggerath, Beiträge z. Struktur u. Entwickelung d. Carcinoms, Wiesbaden, 1892; Watasé, Journ. Morphol., 1892. VI, pp. 481–493.

largely distended and the kidneys were twice the normal size. Ovaries moderately developed, but not sufficiently to account for the abnormal distension. Besides the *Myxosporidia*, the kidneys showed an extensive invasion of bacteria.

Effects.—There can, Ohlmacher says, be scarcely any doubt that the *Myxosporidia* were the direct factors in the pathologic changes. Their number was very great, the tubules of both kidneys being filled. The mere mechanical effect must have been obstruction of secretion and as a remote result ascites and general œdema. Undoubtedly the presence of large numbers of bacteria (to be regarded as a secondary infection) was a potent factor in hastening death.

Subsequent comparisons with sections of the kidneys of other toads show the tubules in the first toad to have been dilated and their lining cells to have been flattened and less rich in protoplasmic material than normal. The kidneys of the 3 comparatively slightly infected toads collected in July, 1893, showed no macroscopic lesions. Microscopically no bacteria could be found. The absence of the bacteria, Dr. Ohlmacher thinks, probably had as much weight in determining the comparative innocuity as the smallness of the number of *Myxosporidia* (letter, 1893).

Through the kindness of Dr. Ohlmacher I have been enabled to examine his specimens, and can add the following:

Orientation of the spore.—The capsules are 2, in 1 group, anterior; valve-junction plane, vertical; shorter axis of spore, antero-posterior; longer axis, transverse. Sporoplasm showing no evidence of a vacuole, even in iodine-stained sections. Beyond a slight median notch in its posterior border (produced, I believe, by a slight inward, as well as outward, projection of the ridge), I was not able to find any evidence of sporoplasm-segmentation, and am therefore compelled to regard this as an optical illusion, produced by the overlying ridge and reinforced by the posterior median notch.

This orientation necessitates the reference of this species to *Chloromyxum* (*Sphærospora*). From *C. (S.) elegans* it is distinguished by its transversely elliptic outline and its dimensions. The fact of its identical organal distribution (renal tubules) should also be noted.

Finally, Dr. J. B. Whinery has recently published the results of a careful detailed restudy of this species. He gives the following table, showing the equivalence of Ohlmacher's nomenclature with that I have adopted:

Ohlmacher's term.	Present equivalent.
Capsule	Shell.
Pole corpuscle	Capsule.
Plasmatic mass	Sporoplasm.
Projectile thread	Filament.
Sides	Anterior and posterior ends.
Ends	Sides.
Vacuole	Pericystic space.

From Dr. Whinery's paper the following data are condensed:

[Page 660] All the toads examined (about a dozen in all) were from Sycamore, De Kalb County, 60 miles west of Chicago. The toads were kept in the laboratory sink, and taken from this, from time to time, for examination.

The extent of the infection must vary with the surroundings and environment of the animals. Seven toads examined—2 males and 5 females—showed 1 male and 4 females infected. It is quite probable that the mortality was increased by the confinement in a comparatively small space. During the confinement the toads became stupid, moved about but little, and in 2 or 3 days began to die, 1 dying every day or two. Some of them lived about 3 weeks. Before death no change in external appearance was noticed, except in some cases a distension of the abdomen. Post mortem some increase in amount of peritoneal fluid was usually noticed, but in the toads examined by Whinery this was never so large in amount as in the toad examined by Ohlmacher. The abdominal viscera showed signs of congestion; the intestines being usually distended with gas and the kidneys enlarged and in a congested state. The parasites were found only in the tubules and in the urinary bladder, and in the spore stage. Ohlmacher's view that they probably kill by mechanical pressure seems very plausible on account of the large number of parasites in the tubules.

[Page 661] This number varies in different specimens; sometimes only scattering tubules, in other cases large areas of tubules being filled with parasites. They were never found in the glomeruli or epithelial cells. In the bladder they were found in the folds of the mucous membrane. Ohlmacher has found them in urine collected during chloroform narcosis, in a clean basin.

Detailed Morphology of Spore.—Length about 6 μ; breadth about 8 μ; size slightly varying in the same preparation. Shape, slightly oval. Shell, showing a distinct striation, the striæ appearing to proceed from the shell of each lateral half and to center at the valve-junction, midway between the anterior and posterior ends. Spore showing at each end a slight projection,[1] running between which 2 points is the faint transparent ridge, marking the valve-junction. The projections represent the vertical optical section of the ridge. The spore is thus composed of 2 valves, their junction plane dividing the spore into 2 symmetrical halves. Two small knob-like thickenings (which show well in the fresh, unstained spore) can be seen at the anterior projection, 1 belonging to each valve. The spores often show cleavage at the anterior end along the line of the valve-junction. Capsules 2, round, 3 μ to 3·5 μ on an average, situate at the anterior end, 1 in each valve. A filament arises from each capsule, and, penetrating the shell, leaves the spore at the anterior end. The capsules seem to have the power of projecting and drawing in these filaments. Length of filaments often more than 4 to 8 times the diameter of the spore. Just after entering the spore, before reaching the capsule, they often appear in a spiral roll preparatory to being coiled in the capsule. Sporoplasm situated in the posterior end, extending to the sides, in form approaching a crescent; not completely filling the space posterior to the capsules; under high powers ($\frac{1}{12}$ Leitz) appearing homogeneous and finely granular; showing in fresh preparations the more highly refractive granules designated nuclei by Thélohan; these apparently vary in number and position in fresh spores, and never appear in hardened and stained preparations.[2] A vacuole could not be discovered in this species.

[1] "Termed by Gurley the 'micronate [mucronate] projection.'" This name was employed by me in a letter in a general sense only (*a* mucronate projection) and was not intended as an additional special term.

[2] Ohlmacher had only hardened material, a fact which, Whinery thinks, explains his failure to find nuclei. I can not believe, from Dr. Whinery's description, that the bodies he calls "nuclei" are really such, since they *disappear entirely* in hardened and stained specimens. Although I have not seen Dr. Whinery's material, I venture to suggest the possibility of their being fat globules.

Micro-chemistry.—The parasites were studied fresh (by teasing kidney tissue, and examining this in a hanging drop, or in fluid media of different kinds), and also after treatment with various fixing and staining agents. In the fresh state, a dilute solution of potassium hydrate caused a swelling of the spore, and brought out the shell and filaments plainly. Glycerin acts well as a medium for the examination of the fresh spore. Probably the best medium to use for the hanging drop is toad's urine. Iodine (aqueous solution) colors the spore a uniform brown. In fixing cover-glass preparations, no advantage was gained by fixing them in alcohol and ether, or in osmic acid, over that obtained by passing the covers through a flame. In the fresh state the filaments were made plainer in fixed cover-glass preparations [Page 662.] by a number of reagents. Aqueous methyl blue and Babes' anilin water safranin bring the filaments into view quite satisfactorily. As fixing agents, Flemming's solution, Heidenhain's mercuric chloride solution, absolute alcohol, Carnoy's acetic alcohol, and Perenyi's fluid were tried, the first and last being found unsuitable on account of the production of shrinkage and distortion. The fixed material was imbedded in xylol paraffin by the usual methods. Numerous separate and combined stains were employed with varying results, the capsules with almost all stains showing the greatest affinity for the coloring matter, the degree of affinity varying somewhat in different spores. Pfitzner's safranin is especially good, with a striking affinity for the capsules. Ohlmacher's dichromophilism was demonstrated with fuchsin and iodine green (Russell's method), and with safranin and methyl blue (Ohlmacher's method). "This chromophilous reaction is a very striking and possibly significant phenomenon in these organisms."

90. Chloromyxum (Sphærospora) perlatum Gurley, 1893. Pl. 40, fig. 2.

(Psorosperm of *Acerina cernua*, Balbiani, 1883, Journ. de Microgr., VII, pp. 201, 204, fig. 44; *ib.*, Balbiani, 1884, Léçons sur les Sporozoaires, p. 133, fig. 40.)
Myxobolus perlatus, Bull. U. S. Fish Com. for 1891, XI, p. 415; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

No description (see also p. 265).

Habitat.—On *Acerina cernua* L.

91. Chloromyxum (Sphærospora?) sp. incert. Pl. 40, fig. 3.

Spore of *Lota vulgaris*, Bütschli, 1882, Bronn's Thier-Reich., I, pl. 38, fig. 22.

Cyst unknown.

Myxosporidium.—Not described. The sporoblast produces a single spore?[1]

Spore.—Not described. For the reasons given on p. 265, the present generic reference of this species is probably the correct one, and the species should be closely compared with *C. mucronatum*.

Habitat.—Ovary of *Lota lota* L. (= *vulgaris*); ling.

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[1] "Each spore in a special transparent membrane."

92. Chloromyxum (Sphærospora) dujardini Thélohan, 1892. Pl. 40, figs. 4-7.

Cyprinus rutilus, "psorosperms" of.	Cyprinus erythrophthalmus, "psorosperms" of.	dujardini.	Date.	Authority; reference.
×	×	....	1841	Müller, Müller's Arch., pp. 481, 486, pl. 16, fig. 4*b*, *c*.
×	×	....	1843	Müller, Rayer's Archiv. Méd. Comp., I, p. 226, pl. 9, fig. 4*b*, *c*.
× (*pars.*)	....	....	1843	Rayer, Rayer's Archiv. Méd. Comp., I, p. 269.
	×	....	1845	Dujardin, Hist. Nat. des Helminthes, p. 644, pl. 12, fig. 12 N_1, 12 N_2.
× (*pars.*)	×	....	1853	Robin, Hist. Nat. Végét. Par., p. 299, pl. 14, fig. 6.
×	....	....	1882	Bütschli, Bronn's Thier-Reich., I, pl. 38, fig. 5.
		Myxosoma et Mixosoma ..	1892	Thélohan, Bull. Soc. philomat. Paris, IV, p. 175.
		Chloromyxum	1893	Gurley, Bull. U. S. Fish. Com., XI, p. 419.
		Myxosoma ...	1893	Braun, Centralbl. Bakt. u. Parasitenkde, XIV, p. 739.
....	....	Chloromyxum	1894	Braun, Centralbl. Bakt. u. Parasitenkde, XV, p. 87.

Synonymy.—The first 6 references in the table, except those to Dujardin and to Bütschli, represent the same form, the later being mere copies of Müller. The fusion of the form observed by Dujardin with that observed by Müller is on the authority of Thélohan, who states (letter to the author, 1893) that he has observed his *Myxosoma dujardini* upon both *Leuciscus rutilus* and *L. erythrophthalmus*, and that he believes that Müller's and Dujardin's figures represent the same species. Bütschli's form is also probably referable here; size of the last, 0·46 mm.

Concerning the form observed by him in *Leuciscus rutilus*, Müller says:

Once there was found on the pseudobranchias (*Nebenkiemen*) a mass of small yellow cysts. The size of this mass was 4 lines. This time all the cysts contained elongate capsules [spores] with pointed anterior and bluntly rounded posterior ends (fig. 4*b*). On the flat border the convex surfaces were exactly equal and the 2 diverging vesicles were attached interiorly at their points.

Thus this form was never found coexisting in the same cyst with *Myxobolus cycloides*. Considering the great frequency of occurrence of the latter species such coexistence would be expected if they were merely different forms of one species. Their persistent nonassociation thus strongly reinforces the argument in favor of their specific distinctness drawn from their different characters.

Cyst not described.

Myxosporidium.—Spores imbedded in and held together by an almost diaphanous, ramified, glutinous mass, 1·25 to 1·50 mm. long, decomposable by water, analogous to the amœbæ, apparently destitute of an envelope (Dujardin).

Spore.—Oval, pointed anteriorly, broadly rounded posteriorly, length, 10 to 12 μ (0·0051‴ to 0·0054‴); breadth, 7 μ (0·0034‴) untailed; capsules 2, of equal size (Müller).

Habitat.—Encysted in the pseudobranchiæ of *Leuciscus rutilus* from German rivers; branchial lamellæ of *Leuciscus* (*Scardinius*) *erythrophthalmus* from the Vilaine, at Rennes, France.

V. CERATOMYXA Thélohan, 1892.

Etymology not given.

Bull. Soc. philomat. Paris, IV, pp. 169, 171, 175; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, pp. 411–12, 420; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 738–9; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Definition.—Chloromyxidæ with bilaterally symmetrical, transversely extended, subisosceles-triangular spores whose breadth greatly exceeds the length; valves hollow-conical with solid tips; sporoplasm unilaterally and asymmetrically situated; type, *C. sphærulosa.*

The position of this genus in the system depends upon the interpretation of its symmetry. Admitting (as we may safely do) that the position of the capsules marks the anterior extremity, the question arises whether the plane of junction of the valves is the vertical or the longitudinal. If it be vertical, we then have: (1) Vertical plane intercapsular; (2) spore laterally extended; (3) valves bilaterally subsymmetrical; (4) decided sporoplasmic bilateral asymmetry.

On the other hand the supposition that this plane corresponds to the longitudinal necessitates the following suppositions: (1) That the vertical plane can be *percapsular;* (2) that the spore is vertically extended; (3) valves superior and inferiorly subsymmetrical; (4) decided (sporoplasmic) supero-inferior asymmetry.

While admitting the striking anomaly exhibited by this species in its bilaterally asymmetric distribution of the sporoplasm (which certainly warrants its generic separation), it seems more easy to accept this than to admit (*a*) that the longitudinal plane can be *percapsular*, [1] and (*b*) that the spore is greatly extended supero-inferiorly, of neither of which conditions any other known species exhibits an example. There are, however, species which exhibit, though in a less degree, bilateral asymmetry (*Myxobolus unicapsulatus*, *M. inequalis*, *M. strongylurus*).

Two other characters should be noted. As in the other forms habitant in the fluid-filled organs, the *Ceratomyxa* species are never seen "encysted." Further, 3 out of the 4 known species possess the striking peculiarity of *bisporogenesis*, each myxosporidium producing only 2 spores. The fourth species presumably (from Thélohan's silence) does not possess this character. It is well to note that this character is possessed by only one other species, viz: Perugia's *Myxosporidium merlucii*, a gall-bladder species provisionally and doubtfully referred to *Myxobolus* (see p. 242).

Finally, while this paper was passing through the press, M. Thélohan's recent paper[2] was seen. It seems to imply very strongly two things,

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[1] No known instance exists of 2 capsules being placed one above the other (i. e., in the vertical plane, which would thus be percapsular). The only species in which by any possibility the vertical plane could be asserted to be percapsular is *Cystodiscus? diploxys*, but here the condition is at least equally well (and I think much better) explained on the view that the *intercapsular* plane is the vertical.

[2] Compt. Rend. Acad. Sci. Paris, 1894, CXVIII, pp. 428–430.

viz: (1) That bisporogenesis must be admitted as a (very striking) generic feature; and (2) that if, as Perugia asserts, *Myxobolus merlucii* possesses this character, it is in all probability a *Ceratomyxa*, and not a *Myxobolus*. And two facts confirm this latter view, viz: The improbability in *Myxobolus* of a gall-bladder habitat and the rarity of spores whose breadth exceeds the length. Perugia's species is, however, provisionally left under *Myxobolus*, on account of his positive statement as to the presence of an iodinophile vacuole.

The following is an abstract of Thélohan's paper:

[Page 429] Besides the species formerly published[1] in which the myxosporidium produces but 2 spores, I have since confirmed the same peculiarity in a rather large number of new forms in the gall-bladders of certain Mediterranean fishes. All these 2-sporing species belong to my family "Myxidiées," the greater part of them being clearly referable to *Ceratomyxa*, while the others, by successive modifications of spore-form, establish a transition between that genus and *Sphærospora*. This last connects the 2-sporing species with the many-sporing, and at the same time, by its habitat, the free species to the tissue-imbedded forms.

There is thus no absolute separation between the 2-sporing and the other *Myxosporidia*. The 2-sporing always live a free amœboid life in the bile-fluid and exhibit a very great motility, owing to specialized pseudopodia heretofore described.

These 2-sporing *Myxosporidia* with localized pseudopodia and rapid movements represent the most elevated type of organization. As regards the interpretation of [Page 430] the facts, are they perfected types derived from inferior, or are they the primitive type, the others, especially the tissue-imbedded species, being forms degraded by a more pronounced (a, so to speak, more intimate) parasitism? Thélohan favors the latter view. Great stress is to be laid upon the progressive increase in the number of spores occurring *pari passu* with degradation of form and increase of parasitism, such increase of reproductive elements being always one of the most constant attributes of parasitism.

84. **Ceratomyxa arcuata** Thélohan, 1892.
Compt. Rend. Acad. Sci. Paris, CXV, p. 1091.

Cyst none.

Myxosporidium.—Of variable form, diameter apparently not exceeding 35 or 40 μ; destitute of prolongations. Endoplasm finely granular and homogeneous, containing some scattered fatty globules; destitute of spherules. Pseudopodia ectoplasmic, lobed; the filiform variety absent.

Spore.—Relatively very small; length, 5 μ; breadth, 40 μ.

Habitat.—Gall-bladder of *Onus tricirratus* (=*Motella tricirrata*) collected at Roscoff, in August, 1892.

Remarks.—This differs from the other species of the genus principally in its much smaller size.

85. **Ceratomyxa agilis** Thélohan, 1892.
Compt. Rend. Acad. Sci. Paris, CXV, pp. 962–3.

Myxosporidium.—Attaining a maximum length of 85 μ, and a maximum breadth of 20 μ; assuming various forms, most frequently elongated, subcylindric, a little swollen at the middle. One end (which on account of being constantly foremost in progression is to be regarded

[1] Compt. Rend. Acad. Sci. Paris, 1894, CXVIII, pp. 428–430.

as the anterior), rounded; the other (posterior) usually attenuated, pointed, sometimes, however, swollen, rounded or bifurcate, or 7–, or 8– (or more) lobed. Limit between ectoplasm and endoplasm almost indistinguishable; myxoplasm finely granular, presenting constantly, near the anterior end, grouped in variable number, some small, very refringent, fatty globules.

Pseudopodia differing markedly from those of other *Myxosporidia*, always limited to anterior end; number variable up to 7 or 8, perfectly distinct from one another, almost filiform, progressively attenuating to their drawn-out pointed extremities; length very considerable, *ad max.* one half that of the myxosporidium; composed of exceedingly fine granular plasma resembling the ectoplasm of other *Myxosporidia*, whence their ectoplasmic nature may be inferred.

Movements of pseudopodia very rapid, describing a semicircle, always from before backward. Thélohan could not determine whether, upon arriving at their limit of backward motion, the pseudopodia fuse with the myxosporidium or move forward to repeat their sweep. Locomotion of myxosporidium thus produced, relatively rapid (3 times its length in 25 seconds). Remainder of myxosporidium motionless, apparently, however, possessing a certain contractility, as is seen when the anterior (pseudopodial) end becomes lodged against an obstacle.

Spore.—Similar to that of *Ceratomyxa sphærulosa;* breadth 60 μ. Never more than 2 spores in one myxosporidium.

Habitat.—Free in the gall-bladder of *Dasyatis pastinica* L. (=*Trygon vulgaris*) sting-ray at Concarneau in September, 1892.

86. Ceratomyxa appendiculata Thélohan, 1892.
Compt. Rend. Acad. Sci. Paris, cxv, pp. 963–964.

Cyst none.

Myxosporidium.—Presenting special characters which clearly distinguish this species. Fully developed forms assume very irregular and very variable shapes; remarkable for the presence of 1 to 4 or 5 immovable prolongations, composed of an endoplasmic axis and an ectoplasmic covering, which extend out from a central portion of a very variable form. Length of prolongations may reach twice the diameter of the central portion. Pseudopodia lobed, originating from the ectoplasm of the central mass at no fixed point, which is changeable from moment to moment.

Spore-formation.—Taking place in the above-mentioned central portion, each myxosporidium producing 2 spores.

Spore.—Length (?), 5 to 8 μ; breadth (?), 65 μ.

Habitat.—Free in the gall-bladder of *Lophius piscatorius* (angler) collected at Roscoff and at Le Croisic in August and September, 1892.

87. Ceratomyxa sphærulosa Thélohan, 1892. Pl. 41, fig. 4.

Bull. Soc. philomat. Paris, IV, pp. 171–3, 175, fig. 1; *ib.* Thélohan, 1892, Compt. Rend. Acad. Sci. Paris, CXV, pp. 961–2; *ib.* Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 420; *ib.* Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, pp. 738–9; *ib.* Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst, none.

Myxosporidium.—Spherical or ovoid; youngest stages exhibiting very distinct amœboid movements, colorless; older individuals yellowish, presenting a very remarkable constitution. Ectoplasm thin, emitting lobed pseudopodia, with very slow movements. Endoplasm appearing riddled with small (3 or 4 μ) clear spheres between which lies a grayish, finely granular plasma. Spheres often exhibiting, grouped at their center, a variable number (most frequently 5 or 6) of small yellow, brown, or greenish granules which resist nitric acid and potassium hydrate longer than the spheres which envelop them. Thélohan was unable to express any opinion as to the nature of the spheres, which, he remarks, constitute one of the most remarkable peculiarities of this species.

Spore formation.—Each myxosporidium forms at the most 2 spores; never more. Solid distal portion of valve folded back along the posterior border during development. Thélohan notes the similarity in this respect to the development in the tailed *Myxobolus* species (see p. 248) and says that the anterior convexity of the curve presented by the long (transverse) axis seems the effect of this primitive arrangement.

Spore.—Transversely extended, symmetrically (or subsymmetrically) double scalene-triangular; length, 8 to 10 or 12 μ; breadth, 90 to 100 μ.[1] Shell bivalve; valves right and left; symmetrical or subsymmetrical; shape of each valve hollow-conical, with the distal extremity solid for a variable distance; valves united along the cone bases, a slender ridge marking their line of junction. The shell cavity thus consisting of 2 (lateral) halves, one of which is always occupied by a variable number of small very pale masses whose exact nature is unknown, but which seem to represent the residue of capsule formation.

Sporoplasm.—Constantly situated in the other half of the shell cavity, of which it occupies only a relatively very small portion; finely granular; no iodinophile vacuole.

Capsules.—Two, the largest known, filament very clearly seen, coiled; extrusion easily produced by potassium hydrate or ether, each capsule presenting as a rule a special opening placed on one side of the suture.

Habitat.—Gall bladder (free floating in bile) of *Galeus mustelus* (=*Mustelus vulgaris*) smooth dogfish and of *Galeorhinus galeus* (=*Galeus canis*) taken at Valéry-au-Caux, by Balbiani, in August, 1891.

[1] Thélohan gives the dimensions reversed (*i. e.*, as length 100, breadth 8 to 10 or 12 μ) but this is of course a wrong orientation. Similarly with other species.

Fam. CYSTODISCIDÆ Gurley, 1893.

Bull. U. S. Fish Com. for 1891, XI, pp. 412–13; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Definition.—Phænocystes whose spores possess antero-posterior and bilateral symmetry; capsules in 2 groups situated at the (anterior and posterior) ends; a bivalve shell, the plane of junction of whose valves is perpendicular to the longitudinal plane; condition of sporoplasm unknown; type genus *Cystodiscus*.

To the family as thus defined, I have provisionally (by way of taxonomic necessity) approximated Thélohan's genus *Sphæromyxa*. It is characterized, Thélohan says, by the structure of the spores, especially by the form of the filaments and their disposition in the capsule. In the absence of figures, the orientation of the spore, upon which classification must be based, is uncertain. The double grouping of the capsules necessitates the approximation (at least among known genera) of this genus to *Myxidium* or to *Cystodiscus*. Between the last two, the presence of a membrane around the myxosporidium and especially the bivalve structure of the spore would seem (at a taxonomic guess) rather to approximate *Sphæromyxa* to *Cystodiscus*.

It may be frankly admitted that, as at present composed, this family is somewhat unsatisfactory and must be held subject to revision, probably in the direction of elision. For of the species with the capsules in 2 groups we now know (excluding *Myxidium ? sp.* 102, about which hardly any data exist) 5 species: *Cystodiscus immersus*, *Cystodiscus ?? diploxys*, *Sphæromyxa balbianii*, *Myxidium lieberkühnii*, *Myxidium ? incurvatum*. Of these *M. lieberkühnii* presents a sufficiently distinct group of characters to warrant its delimitation as the type of a family. The other 4 species then agree in two very important characters, viz:

1. Arrangement of capsules in 2 groups.
2. Presence of a bivalve shell.

Further than this, however, our analysis can not, for want of data, be at present safely pushed. Indeed, I have even left *Myxidium ? incurvatum* under *Myxidium* (where in all probability it does not belong) rather than place it elsewhere at random. Obviously the next step is the determination of the 3 symmetry planes and the orientation of the valve-junction plane. I suspect the future will separate generically *C. ?? diploxys* from *C. immersus*, the former appearing to have the valve-junction plane parallel and the latter to have it perpendicular to the longitudinal plane. In the present uncertainty, however, especially as long as the symmetry-relations of *Sphæromyxa* are so dubious, the present provisional arrangement is probably preferable to another new genus, and perhaps a family.

VII. CYSTODISCUS Lutz, 1889.

Etymology not given.

Centralbl. f. Bakt. u. Parasitenkde, v, p. 88; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, xi, pp. 411–13; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, xv, p. 87.

Definition.—Characters those of the family; type, *C. immersus.*

Whatever may be the ultimate taxonomic destination of the species here included, the genus will, I think, stand, as it is the first in order of priority, having the spore with the capsules in 2 groups, and a bivalve shell.

97. Cystodiscus immersus Lutz, 1889. Pl. 42, figs. 1–10.

Centralbl. f. Bakt. u. Parasitenkde, v, pp. 84–88, figs. 1–10 separately and subsequently; *ib.*, Gurley, 1893, Bull. U. S. Fish Com. for 1891, xi, p. 413; *ib.*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, xv, p. 87.

Cyst none.

Myxosporidium.—Youngest forms unknown. Hoping to find them in the tadpoles, Lutz examined about a dozen, but the gall-bladders were entirely free; in frogs and toads only a little larger, however, myxosporidia were found, but they (even the very small ones, less than 0·1 mm. in diameter) already showed the stiff disk form. In number, usually several, often very many (30 to 50), visible through the bladder wall, appearing macroscopically as round transparent disks or leaflets, as thin as paper, with frequently a whitish border in which the upper and under surfaces meet directly (without the intervention of a lateral surface as in a cylinder); upper and under surfaces very slightly convex, the thickness being only $\frac{1}{20}$ to $\frac{1}{10}$ of the diameter; body-form thus feebly biconvex lenticular, ranging in diameter from the limits of visibility to 1·5 or 2 mm.

Ectoplasm forming a plainly perceptible, transparent, structureless membrane, completely resistant to the bile and noticeably so to chemical reagents, disintegrating on prolonged immersion in water; preserving the form of the organism which otherwise almost certainly would, on account of its great thinness, become wrinkled and folded, but whose borders have a subcircular outline. Ectoplasm often containing great numbers of micrococcus-like bodies, which, as they brown only very slightly with osmic acid, can scarcely be pure fat. They also can not be cell-nuclei.

Endoplasm containing numerous large vesicles, polygonal-flattened by mutual pressure, producing the appearance of a cellular structure. Vesicles possessing a subglobular contour, showing no trace of a nucleus; upon rupture of the ectoplasm, escaping spontaneously into the bile, in which (also in alkaline solutions) they immediately vanish under the eyes of the observer, probably on account of the solution of a delicate surrounding membrane and the subsequent solution of their contents. Amœboid movements are completely excluded by the membranous character of the ectoplasm. No traces of change of form or place were seen.

Spore formation.—Beginning with individuals scarcely one-tenth the maximum size, the number of spores being then, however, relatively as well as absolutely less; number increasing *pari passu* with growth, individuals of equal size not necessarily showing, however, equal numbers. In specimens largest and most rich in spores the latter show themselves scattered over the surface at very short intervals, while on the borders they form a compact zone visible macroscopically as a white ring.

Pansporoblast?: Myxosporidia of various ages tolerably frequently show a spore-foundation [*Sporenanlage*] in the form of a smaller, more elongate, and only delicately outlined oval, containing two small pale perfectly round capsules (somewhat removed from the poles), which inclose a tolerably large dark biconcave-ended cylindrical rest-body (*Restkörper*). The delicately outlined oval contracts its bulk, its outline clears up, and the shell and capsules become thicker and very prominent. Valve-connection takes place through a process of the shell, and the spore becomes more ventricose.

Spore.—Lying outside the vesicles, always arranged in pairs, the latter rather irregularly scattered under and only loosely connected with the ectoplasm, concentrated in greatest numbers along the borders, forming a white ring. Length of mature spore, 12 to 14 μ; breadth, 9 to 10 μ; regularly oval, with blunt ends; spore showing no independent movements except filament extrusion.

Shell rather thick and firm, indistinctly and finely transversely striate, possessing the usual resistance to chemical reagents; bivalve, the valve-junction plane oblique (like the diagonal of a rectangle), inclined about 45° to the "equatorial" [transverse?] plane. This condition doubtless stands, Lutz says, in connection with the position of the capsules at either end, one valve lodging each. Around the border of each valve is placed, hoop-like, a little elastic rod, plainly projecting in profile, rebounding, when treated with potassium hydrate, in the form of a more or less extended band, the valves thereby becoming loosened, a piece often being torn away. Lutz remarks that these observations agree with Balbiani's (p. 223). Lutz, however, never saw any connection of spore-pairs through the medium of the loosened bands.

Capsules 2, separated, 1 at each end, subglobular-pyriform, slightly sharper anteriorly, glittering strongly in water or in bile, only slightly so in glycerin and other refractile fluids; size diminished by extrusion of filaments, walls plainly double-contoured. Filaments difficultly perceivable when fully coiled, plainly visible when half uncoiled; extrusion frequent in bile, not so common in water; extrusion also producible by various reagents, most certainly by potassium hydrate. Length, 4 to 5 times that of the spore-length.

Sporoplasm transparent, first becoming plainly visible after the action of coagulants, as an irregular, very low and biconcave-excavated cylinder. Lutz could find no true nuclei, either before or after development. Micrococcus-like corpuscles (similar to those in the ectoplasm, see above) were present, but on account of their inconstancy, these must be regarded as plasmatic secretions.

Exit of sporoplasm.—Never observed, prolonged immersion in water producing only a gaping of the valves, with or without a falling out of the capsules.

Habitat, etc.—Gall-bladder (free-floating in and escaping with the bile) of *Bufo agua* (toad) in every one of 50 half-grown to grown individuals taken at the most various times at one locality in Brazil; parasites mostly multiple, sometimes as many as 50; also in young specimens of *Cystignathus ocellatus* (toad) from 2 localities in Brazil. On the contrary they were absent from 2 large individuals of *Bufo agua* from other provinces of Brazil. They were also absent from all the tadpoles examined and from metamorphosed toads from several localities.

Effects.—The myxosporidia observed appeared in nowise to impair the histological integrity of the gall-bladder.

98. Cystodiscus ? ? diploxys Gurley, 1893. Pl. 42, figs. 11–13.

Pyralis (or Tortrix) viridana, psorosperms of.	diploxys.	Date.	Authority; reference.
×	....	1866	Balbiani, Journ. Anat. et Physiol., Paris, III, pp. 600–2.
×	....	1867	Balbiani, Journ. Anat. et Physiol., Paris, IV, pp. 275, 276, 335 (footnote), pl. 12, figs. 10–12.
×	....	1882	Bütschli, Bronn's Thier-Reich, I, p. 590.
×	....	1890	Pfeiffer, Virchow's Arch. f. path. Anat. u. Physiol., CXXII, p. 559.
×	....	1890	Thélohan, Annal. d. Microgr., Paris, II, p. 193.
×	....	1892	Henneguy and Thélohan, Compt. Rend. hebdom. Soc. Biol. Paris, IV, p. 587.
×	....	1893	Perrier, Traité de Zool., p. 459.
....	Cystodiscus?	1893	Gurley, Bull. U. S. Fish Com. for 1891, XI, pp. 411–13.
×	....	1893	Braun, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739.
....	Cystodiscus?	1894	Braun, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Cyst.—Spherical, 12 to 15 (in 1 individual 4) in number, 230 to 400 μ. Membrane rather thick. Contents rounded masses composed of fine brownish granulations suspended in a viscid homogeneous liquid. In 1 cyst (pl. 42, fig. 12) the parasites were mixed with numerous fat-like globules, insoluble in caustic soda; coloring wine red with iodine.

Spore.—Greatly resembling the "psorosperms" of fishes; elliptic or slightly flattened, traversed by a ridge apparently marking the line of valve junction. Sometimes showing 2 small brilliant twin grains placed at one of their extremities, sometimes 4 grains disposed in pairs at the 2 "ends"; not visibly affected by concentrated alkalies or feeble acids; becoming brilliant and homogeneous in salt water.

Habitat.—In the free state or inclosed in great spherical cysts in the abdominal cavity of the butterfly of *Tortrix viridana* (an insect).

Concerning this species Bütschli says:

Balbiani has observed cysts in the body cavity of a butterfly (*Pyralis viridiana*) which were filled with corpuscles possessing a structure similar to that of the myxosporidian spore. The observation is, however, not sufficient to demonstrate that it belongs to the *Myxosporidia*.

Thélohan and Henneguy regard it as a myxosporidian, and it is difficult for me to think otherwise.

VIII. SPHÆROMYXA Thélohan, 1892.

Etymology not given.

Compt. Rend. Acad. Sci. Paris, CXV, p. 1093; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 737.

Definition.—Characters to be inferred from those of the type species, *S. balbianii.*

After several vain attempts to draw up a satisfactory generic definition as between this genus and *Cystodiscus*, I have concluded that at present there are not in the record sufficient data for their accurate delimitation.

99. Sphæromyxa balbianii Thélohan, 1892.

Compt. Rend. Acad. Sci. Paris, CXV, pp. 1091–3; *ib.*, Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 738.

Myxosporidium.—Generally visible to the naked eye as a small opaque, more or less regular, usually subspherical mass, occupying a variable part of the bladder and escaping with the bile; yellowish or greenish-yellow, of a relatively firm consistence, permitting of handling. Attempts at teasing render evident the presence of a thin membrane. Under the microscope the myxosporidium shows absolutely exceptional characters. Ectoplasm forming a clear, homogeneous zone, presenting in sections a very clear striation. Endoplasm more granular, inclosing numerous spores.

Spore.—Resembling that of *Myxidium lieberkühnii*, elongate, slightly swollen at middle; extremities abruptly truncate, cut squarely off, so to speak, so as to present very sharp "lateral" angles; "length" [?] 13 to 16 μ; "breadth" [?] 5 μ. Shell bivalve, finely striate, parallel to the longer axis. Capsules 2, one at each "extremity," their axes oblique and oppositely directed with reference to the longer [transverse?] diameter of the spore. Filament very peculiar, forming a relatively very short (average length 15 μ) cone, the diameter of whose base nearly equals the breadth of the extremity of the spore. Exit produced by iodine water, potassium hydrate, sulphuric acid, etc. The mode of coiling is equally peculiar, the axis of the coil being perpendicular to the long axis of the capsule. Sporoplasm forming a single mass, destitute of an iodinophile vacuole; nuclei, 2; the pericornual nuclei (Thélohan's "nuclei of the capsulogenous cellule") are also present.

Habitat.—Free in the gall bladder of *Onus tricirratus* and *O. maculatus* (=*Motella tricirrata* and *M. maculata*); very common, especially at Roscoff.

Fam. MYXIDIIDÆ Gurley, 1893.

("Myxidiées" (*pars*) Thélohan, 1892, Bull. Soc. philomat. Paris, IV, pp. 173, 175); *Myxidiidæ*, Bull. U. S. Fish Com. for 1891, XI, pp. 412, 420; Myxidiea [Thél.] Braun, 1893, Centralbl. f. Bakt. u. Parasitenkde, XIV, p. 739; *Myxidiidæ*, Braun, 1894, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

Definition (provisional as regards negative characters).—*Phænocystes* destitute of antero-posterior, but possessing bilateral symmetry; capsules in 2 groups in the (right and left) wings; no bivalve shell; no vacuole; type (and only) genus *Myxidium*.

IX. MYXIDIUM Bütschli, 1882.

Etymology not given.

Bronn's Thier-Reich, I, pl. 38; *ib.*, Lankester, 1885, Encycl. Britan., 9 ed., XIX, p. 855; *ib.*, Thélohan, 1892, Bull. Soc. philomat. Paris, IV, p. 175; *ib.*, Weltner, 1892, Sitzgsber. Ges. Naturf. Freunde Berlin, p. 351; *ib.*, Perrier, 1893, Traité de Zool., p. 460.

Definition.—Characters those of the family; type, *M. lieberkühnii.*

100. Myxidium lieberkühnii Bütschli, 1882. Pls. 43-46; pl. 47, figs. 1-5.

Esox lucius "psorosperms" etc., of.	lieberkühnii.	esocis.	Date.	Authority; reference.
×	....	....	1854	Lieberkühn, Müller's Archiv., pp. 5, 6, 349-52, pl. 14. figs. 1-4.
×	....	....	1854	Lieberkühn, Bull. Acad. Roy. Belg., XXI, pt. 2, p. 23.
×	....	....	1879	Leuckart, Parasiten des Menschen, p. 246, fig. 98.
×	....	....	1880	Gabriel, Jahres-Ber. schles. Gesellsch. f. vaterl. Cultur f. d. J. 1879, LVII, pp. 188-95.
×	....	....	1881	Bütschli, Ztschr. f. wiss. Zool., XXXV, pp. 638-48, pl. 31, figs. 25-40.
×	....	....	1882	Zoolog. Record for 1881, XVIII, *Prot.*, pp. 34-35.
	Myxidium.	....	1882	Bütschli, Bronn's Thier-Reich, I, pp. 593-5, pl. 38, figs. 12-15.
×	....	....	1883	Balbiani, Journ. de Microgr., VII, pp. 200-1, 274-5, fig. 64.
×	....	....	1884	Balbiani, Léçons sur les Sporozoaires, pp. 126, 129-30, fig. 45.
	Myxidium.	....	1885	Lankester, Encyclop. Britan., 9 ed., XIX, p. 855, fig. xvii, 34.
×	....	....	1886	Leuckart, Parasites of Man, 2 ed., p. 196, fig. 98.
		Psorospermium.	1887	Koch, Encyklop. d. gesammt. Thierheilkde u. Thierzucht, IV, p. 94, fig. 668, 1.
×	....	....	1888	Pfeiffer, Zeitschr. f. Hygien. Leipzig, IV, p. 409.
×	....	....	1890	Thélohan, Annal. de Microgr. II, p. 198.
×	....	....	1890	Pfeiffer, Archiv. f. pathol. Anat. u. Physiol., CXXII, pp. 559-60.
×	....	....	1890	Pfeiffer, Die Protozoen als Krankheitserreger, 1 ed., pp. 41-9, 55, 98, figs. 12, 13, 15, table, figs. I-III.
×	....	....	1891	Pfeiffer, Die Protozoen als Krankheitserreger, 2 ed., pp. 20, 91, 105, 127-33, figs. 52, 53, 55.
	Myxidium.	....	1892	Thélohan, Bull. Soc. philomat. Paris, IV, pp. 166, 169, 175.
	Myxidium.	....	1892	Engler & Prantl, Die natürlich. Pflanzenfamilien, Leipzig, Lfrg. 76, fig. 22.
×*	....	....	1893	Perrier, Traité de Zool., pp. 459-60.
×	....	....	1893	Ohlmacher, Journ. Amer. Med. Assoc., XX, p. 562.
	Myxidium.	....	1893	Gurley, Bull. U. S. Fish Com. for 1891, XI, pp. 410, 420.
	Myxidium.	....	1893	Braun, Centrabl. f. Bakt. u. Parasitenkde, XIV, pp. 738-9.
	Myxidium.	....	1894	Braun, Centralbl. f. Bakt. u. Parasitenkde, XV, p. 87.

*Of air bladder; error.

The description is based upon the (in the main) accordant results of Lieberkühn, Balbiani, Bütschli, and Pfeiffer, particularly upon those of the last two observers. Gabriel's accordant results have been incorporated, his divergent ones mostly footnoted.

Life-history (Pfeiffer).—Emerging from the spore, the young myxosporidium (until now the sporoplasm) next penetrates into the interior of the red blood corpuscles or of the cells of the bladder epithelium. Its intracellular existence continues until its increasing size ruptures the cell wall, when it escapes, differentiates its own protective ectoplasmic layer, and resumes amœboid movements. Finally endogenous (pansporoblastic) spore formation takes place, the spores ultimately become free, and the life-cycle is complete.

Cyst none.

Myxosporidium.[1]—Form varying much with age; at exit from spore globular-amœboid: while within, and at the time of exit from the epithelial and red blood cells, roundish; older forms cylindrical, ribbon or club shaped, or irregularly amœboid, presenting a very grotesque appearance, with branches, forkings, and long appendages. Size varying with age up to a maximum length of 300 μ (Bütschli) by a breadth of 136 μ. Youngest myxosporidia colorless; older ones colored yellowish or reddish or brownish-red by inclusions of extraneous pigment in the endoplasm. Myxoplasm, in all but the youngest stages, presenting a clear differentiation of ectoplasm and endoplasm.

Ectoplasm forming a rather thick, very transparent, colorless, delicate, finely granular layer, containing none of the characteristic endoplasmic elements; end in contact with the mucous membrane, colorless, destitute of granules, leafy or pronged for attachment. Opposite end richest in granules and in pigment, free-floating, usually rounded; free-floating forms partly agreeing with the above, differing, however, in being destitute of pronged processes, showing at times some peculiar differentiations, particularly the appearance shown on pl. 44, fig. 3, where it seems permeated by a system of canals. One end of body often more or less plainly radiate-striate, the usual distinction between the ectoplasm and endoplasm being here absent. This Prof. Bütschli regards as the attached (pronged) end. Also not rarely are seen a series

[1] Gabriel believed that the bladder does not furnish a suitable environment for metasporal development, consequently the latter must, he thinks, take place in or *via* the external world. In his opinion the myxosporidia living within the bladder represents not normally developing, but progressively degenerating forms. Such development as occurs within the bladder, by which apparently the way has been prepared for the replacement, at least within certain limits, of the perishing mother organisms, does not exclude the possibility of ripe spore-containers or free spores finding their way to the outer world and there under favorable (but as yet unknown) conditions developing. This supposition, a necessary postulate, becomes a certainty when it is remembered that only thus [by active or passive migration] could the parasite have reached the bladder. Probably repeated, though perhaps (as indicated by the variations in their occurrence) not continuous, infection-immigrations occur.

of dark, longitudinal, ectoplasmic laminæ separated by clear, somewhat reddish, apparently semifluid interlaminæ. Not infrequently there exists a similar clear reddish boundary layer between ectoplasm and endoplasm (Bütschli).

Endoplasm consisting of colorless or yellowish myxoplasm, usually tinted reddish to reddish-brown (see *Hæmatoidin* below); distinguished from the ectoplasm by its color and by the presence of granules, globules, numerous small nuclei, vacuoles and inclusions (notably hæmatoidin crystals). Granules minute, arranged without order. Globules numerous, irregularly scattered; in all probability fatty, being soluble in alcohol;[1] containing hæmatoidin crystals. The older writers also include the nuclei under the term globules.

Nuclei very numerous, small, with a dark surrounding membrane, granular contents, nucleolus and radiating fibrillæ (Bütschli). Pfeiffer remarks[2] that these are to be referred back to the original single nucleus of the young myxosporidium.

Vacuoles (apparently nonpulsating; indefinite as regards number and position), are sometimes seen in forms with few granules.

Hæmatoidin crystals: These were first observed by Lieberkühn.[3] They were subsequently noted by Bütschli,[4] who rightly remarked that they must be derived from the blood of the host; i. e., that they are of extramyxosporidian origin. They occur in the fat globules, and are found free in the protoplasm only after solution of these globules by alcohol. They can be found from the smallest beginnings up to a more conspicuous size, the fat-globules then forming a proportionally slight covering for them (Bütschli).

Pfeiffer[5] describes and figures a red blood corpuscle as included within the endoplasm. This he regards as the source of the hæmatoidin crystals. He asserts that they are constantly present and that they occur free or within the fat-globules. He adds that if the myxosporidium has amœboidly surrounded these blood corpuscles and now consumes them, then in spite of the structure of the spores the *Myxosporidia* can no longer be regarded as Gregarines.

Pseudopodia of 2 kinds: (1) Blunt, obtusely rounded, usually formed of ectoplasm alone, endoplasm taking part in formation only where the body as a whole forks. (2) Fine, hair-like or bristle-like, usually rigid, frequently branched, comparable to similar processes of many amœbæ, frequently covering whole surface, not rarely, however, limited to a certain region of same (e. g., the end, as in certain amœbæ);

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[1] Bütschli, Bronn's Thier-Reich, 1882, I, p. 594.

[2] Die Protozoen als Krankheitserreger, 1890, 1 ed., p. 44.

[3] Müller's Archiv., 1854, p. 350; see also next footnote.

[4] Ztschr. f. wiss. Zool., 1881, XXXV, p. 642; Bronn's Thier-Reich, 1882, I, p. 594. Bütschli credits their discovery to Lieberkühn and Meissner. I infer from Lieberkühn's statement, that Meissner's results were communicated to him orally but were not published.

[5] Die Protozoen als Krankheitserreger, 1890, 1 ed., p. 46; *ib.*, 1892, 2 ed., pp. 17, 132.

both varieties may be retracted and again extruded; some of these processes are, however, optical illusions, being views in optical section of transverse ectoplasmic folds (Bütschli; Pfeiffer).

Amœboid movements[1]: Slow, well seen when examined in the urine of the fish; absent (from rapid death of myxosporidium) in water and many "indifferent" fluids, e. g., egg-albumen solution. Best seen in pike's urine at 24° C.; the ectoplasm executes very extensive amœboid movements, wrinklings, and foldings (Pfeiffer).

Spore formation.[2]—Not confined to adult forms, but found in myxosporidia of all sizes. Thus few-spored large, and many-spored small myxosporidia are often seen (Gabriel). This occurrence at different times is explained by successive ripenings of the different individual myxosporidia composing the plasmode. Small round myxosporidia not yet entirely freed from the epithelial cell-remnants often contain 2 or more spores (Pfeiffer).

Pansporoblast formation: This, the first step toward spore formation, takes place by the differentiation within the myxoplasm of a number of small, clear, transparent plasma-spheres (*pansporoblasts*), each consisting of one of the many nuclei of the myxosporidium, together with a portion of the surrounding myxoplasm which it has attracted to it. Sometimes early, and in all cases later, each pansporoblast is surrounded by a thin dark membrane,[3] and is found to contain a number of nuclei, usually 6.

Pansporoblast-segmentation: Subsequently, instead of the pansporoblast consisting, as originally, of the pansporoblast membrane containing a single (usually sexanucleate) plasma-sphere, it comes to consist of the same membrane containing two [4] (usually trinucleate) plasma-

[1] Gabriel (loc. cit.) gives a very detailed description of these movements, concluding that they are so complex and peculiar as to find no parallel with the Gregarines, and none appears admissible with the pseudopodial movements of the *Protozoa*. Special emphasis is placed on the presence in the myxoplasm of a "thread-drawing" (*Fadenziehenden*) substance, capable of *emitting pseudopodioid processes, but incapable of retracting them.* This, Gabriel asserts, finds a parallel only in myxomycete plasmodes, of which it is an exclusive feature. Bütschli (1881, p. 610) has, however, observed the retraction of these processes.

[2] Description Bütschli's, unless otherwise stated.

[3] Pfeiffer confirms. Upon examining a myxosporidium in a dilute solution of eosin, or other stain, the spores stain only after rupture (by pressure on cover-glass) of this membrane. Gabriel dissents, regarding the pansporoblast as a "wall-less vacuole, which first takes on the vesicular appearance described by Leydig at a later stage." According to Gabriel the pansporoblast does not always persist to maturity, so that in the later stages it may be vainly sought. Gabriel was unable to trace a genetic relation between the "granules" (? nuclei) of the myxosporidium and the spores, whence he concluded that the latter originate by a process, not of myxoplasmic integration but by one of secretion, the morphologic substratum of the sporigenous vacuoles being regarded as *polysporogenetic centers* strongly contrasted with the *monosporogenetic centers* of the Gregarines.

[4] Spores in this species always developed in pairs (Bütschli). Spores not always, though usually, developed in pairs; such paired development may be absent among both developing and free spores (Gabriel).

hemispheres (*sporoblasts, sens. strict.*) which ultimately develop into 2 spores still contained within the pansporoblast membrane.

Development of sporoblast to spore: The fate of the 3 nucleus-like bodies remains in doubt. The central one Bütschli observed to develop into the spore-"nucleus." The other two do not[1] (as would naturally be supposed) develop into the capsules; on the contrary, the 2 nuclei disappear, while the capsules appear in the protoplasm independently of them. Gabriel sometimes observed the sporoblasts (i. e., spores still within the pansporoblast membrane) to undergo a slow progressive contraction to a globular shape, showing their membrane (presumably the future spore-shell) to be not yet rigid. A similar contraction was seen by the same observer in spores with partially disorganized shells.

Spore.—Transversely and unequally biconvex-lenticular; length, 5 μ ($\frac{1}{400}'''$, Lieberkühn; 4 to 6 μ, Thélohan); breadth, 20 μ or less (Bütschli; 15 to 20 μ, Thélohan). Shell plainly visible, sharp contoured, rather thick, frequently showing a delicate antero-posterior striation; bivalve structure unknown, sulphuric acid producing no effect. Capsules 1 in each wing[2]; filaments 2 to 3 times the breadth of the spore. Sporoplasm almost completely filling the shell-cavity, extending even to the wings, there surrounding, as a thin layer, the capsules. Nuclei, 2 (*fide* Thélohan, letter 1893). Concerning them and the vacuole-like structure shown in Bütschli's figures, M. Thélohan writes:

> The spore of *Myxidium lieberkühnii* does not contain a vacuole. This is a fact of which I have assured myself many times. The dark streak shown in Bütschli's figures belongs, without doubt, to the 2 nuclei of the plasmic mass which are often approximated, and, after the action of slightly elective stains, appear blended into a single mass.

Exit of sporoplasm (Pfeiffer).—Easily observable by examination of bladder-mucus in urine of pike at 24° C. After 4 to 12 hours a scattered mass of burst shells are seen; also many spores not yet burst, showing the contents much more plainly separated than in fresh specimens. In some individuals the sporoplasm is seen to flow amœboidly out "between the shells" (which are peculiarly unraveled) and wander away.

Gabriel states that during the whole year that he studied this species he never saw the shell split to give exit to the sporoplasm. On the contrary, he describes the process substantially as follows:

> Shell undergoing a rather easily observable fluidification or resorption, its contour (heretofore, though thin and delicate, plainly perceptible), after a variable period, entirely disappearing. Sometimes during the resorption stage, always by time of

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[1] On the contrary, Pfeiffer (Die Protozoen als Krankheitserreger, 1890, 1 ed., p. 98; 1891, 2 ed., p. 132), however, states that the capsules are formed from these 2 nuclei.

[2] Sometimes only 1 capsule at 1 "end," very rarely 2 capsules together in the center (Lieberkühn). Rarely ventricose monstrosities are seen with 2 capsules situated together at 1 "end" (Bütschli). Balbiani figures, beside the usual forms, others with 2 capsules in each wing.

disappearance of shell-contour, significant changes occur, involving capsules as well as sporoplasm, the capsules behaving throughout as integral parts of the "protoplasmic contents." The sporoplasm, previously very transparent, bluish, rather strongly refringent and destitute of granules, becomes paler, sharply contoured granules rapidly appear in spots, and these very delicately contoured, round-elongate or irregular [formerly sporoplasmic, now become myxoplasmic] masses grow slowly or rapidly to small, strongly granulated plasmodes which already show some yellowish or reddish-yellow pigmented spots.

Gabriel has also the following strange statement as to the subsequent course of development:

Now it appears very peculiar that these 3 constantly present, morphologically individualized, delimited, constituent parts [sporoplasm and 2 capsules] should, in their further development, be restricted to a *double course*, viz, either fusing to a single protoplasmic mass or remaining in the original state of separation; in the latter case, falling apart by a rapidly progressing division, each into 2 (rarely more), approximately equal, parts.

Growth of myxosporidium (Pfeiffer).—The young myxosporidium [heretofore termed the sporoplasm], immediately after its exit from the spore, penetrates into the interior of the red blood corpuscles and of the cells of the bladder epithelium. The infection of the former may be followed under the microscope. After 8 to 12 hours they show a noteworthy alteration, having become pale and, instead of 1 nucleus, containing 2, 3, or more nuclei. One of these nuclei is *jagged*, or wrinkled; the other (or others) is somewhat smaller, *smooth*, round, shining, and occupies (with reference to the jagged nucleus) a variable position. Hæmatoxylin stains the jagged nucleus dark, the smooth one bright. With the increasing growth of the smooth nucleus the jagged one rapidly falls to pieces, and its remnants become pressed against the cell wall. Methylen blue and phloxin red stain the disrupted jagged nucleus black-blue, the other a uniform red. From these observations and the analogy of *Lacerta* and *Testudo* blood, the jagged nucleus is to be regarded as the cell nucleus, and the smooth nuclei as intruded myxosporidian germs. Here, too, the multiple infection (*Mehrlingsinfektion*) is repeated.

Microscopic technique.—Removed from their normal habitat, the myxosporidia rarely remain intact more than 24 hours, and then only in "indifferent" liquids, preferably (besides iodized serum) a 1·5 per cent sodium carbonate solution or a 0·5 per cent sodium chloride solution (Gabriel). Phloxin red and methylen blue stain the ectoplasm a sharply defined red, the entoplasm inclusions blue. This striking result causes the myxosporidium to resemble a true rhizopod (Pfeiffer).

Habitat and frequency.—Urinary bladder of *Lucius lucius* (pike). Most frequent and most highly developed in late summer and autumn; rare in winter: thence increasing in frequency. Size and age of host exert no influence (Gabriel). Free-floating in urine or attached (by pronged end). Bütschli observed young examples with one end partly surrounding an epithelial cell which had been torn away, thus presenting a Gregarine-like mode of attachment. Observed by Lieberkühn attached firmly to *Distoma folium* (frequently found in the pike's bladder); also attached to other myxosporidia. Observed by Bütschli in December.

All individuals of *Lucius* from the Rhine and Saar have myxosporidia in the bladder, while those from the Elbe and Weser territory only exceptionally show them (Pfeiffer, 1891, p. 110).

Perrier erroneously cites the habitat as the *air bladder.*

Pathology (Pfeiffer).—The coarser anatomical details can be seen (under 300 or 400 diameters) by carefully stretching a bladder tightly over a cork, placing a cover glass underneath, brief fixation, and hardening by alcohol and staining. Control experiments may be made by maceration in diluted acetic acid. The infection of the bladder was also followed by capillary cultures.

Mucous membrane, when slightly affected, showing individual clusters of 4, 5, 100 or more epithelial cells infected with myxosporidia; thence all grades of hypertrophy (up to 10 to 30 times the normal size) can be traced.

Hypertrophy of epithelial cells: When slight, the cells are swollen, shining, apparently lobed. Pfeiffer failed to differentiate the nucleus and the intruder, probably owing to early succumbing of the nucleus. With greater hypertrophy the cells are filled with and overdistended by the parasites; subsequently, continued growth of the myxosporidium ruptures the cell membrane; the myxosporidium flows amœboidly out in grotesque shapes, and immediately differentiates its hyaline ectoplasm; rupture of cell membrane visible under the microscope. Hæmatoxylin or phloxinred-methylenblue stains a narrow-bordered, dark globule in the interior of the swollen epithelial cells; nucleus of latter invisible; largest cells indicating, by ragged coloring of contour, the degeneration of the epithelial remains.

Effects (of this species??).—Of late years dead pike and perch have frequently floated down the Mosel and the Rhine. It is doubtful whether the disease here is the same as the muscle infection of the barbel. According to a statement [unpublished, I infer] by Dr. T. W. Müller in Greifswald, the spore found in the flesh of the pike is not the same as that of the barbel, but is formed upon the type of *M. lieberkühnii* (Pfeiffer).[1]

Whether the pike and perch in the Mosel die from myxosporidiosis is unknown. With the perch, fungous disease concurs (Ludwig).[2]

101. Myxidium ? ? incurvatum Thélohan, 1892.

Compt. Rend. Acad. Sci. Paris, cxv, pp. 1093–1094.

Cyst, probably none.

Myxosporidium.—Small, feebly motile. Ectoplasm (in sections) very clearly striate. Pseudopodia lobed, sometimes forming a bristly, shaggy coat, as in *Myxidium lieberkühnii.*

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[1] Die Protozoen als Krankheitserreger, 1892, 2 ed., p. 105.

[2] Jahresber. d. rhein. Fisch.-Vereins Bonn, 1888, pp. 27, 28.

Spore.—Possessing only one plane of symmetry, viz, the valve-junction plane, differing in this respect from most other myxosporidian spores, which have another such plane perpendicular to valve-junction plane. Form very remarkable, comparable to a pod whose acuminate extremities are oppositely directed; length (?), 4 to 5μ; breadth (?), 8 to 9μ. Capsules, 1 at each end (or wing?), their long axes oblique and oppositely directed with reference to the long (transverse?) diameter of the spore. Filament extrusion very difficult of production; produced by nitric acid; length of filament, 12μ; sporoplasm nonvacuolate.

Habitat.—Gall bladders of *Onus tricirratus* (=*Motella tricirrata*), *Syngnathus* (=*Entelurus*) *æquoreus* (pipefish), and *Blennius pholis*, all from Roscoff; in *B. pholis* from Concarneau; in *Siphostoma* (=*Syngnathus*) *acus* (pipefish) and *Callionymus lyra*.

The description of this species is not sufficient, in the absence of figures, to warrant a positive opinion as to its generic affinities. I have attempted to construct from Thélohan's description a diagram of the spore, but without success. The prevalent very loose use of such terms as "ends," "extremities," "length," "breadth," etc., renders them invalid for taxonomy, and the only course open seems to be to retain this provisionally in *Myxidium*, noting that in its bivalve structure it differs markedly from *M. lieberkühnii*, the type species.

102. Myxidium? sp. incert. Pl. 47, fig. 6.

Psorosperms of *Raja batis*, Leydig, 1851, Müller's Archiv., pp. 226, 234, pl. 8, fig. 4*g*; *ib.*, Leuckart, 1852, Archiv. f. physiolog. Heilkde., XI, p. 436, fig. 21*b*.
Myxidium? sp. Gurley, 1893, Bull. U. S. Fish Com. for 1891, XI, p. 420.

No description. The distinctness of this form from *Chloromyxum incisum* was recognized by Leydig (p. 234).

Habitat.—Free in bile ducts of *Raja batis* L. (skate).

EXPLANATION OF PLATES.

All figures copied are either of the same size as, or $1\frac{1}{2}$ times the size of, the figures from which they were copied; that is, in copying only 2 ratios were used, 1:1 and $\frac{3}{2}$:1. The relative sizes of the copied and the original figures are in every case indicated by the figures *within the parentheses.* All figures outside the parentheses indicate the total amplification from the specimens. For the derivation of any figure, see table, pp. 131–134.

Plate 1.

Figs. 1–4. *Psorospermia sciænæ-umbræ* (after Robin. × $\frac{3}{2}$).
- 1*a*. The convoluted string (*cordon enroulé*). × $1\frac{1}{2}$.
- 1*b*. Section of fig. 1*a*. × $1\frac{1}{2}$.
- 2. Cells of variety 1. × 600.
- 3. Cells of variety 2. × 600.
- 4. Operculate cells of variety 3. × 600.

Plate 2.

Figs. 1–2. *Lithocystis schneideri* (after Cuénot. × $\frac{3}{2}$).
- 1. Gregarine stage, with voluminous nucleus and clinorhombic crystals.
- 2*a*. Spore at the extremity of the tube, showing the truncated distal and rounded proximal extremities, and the sporozoites in course of formation.
- 2*b*. Fully developed spore containing 8 sporozoites.

Fig. 3. *Genus incert. sp.* 3 (after Müller & Retzius. × $\frac{3}{2}$). Spores from the diseased air bladder of *Gadus morrhua.*

Plate 3.

Figs. 1–5. *Balbiania rileyi* (after Stiles. × 1).
- 1. A portion of the pectoral muscles of *Anas boschas* in the condition known as "measly duck."
- 2. Longitudinal section of parasite (greatly enlarged).
- 3. Transverse section (greatly enlarged): *ct*, connective tissue cyst with numerous nuclei; *cu*, cuticle of the parasite; *m*, sections of muscle.
- 4. Microtome section of meshes containing falciform bodies greatly enlarged.
- 5. Falciform bodies: *a*, stained, showing nucleus and vacuole; *b*, unstained.

Plate 4.

Fig. 1*a–m*. *Genus incert sp.* 4 (after Valentin. × $\frac{3}{2}$).
- 1*a*. The original globular form.
- 1*b–d*. Different stages of the unrolling of the tail.
- 1*e*. A globule in which the separate dark granules appear to be inclosed in separate peduncles.
- 1*f*. Peduncle ideally enlarged.
- 1*g–m*. Various forms of the developed animal.

Figs. 2–8. *Genus incert. sp.* 6 (after Schewiakoff. × 1).
- 2. Amœbiform stage. × 1500.
- 3–5. Encystment. × 1500.
- 6. Cyst with 6 spores. × 1500.
- 7. Cyst thickly filled with spores. × 1500.
- 8. Plasmode proceeding from the fusion of 3 amœbæ. × 1500.

PLATE 5.

Figs. 1–11. *Genus incert. sp.* 6 (after Schewiakoff. × 1).
1–3. Developmental stages of the plasmode. × 1500.
4. Encystment. × 1500.
5. Cyst-tube with spores. × 1500.
6. A ruptured cyst with emerging spores. × 1500.
7. Spores sessile on the muscles. × 1500.
8. Individual spore. × 2600.
9. Small plasmatic corpuscles proceeding from the spores. × 2600.
10*a–l*. Transverse division of the spore; the nucleus dividing karyokinetically. × 2600.
11*a–b*. Conjectural conjugation stages of the spores. × 2600.

PLATE 6.

Fig. 1. *Genus incert. sp.* 9 (after Lieberkühn in Bütschli. × ⅔). × about 195. Myxosporidium from the gall bladder of *Lota lota.*
Fig. 2. *Genus incert. sp.* 10 (after Lieberkühn in Bütschli. × ⅔). × about 195. Myxosporidium from branchiæ of *Lota lota* with a very thick ectoplasm.
Figs. 3–8. *Genus incert.* (*"Myxosporidium"*) *congri* (after Perugia. × 1).
3–4. Two forms with "vacuoles."
6. An individual attached to a vegetable filament.

PLATE 7.

Figs. 1–3. *Genus incert. sp.* 12 (after Linton. × 1).
1. *Notropis megalops* with dermal cysts caused by "psorosperms." × 1½.
2. Spores from cysts, highly magnified.
2*a*. Vertical view of spores in caustic potash.
2*a'*. Same, more highly magnified.
2*b*. Transverse view of spore.
2*b'*. Same, more highly magnified.
2*c*. Spore treated with sulphuric acid.
3. Portion of thin section of cyst: *a*, pigment spot; *b*, granular protoplasm; *c*, spores; *d*, wall of cyst and dermis. × about 150.
Fig. 4. *Genus incert. sp.* 13 (after Lieberkühn. × ⅔).
4*a*. Spores from a subcutaneous cyst of *Gasterosteus aculeatus.* × 870.
4*b–e*. The same in different stages of development; *b*, spore with plain "nucleus" of usual size; *c*, *d*, with smaller "nucleus;" *e*, "nucleus" scarcely perceptible, the previously plain membrane no longer visible, animal mature.
Fig. 5. Sarcosporidian spore of sheep with a "capsule" (after Pfeiffer. × 1).

PLATE 8.

Figs. 1–4. *Genus incert.* (*"Myxosporidium"*) *bryozoides* (after Korotneff. × 1).
1. Funicle of *Alcyonella fungosa,* with the spermatozooids and the parasite on them. × 350.
2. A parasite inclosed in an *Alcyonella* zooid. × 350.
3, 4. Creeping adults with nuclei and spores. × 750.

PLATE 9.

Figs. 1–4. *Genus incert.* (*"Myxosporidium"*) *bryozoides* (after Korotneff. × 1).
1*a*. Group of spermatoblasts, 2 of them containing very young stages of the parasite. × 900.
1*b–d*. Different stages in the conversion of a spermatoblast into a plasmode; cell nuclei and parasite nuclei shown. × 900.
1*c*. Plasmode in which 1 daughter, and 2 granddaughter cell nuclei are visible. Nuclei of parasite numerous. × 900.
2. A plasmode in which the cell nuclei are atrophying and possess a jagged contour. × 900.
3. Spores in which vacuoles and urticant organs are to be distinguished. × 900.
4. Nuclei of the parasite of plate 8, fig. 3.

PLATE 10.

Figs. 1–3. *Glugea anomala.*
1*a*–*h*. (After Gluge. × 1.)
1*a*, *b*. Showing *Gasterosteus aculeatus* with tumors on sides of body and on tail. × 1.
1*c*–*e*. Spores variously magnified. × 255–840.
1*f*, *g*. The same "coagulated."
1*h*. Cyst membrane.
2. Section showing, from above downward, subcutaneous connective tissue, cyst membrane, protoplasmic contents of cyst, and spores (after Thélohan. × 1).
3*a*–*i*. Group of spores: *a*, *b*, fresh; *c*–*i*, safranin stained; *c*, *d*, spores with 1 nucleus; *e*, *f*, with 2 nuclei; *g*, with 3; *h*, *i*, with 4 (after Thélohan. × 1).
Figs. 4–5. *Thelohania contejeani* (after Henneguy and Thélohan).
4. Longitudinal section of diseased crayfish muscle (× 1).
5*a*. Spores in sporophorous vesicle, and free (× $\frac{3}{2}$).
5*b*. Individual spore, more highly magnified (× $\frac{3}{2}$).
Fig. 6. *Thelohania octospora* (after Henneguy. × 1).
6*a*. Sporophorous vesicle with spores.
6*b*. Individual spores.
6*c*. Longitudinal section of diseased muscle of *Palæmon rectirostris*, showing sporophorous vesicles between the separated fibrillæ.
6*d*. Portion of *c* more highly magnified.

PLATE 11.

Figs. 1–5. *Thelohania octospora* (after Henneguy and Thélohan. × 1 except fig. 5).
1. Transverse section of entire abdomen of a badly diseased *Palæmon rectirostris*, showing, opposite the letters, the following: *m*, *m*, affected muscles; *dt*, digestive tube; *n*, nerve cord; *cl*, sections of the claws.
2. Longitudinal section of muscle showing the dissociation of the fibrillæ.
3. Transverse section of diseased muscle.
4. A part of fig. 2, more highly magnified, showing fibrillæ with very clear striation, and the sporophorous vesicles.
5*a*–*d*. Showing the spores: *b*, in the fresh state showing the vacuole; *a*, *c*, *d*, after action of ether; *a*, with the filament partially, *c* and *d* with it completely, extruded (× $\frac{3}{2}$).

PLATE 12.

Figs. 1–2. *Thelohania giardi* (after Henneguy and Thélohan).
1. Spore formation (× $\frac{3}{2}$).
1*a*. Young pansporoblast.
1*b*. Pansporoblast whose nucleus has lost its membrane and presents itself under the form of an equatorial plate.
1*c*. Pansporoblast whose nucleus has segmented into 2.
1*d*. Pansporoblast the protoplasm of which has segmented into 2 uninucleate plasma hemispheres.
1*e*. Pansporoblast in the IV stage; fresh state.
1*f*. Pansporoblast in the IV stage, the augumentation of size of nuclei and change in disposition of chromatin preliminary to division.
1*g*. Pansporoblast in the IV stage; nucleus in repose.
1*h*, *i*. Pansporoblast in the VIII stage; different dispositions of the sporoblasts (the 8th in *i* is not represented, being hidden by the others).
1*k*. Sporophorous vesicle inclosing 8 ripe spores.
1*l*. Pansporoblast inclosing 4 normal spores, and 2 bodies each formed by the soldering together of 2 spores by their large ends: *a*, thickening of the pansporoblast membrane; *b*, spores soldered; *s*, normal spores.
1*m*, *n*. 2 sporoblasts with crescentic nucleus. In the concavity of the latter, a clear vacuole. At *n* a small protoplasmic button projects into the vacuole.
1*o*. Spores in fresh state showing at the large end a clear vacuole and at the small, a brilliant point corresponding to the capsule.
1*p*. Spores showing the vacuole and the longitudinal shell-striæ.
1*q*, *r*. Spores after action of sulphuric acid: *q*, filament incompletely unrolled; *r*, filament completely unrolled.

PLATE 12—Continued.

Fig. 2. Pathological anatomy (× 1). Longitudinal section of diseased muscle of *Crangon vulgaris*, showing fibrillæ with normal aspect preserved, and pansporoblasts in different stages of development, and spores.

Fig. 3. *Thelohania macrocystis* (after Garbini. × 1).
3*a–c*. Sporophorous vesicle and spores.
3*d*. Spores.
3*e*. A section of the diseased tissue.

PLATE 13

Fig. 1. *Myxobolus unicapsulatus* (after Müller. × 1).
1*a*, *b*. Vertical view of spores, showing the single capsule and the sporoplasm.
1*c*. Vertical view of spore, showing sporoplasm (and vacuole?).
1*d*. Transverse view of spores.

Fig. 2. *Myxobolus inequalis* (after Müller. × 1).
2*a*. Vertical view, showing the unequal capsules and the sporoplasm.
2*b*. Transverse view.

Fig. 3. *Myxobolus piriformis* and *M. ellipsoides*. Spores highly magnified from Malpighian corpuscles of spleen of *Tinca tinca* (after Balbiani. × 1).
3A. Nos. 1, 2, 6, *Myxobolus piriformis?* (see p. 211, footnote 1), showing the elongate pyriform outline and the single capsule.
Nos. 3, 4, 5, 7, *Myxobolus ellipsoides?* (see p. 211, footnote 1).
3B, C. *Myxobolus piriformis* or *M. ellipsoides* (which?).

Fig. 4. "Degenerated forms" from the spleen, liver, and kidney of *Tinca tinca* (after Balbiani. × $\frac{3}{2}$).
4*a*. *Myxobolus ellipsoides?* (see p. 211).
4*b*, *c*. *Myxobolus piriformis* (see p. 211).
4*d–f*. *Myxobolus piriformis* or *M. ellipsoides* (which?).

PLATE 14.

Figs. 1–3. *Myxobolus brachycystis* (after Remak).
1. Pigment follicle from spleen of *Tinca tinca*, containing 3 "vesicles" [pansporoblasts], each with a pyriform spore. To the right some of the pigment-containing vesicles which fill the cyst. (All *fide* Remak. × 1.) × 200.
2. Three oval vesicles with pyriform spores from the kidney of *T. tinca* (× $\frac{3}{2}$). × 375.
2*a*. Showing spores and numerous pigment cells.
2*b*. Showing 2 smaller vesicles, each with a pyriform spore.
2*c*. A vesicle showing conspicuous thickenings of its wall.
3. Vertical view of 2 pyriform spores with 2 capsules from tubiform cysts of the spleen of *T. tinca*. Similar spores are also found on the branchiæ and in the kidneys. (All *fide* Remak. × $\frac{3}{2}$.) × 675.

Fig. 4*a–g*. *Myxobolus? sp.* 38 (after Lieberkühn. × $\frac{3}{2}$). × 675.
4*a*. Vertical view of spore.
4*b–d*. Spore in act of giving exit to sporoplasm.
4*e–g*. Free sporoplasmata of spores.

Figs. 5, 6. *Myxobolus? mugilis* (after Perugia. × 1).
5. Branchial lamella of *Mugil auratus* with cysts.
6. Vertical view of spore.

Fig. 7. *Myxobolus sp.* 40 (after Lieberkühn in Bütschli. × $\frac{3}{2}$). × about 1050.
7*a*. Vertical view.
7*b*. Transverse view.

Figs. 8*a–d*. *Myxobolus oviformis*. From cyst of fins of *Gobio gobio;* safranin and gentian violet (after Thélohan. × 1).
8*b*. Vertical view of spore showing 1 nucleus.
8*c*. Same, with 2 nuclei.
8*d*. Same, with 3 nuclei.

PLATE 15.

Figs. 1–6. *Myxobolus? sp.* 41 (after Lieberkühn; except 1).

1. Two spores inclosed in the pansporoblast membrane (after Bütschli. × $\frac{3}{2}$). × about 1050.
2. Cyst from branchiæ of *Gasterosteus aculeatus* (× 1).
3. Free spores from cyst of fig. 2. (× $\frac{3}{2}$.) × 675.
4. Another cyst in which spore formation has taken place (× 1). × 330.
5. Another cyst (× 1). × 220.

6*a–c*. "Different forms [? developmental stages] of spores" of this species (× $\frac{3}{2}$.)

Fig. 7*a–c*. *Myxobolus sp.* 44.

7*a*. Transverse view of spore (after Lieberkühn in Bütschli. × $\frac{3}{2}$). × 1350.

7*b*. Spore with valves separating, giving exit to sporoplasm (after Lieberkühn. × $\frac{3}{2}$). × 1350.

7*c*. Sporoplasm undergoing amœboid movements (after Lieberkühn. × $\frac{3}{2}$). × 1350.

PLATE 16.

Figs. 1–6. *Myxobolus mülleri* (after Bütschli. × 1, except fig. 1).

1. Two branchial lamellæ of a cyprinoid, one containing a conspicuous myxosporidium. *c*. The cartilaginous rod supporting the lamella (× $\frac{3}{2}$).
2. A portion of the membrane of fig. 4, more strongly magnified, showing "nuclei."

3*a*. Transverse view of spore.

3*b*. Transverse view of 2 separated valves.

4. An isolated small myxosporidium with its membrane.
5. Nuclei of the myxosporidium.
6. A series showing the developmental stages of the spore.

6*a*. Sporoblast which has segmented into the 2 protocysts and the protosporoplasm.

b–c. The segments have oriented themselves; the protocysts show beginning capsule formation.

d, e. Later stages of capsule formation. In *e* orientation of the capsules has taken place.

PLATE 17.

Figs. 1–7. *Myxobolus mülleri* (after Bütschli. × 1).

1*a*. Vertical view; showing capsules, sporoplasm, vacuole and pericornual nuclei.

1*b*. Vertical view; showing capsules, "globules," sporoplasm, and vacuole.

1*c*. Vertical view, showing a common focus-appearance (?focus-illusion), the pericornual nuclei apparently attached to the posterior extremity of the capsules. Bütschli says the sporoplasm is "contracted" and hence the vacuole is invisible.

2. Transverse view of spore after action of concentrated sulphuric acid; the filaments are extruded and the valves are beginning to gape apart.
3. Vertical view of spore with extruded filaments, sporoplasm, and "globules."

4*a–d*. "Abnormal" tailed spores; *c*, spore with 3 capsules.

5. A separated valve, viewed transversely.
6. Spore with filaments extruded by pressure.

7*a*. Capsule not yet completely developed, with the filament extruded.

7*b*. A fully-developed capsule with extruded filament.

PLATE 18.

Figs. 1, 2. *Myxobolus piriformis* and *M. ellipsoides* (after Balbiani. × 1).

1. Section of splenic artery of *Tinca tinca*, showing on the branches Malpighian corpuscles, most of them containing *Myxosporidia*.
2. The same, more highly magnified, showing well-developed bicapsulate forms (*M. ellipsoides*) and pyriform unicapsulate or noncapsulate and degenerate forms (*M. piriformis*).

PLATE 19.

Fig. 1. *Myxobolus bicostatus* (after Lieberkühn in Bütschli. × ⅗). Vertical view of spore showing the 2 oblique ridges on the shell, the capsules, and the sporoplasm.

Figs. 2–8. *Myxobolus ellipsoides.*

2, 3. Pfeiffer's copies of figs. 1*a*, 1*b* of plate 20 (× 1).

4. Mesenteric artery of *Tinca tinca* with sessile or pedunculate cysts developed at the expense of the connective tissue coat of the vessel. Cyst contents myxosporidia, alone or with imbedded brown (hæmatoidin-colored) granular matter (after Balbiani. × 1).

5. Section of diseased air bladder of *T. tinca*, showing spores and, at the left-hand margin, the internal epithelial surface of the air bladder. Borax carmine, gentian violet (after Thélohan. ×1).

6. Section of cyst of branchiæ of *T. tinca*; showing in order, from above downward, the branchial epithelium, cyst membrane, myxoplasm, spores, and the nuclei of the last. Picro-carmine and gentian violet (after Thélohan. × 1).

7. Transverse section of air bladder; carmine, celloidin (after Pfeiffer. × 1). × 100.

8. Portion of fig. 7 (after Pfeiffer. × 1). × 400. On the wall of the cyst the younger, still uninuclear, parasites; to the right trinucleate sporoblasts.

PLATE 20.

Figs. 1–4. *Myxobolus ellipsoides.*

1*a–c*. Myxosporidium and cyst from fins of *Tinca tinca*, with spores in course of development (after Balbiani. × 1).

1*a*. Small myxosporidium containing only nuclei.

1*b*. More advanced stage.

1*c*. Large encysted myxosporidium containing numerous spores, mostly mature.

2*a–c*. Three stages in spore formation, showing paired development of spores in a mass of homogeneous plasma, and the spores contained at maturity in a vesicle (after Balbiani. × ⅗).

3*a–c*. Spores from air bladder of *T. tinca* showing ribbons (after Balbiani. × ⅗).

3*a*, *b*. Spores united by the ribbons, the sporoplasm rolled into a ball, and the "accessory" capsules.

3*c*. Isolated spore with extended ribbons; capsules empty; sporoplasm in a ball.

4*a–e*. Spores from the air bladder of *T. tinca*, showing different stages of development of the nuclei; carmine, gentian violet (after Thélohan. × 1).

4*a*. Spore with 1 nucleus.

4*b*. Spore with 2 nuclei.

4*c*. Spore with 3 nuclei.

4*d*, *e*. Spores with 4 nuclei.

PLATE 21.

Figs. 1, 2. *Myxobolus ellipsoides.*

1*a–h*. (After Balbiani. × ⅗.)

1*a*. Vertical view of spore, showing pericornual nuclei and anteriorly a "globule."

1*b*. Transverse view, showing the equal convexity of the valves and the equality of the two ends of the spore.

1*c*. Vertical view of spore, showing capsules with filaments extruded, pericornual nuclei, anteriorly a "globule," and posteriorly the sporoplasm (? contracted under the action of reagents).

1*d*. Spore in vertical view, showing ribbons, and sporoplasm in act of exit.

1*e*. Capsule with filament coiled.

1*f–h*. Different degrees of extrusion of filament.

2*a–e*. Sporoplasm after exit, showing changes of form (after Balbiani. × ⅗). *n*, "nucleus" [? vacuole].

Fig. 3. "Degenerate processes of the spores of *Tinca tinca* with 3, with 2 approximated, with 1 capsule, with caudiform drawing out of one pole, with approximation to the sarcosporidian germs. The same are found in the gall bladder of the tench and in aneurisms on the splenic artery" (after Pfeiffer. × 1). × 1000.

d. *Myxobolus ellipsoides* (apparently; remainder indeterminate).

Fig. 4*a–b*. *Myxobolus ellipsoides??* "Spores inclosed in a cell [?pansporoblast] membrane becoming stained at the moment of birth, with eosin" (after and *fide* Pfeiffer. × 1). × 750.

Fig. 5. *Myxobolus ellipsoides.* "Mature spore, with band-like connection of shell, and with vacuole at place of expelled germ" (after and *fide* Pfeiffer. × 1). × 750.

PLATE 22.

Figs. 1–3. *Myxobolus ellipsoides?* (after Pfeiffer. × 1).
  1, 2. Spores from the gall bladder of *Tinca tinca.*
  3. Spores from the air bladder of *T. tinca.*
Fig. 4*a*, *b*. *Myxobolus sp.* 50 (after Leuckart. × 1).
  4*a*. Vertical view of spore.
  4*b*. Transverse view of spore.
Figs. 5, 6. *Myxobolus sp.* 51 (after Pfeiffer. × 1).
  5. Myxosporidian infection of *Barbus barbus.*
  6. Tumors of muscle.

PLATE 23.

Figs. 1–2. *Myxobolus sp.* 51. Myxosporidian infection of *Barbus barbus* (after Pfeiffer. × 1).
  1. From a photomicrograph.
  2. Infection of the muscle cells and the interfibrillar connective tissue.
  2*a*. General immigration of myxosporidian spores into muscle with degeneration of the neighboring parts of the muscle and with beginning of incapsuling on the part of the host.
  2*b*. Split spores. To the left, the exit of the sporoplasm; to the right, empty shells undergoing solution.
  2*c*. The myxosporidium (sporoplasm) in the first stages of growth; on the right the same, after hardening and hæmatoxylin.
  2*d*. Next growth-stage of myxosporidium; adhesion of individuals to a "sorus."

PLATE 24.

Figs. 1, 2. *Myxobolus sp.* 51 (after Pfeiffer. × 1).
  1*a-h*. Sections of muscles of *Barbus barbus*, showing myxosporidian cysts, spores, etc. For details, see Bibliography, LXXII. p. 127.
  2*a*. A large muscle cell of abdominal wall beaded by myxosporidian cysts; the transverse striation and the substance of the muscle has disappeared. Size of cysts, variable; contents, spores. × 100.
  2*b*. Fragment of muscle cell. Showing 5 spore cysts. Between the upper and the next to the upper cysts lie 7 spores in the muscle cell (supplementary immigration ?). × 100.
  2*c*. Fragment of another muscle cell with 6 cysts. The upper 2 with mature spores; between them 6 spores, whose capsules lack the oblique striation (filaments extruded ?). The third cyst with the contents divided into pansporoblasts, in which as yet no spores are visible. The fourth and fifth (from above) showing nuclei, surrounding dancing granules, and a hyaline ectoplasm; both are inclosed in a mesh of the original muscle cell. × 400
  2*d*. Myxosporidium free in the interfibrillar connective tissue. × 750.
  2*e*. Mature spore. × 750.

PLATE 25.

Figs 1-6. *Myxobolus sp.* 51.
  1 *a–h*. Group of spores, most of them viewed vertically (after Mégnin. × $\frac{3}{2}$).
  1*b*. Spore with filaments extruded.
  1*c*. Isolated capsules.
  1*d*. Same, with extruded filament.
  1*e*. Spores viewed transversely.
  1*f–h*. Spores apparently imbedded in the myxosporidium.
  2. Showing *a*, vertical, and *b*, transverse views of spore, and *c*, a transverse view of a separated valve (after Ludwig. × 1). × 2000.
  3. Spore viewed vertically (after Pfeiffer. × 1).
  4. Isolated myxosporidium, showing spore formation (after Pfeiffer. × 1).
  5. Spores and the extruded amœboid sporoplasm (after Pfeiffer. × 1).
  5*a*. Vertical view, showing one capsule with filament extruded, sporoplasm, vacuole, and 3 refringent bodies of undetermined significance.
  5*b*. Transverse view of spore showing ridge.
  5*c*. Sporoplasm, after exit, in various locomotive stages.
  6. Spores, showing filaments extruded, and sporoplasm in the act of, and after exit, apparently also the vacuole (after Pfeiffer. × 1). × 1400.

PLATE 26.

Fig. 1. *Myxobolus sp.* 52. Section of a pigment follicle of the walls of the splenic artery; after slight pressure the pigment globules are seen showing untailed spores (after Remak. × 1). × 200.

Fig. 2. *Myxobolus sp.* 53 (after Rayer. × 1). Vertical views of spores.

Figs. 3–6. *Myxobolus oblongus.*

3. Branchiæ with cysts (after Müller. × 1).
4. Individual lamellæ with cysts (after Müller. × 1).
5. Spores (after Müller. × 1).

5a. Vertical view.

5b. Transverse view.

6. Spores (original).

6a. Broadest form, showing, in the sporoplasm, the central tongue-shaped dark-staining portion and the first and third series of nucleiform bodies. Gentian violet; slightly diagrammatic.

6b. More elongate form, showing the tongue-like process and the second and third series of nucleiform bodies. Gentian violet; somewhat diagrammatic.

6c. Narrower form, showing the first and second series of nucleiform bodies. Hydrochloric acid alcohol carmine.

6d. Narrow form, showing the 3 series of nucleiform bodies and posteriorly an unusual appearance. Hydrochloric acid alcohol carmine.

6e. Transverse view of spore, showing equality of valves and relative width of ridge (ridge index).

Figs. 7–8. *Myxobolus lintoni* (original). Vertical views of 2 spores, showing capsules and sporoplasm, the latter with vacuole and 4 nuclei (2 of them the pericornual). Hydrochloric acid alcohol carmine.

PLATE 27.

Myxobolus lintoni (after Linton. × 1). Nos. 2–13, highly magnified.

1. *Cyprinodon variegatus*, with excrescences caused by this species; one on right side, and another on left side showing above outline of back. × 1½.

2–3. Spores showing the pericornual nuclei. In fig. 3 there are a few small refractile globular masses near the posterior end.

4. Spore treated with osmic acid, showing mouths of the ducts.

5–6. Spores in transverse view, showing the ridge.

7. Spore treated with acetic acid, showing vacuole (exaggerated).

8. Diagram of cross-section, showing lenticular shape of spore.

9–11. Specimens treated with concentrated sulphuric acid.

9. With a few refractile bodies and 1 filament extruded.

10. Spore with both filaments extruded and a number of small refractile globules.

11. Spore with sporoplasm "contracted" [? shrunken by reagents]; "a thread also appears at the end opposite the polar vesicles."

12–13. Free capsules and filaments, after treatment with concentrated sulphuric acid.

14. Calcareous bodies found in the abnormal tissue, associated with the *M. lintoni*. × 200.

15. Three of the same, with a few spores. Sketch from material after action of potassic hydrate. × 400.

16. Spores *in situ*: (*a*) nests of spores; (*b*) section of blood capillary; (*c*) connective tissue. Sketch made from a section of decalcified abnormal tissue.

PLATE 28.

Figs. 1–3. *Myxobolus globosus* (original).

1a. Vertical view of spore, showing capsules and sporoplasm, the latter containing a vacuole and 4 nuclei, 2 of them being the pericornual.

1b. Transverse view of spore, showing the equal convexity of the valves and the wide ridge.

2, 3. Vertical views of spores exhibiting the same features as fig. *1a*.

Fig. 4. *Myxobolus sp.* 56 (original). Vertical views of spores, showing capsules and sporoplasm, the latter with the vacuole.

PLATE 28—Continued.

Fig. 5.* *Myxobolus cycloides* (after Müller. × 1). × 1.
5*a*. Group of cysts, natural size.
5*d*. Vertical view of broad form.
5*e*. Transverse view of same.
5*f*. Vertical view of elongate form.
5*g*. Transverse view of same.
Fig. 6. *Myxobolus sp.* 61 (after Müller. × 1).
6*a*. Vertical view of spores.
6*b*. Transverse view.
6*c*. Rare aberrant form among the remaining normal forms in the same cyst.
6*d*. Pansporoblasts with 2 spores.
6*e*. Rare forms of pansporoblast containing 3 spores.
6*f*. A rare method of grouping of 3 spores.
6*g*. Spores with punctate borders [illusion due to the simultaneous presence in (approximate) focus of the supero-anterior and infero-anterior borders of the sporoplasm].
6*h*. Spore with developing germs (see p. 240).
6*i*, *k*. Rare spores with 3 "vesicles."
6*l*. Rare form; seen only once.
Fig. 7. *Myxobolus obesus* (after Balbiani. ×$\frac{3}{2}$).
7*a*. Vertical view of spore, showing pericornual nuclei.
7*b*. Vertical view of spore, showing capsules with filaments extruded, and the sporoplasm with its cornua, and the supero- and infero-anterior margins.

PLATE 29.

Fig. 1*a*–*d*. *Myxobolus transovalis* (original).
1*a*–*c*. Vertical view showing outline, capsules, sporoplasm, vacuole, and nuclei. Hydrochloric acid alcohol carmine.
1*d*. Transverse view showing equal convexity of valves, and the narrow ridge.
Figs. 2–7. *Myxobolus? merlucii* (after Perugia. × 1).
2–6. Various forms of the myxosporidium; showing also the spores.
7. Two spores making their exit from the myxosporidium.
Fig. 8. *Myxobolus sp.* 67 (after v. d. Borne. × 1).
8*a*. Group of spores.
8*b*. *Leuciscus rutilus* with the myxosporidian tumors.

PLATE 30.

Fig. 1*a*–*q*. *Myxobolus cf. creplini* showing different views of spores (after Weltner. × 1). *a*–*p*, × 528; *q*, × 720. All were drawn with Abbe camera; *m*, *n*, are optical sections at the level of posterior end of capsules; *q*, separate capsules; one dull and with filament still coiled; the other transparent with filament extruded.

PLATE 31.

Fig. 1*a*–*c*. *Myxobolus ?? zschokkei* (after Zschokke, Schieck Oc. 2, Obj. 7. × $\frac{3}{2}$). Vertical views of spores with extruded "tails"; also the capsules (?).
Fig. 2. *Myxobolus medius and Chloromyxum elegans.* Section of tube of kidney of *Pygosteus pungitius,* showing spores of the two species surrounded by epithelium of tube. Borax carmine and gentian violet (after Thélohan. × 1).
Fig. 3. *Myxobolus medius* (original enlargement from preceding. × about 4).
Fig. 4. *Myxobolus medius.* Spore in pansporoblast (after Thélohan. × 1).
Fig. 5. *Myxobolus strongylurus* (after Müller. × 1).
5*a*. Vertical view.
5*b*. Transverse view.

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* For *b* and *c*, see *Chloromyxum dujardini*, plate 40, fig. 4.

PLATE 32.

Figs. 1, 2. *Myxobolus creplini.*
1*a–e.* (After Creplin. × 1.)
1*a, b.* Vertical view of spores.
1*c.* Transverse view.
1*d.* Vertical view (of an illusory appearance? See p. 249). The larger size of this figure merely represents higher magnification.
1*e.* Transverse view of spore with the valves gaping anteriorly.
2. Vertical view of spore (after Leuckart. × 1).
Figs. 3, 4. *Myxobolus monurus* (after Ryder. × 3).
3*a.* *Aphredoderus sayanus* with tumors.
3*b.* Cyst, much enlarged.
3*c.* Vertical views of 2 spores, showing capsules and tails.
4*b–d.* * Vertical views of spores.
Fig. 5. *Myxobolus macrurus* (original). Vertical view of spore, showing capsules, sporoplasm with vacuole and 3 nuclei (2 the pericornual), and the full length of the tail (about 4 times that of the body).

PLATE 33.

Figs. 1–4. *Myxobolus macrurus* (original).
1. Transverse view showing, on the right side, the more convex superior valve and the greater anterior projection of the supero-median cornu; on the left, the less convex inferior valve; along the center, the narrow ridge.
2. Vertical view, showing the vacuole and nuclei.
3. The same, showing also the beading of the tail after the action of iodine.
4. A tail separated from the body by iodine.
Figs. 5–8. *Myxobolus cf. linearis* (original).
5. Vertical view, showing divergence of valves under action of sulphuric acid, and the tail separating into a superior and an inferior half.
6. Transverse view, showing supero-inferior symmetry and narrow ridge.
7. Vertical view of unstained spore, showing vacuole.
8*a–d.* Vertical views of spores, showing vacuole, nuclei, and flexibility of tail. Hydrochloric acid alcohol carmine.

PLATE 34

Figs. 1–4. *Myxobolus psorospermicus.*
1. From branchiæ of *Perca fluviatilis* (after Lieberkühn in Bütschli. × $\frac{3}{2}$). × about 975.
1*a.* Vertical view of spore with a simple tail.
1*b.* Transverse view of same.
1*c.* Vertical view of spore with a double tail.
2*a–c.* From a branchial cyst of *P. fluviatilis*, showing capsules, sporoplasm, vacuole, and nuclei. *a*, with 1 nucleus; *b*, with 2 nuclei; *c*, with 3 nuclei. Carmine and gentian violet (after Thélohan. × 1).
3*a–d.* Spores from *Perca fluviatilis* (after Balbiani. × $\frac{3}{2}$).
3*a.* Vertical view.
3*b.* Transverse view of spore with 2 tails.
3*c.* Form slightly abnormal.
3*d.* Vertical view of spore, showing capsule with filaments extruded, cornua of sporoplasm, and pericornual nuclei.
4. Spores from *Lucius lucius* (after Balbiani. × $\frac{3}{2}$).
4*a.* Vertical view.
4*b.* Transverse view.
4*c.* Spore with valves separating to permit exit of sporoplasm
4*d.* Vertical view showing filaments extruded, and cornua of sporoplasm.

PLATE 35.

Figs. 1–7. *Myxobolus kolesnikovi* (after Kolesnikoff).
1–6. Cysts (× 1).
7*a–o.* Spores showing extruded filaments and single and double tails (× $\frac{3}{2}$).
7*g.* Separated capsule with extruded filament.

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* No *a* to this figure.

PLATE 36.

Fig. 1. *Myxobolus schizurus* (after Müller. × 1).
1*a*. Showing cyst contents, consisting of spores and finely granular matter.
1*b*. Individual spores.
1*c*. Aberrant spores seen only once among the contents of a cyst.
1*d*. Group of spores; vertical and transverse views.
Fig. 2. *Myxobolus linearis*. Group of spores showing the narrow outline and the single and double tails (after Müller. × 1).
Fig. 3. *Myxobolus sp.* 61. Rare forms of spores reproduced among tailed forms, from plate 28, fig. 6.
Fig. 4. *Myxobolus diplurus* (after Lieberkühn in Bütschli. × $\frac{3}{2}$). × about 1050. Vertical view showing posterior position of capsules and double tail.

PLATE 37.

Fig. 1 *a–f*. *Chloromyxum incisum* (after Leydig. × 1).
1*a*. Myxosporidium without pansporoblasts.
1*b*. Same with 1 pansporoblast, but no spores.
1*c*, *d*. Same with sporoblasts.
1*e*, *f*. Same with fully developed spores showing the crenate posterior border.
Fig. 2-7. *Chloromyxum leydigii* (after Perugia. × 1).
2. The myxosporidium.
3. The same, containing numerous spores.
4. The same, giving exit to 3 monosporophorous pansporoblasts.
5, 6. Pansporoblasts with spores; in fig. 5 the spores with 4 capsules.
7. Spore giving exit to the sporoplasm.

PLATE 38.

Figs. 1, 2. *Chloromyxum leydigii* (after Leydig. × $\frac{3}{2}$).
1. From gall bladder of *Raja batis*.
1a_1, a_2. Myxosporidia of various sizes without pansporoblasts.
1*b*, *e*. Myxosporidia, showing (*b*) pansporoblasts and various stages in spore formation; also outline of spore.
1*f*. Longitudinal ("end") view of spore, showing the 4 capsules.
2*a-c*. From gall bladder of *Squalus acanthias*. Myxosporidia without pansporoblasts.

PLATE 39.

Figs. 1–3. *Chloromyxum leydigii*.
1. Myxosporidia from gall bladder of *Torpedo torpedo* (after Leydig. × $\frac{3}{2}$).
1*a*. Without pansporoblasts.
1*b*. With pansporoblasts and spores.
1*c*. With pansporoblast and sporoblast.
2*a–b*. Myxosporidia from gall bladder of *Scylliorhinus canicula* (after Leydig. × $\frac{3}{2}$).
2a_1, a_2. Myxosporidia without pansporoblasts.
2*b*. Myxosporidium with 12 pansporoblasts, each containing 1 spore.
3. Myxosporidium. This figure appears to be generalized from figures a_1, a_2, of the preceding (after Leuckart. ×1).
Fig. 4. *Chloromyxum fluviatile* (after Thélohan. × $\frac{3}{2}$). Vertical view showing the capsules in 2 lateral pairs, the nonvacuolate sporoplasm, the vertical position of the ridge, and the minute spines on the shell.
Figs. 5, 6. *Chloromyxum mucronatum*.
5*a*, *b*. From urinary bladder of *Lota lota* (after Lieberkühn. × $\frac{3}{2}$).
5*a*. Longitudinal view of spore, showing the 4 capsules.
5*b*. Vertical view showing the mucronate anterior extremity, capsules, and sporoplasm.
6. From *Lota lota* (after Balbiani. × $\frac{3}{2}$).
6*a*. Vertical view showing capsules, pericornual nuclei, and vertical position of the ridge.
6*b*. The same; also beginning of valve separation.
6*c*. The same; also corkscrew extrusion of filaments.

PLATE 40.

Fig. 1 *a–c*. *Chloromyxum elegans* (original enlargement from plate 31, fig. 2. × about 3). Three views of spores, showing outline, ridge, and capsules.
Fig. 2*a–b*. *Chloromyxum perlatum* (after Balbiani. × ⅔). Vertical views of spores showing outline, capsules (*b* with filaments extruded), and vertical position of ridge.
Fig. 3. *Chloromyxum sp.* 91. Vertical (?) view of spore from the ovary of *Lota lota* (after Bütschli. × ⅔). × about 900.
Figs. 4–7. *Chloromyxum dujardini*.
4. From *Leuciscus rutilus* (after Müller. ×1).
4*b*. Vertical views.
4*c*. Transverse views.
5. Myxosporidium from branchiæ of *Leuciscus erythrophthalmus* (after Dujardin. × ⅔). × 12.
6. Spore showing outline and capsules; from *L. erythrophthalmus* (after Dujardin. × 1). × 800.
7. Free amœboid myxosporidium from a branchial lamella of *Leuciscus erythrophthalmus* (after Bütschli × ⅔). × about 30.
Fig. 8. *Chloromyxum ohlmacheri* (after Ohlmacher, Leitz obj. 3, oc. 4. × 1). From photomicrograph of section of kidney; showing at *a*, and elsewhere, myxosporidian masses in the tubules; at *b* extravasated blood corpuscles; at *c* a large blood vessel filled with blood corpuscles. Fuchsin and iodine green.

PLATE 41.

Figs. 1–3. *Chloromyxum ohlmacheri*.
1. Spores (after Ohlmacher. Leitz pantachromatic oil imm. 2 mm., oc. 4. × 1).
1*a*. Vertical view of spore, showing capsules with extruded filaments. Camera lucida; Babes's anilin water safranin.
1*b*. Vertical view showing capsules, spiral-coil structure of shell, and vertical position of ridge.
1*c*. Striæ are seen "running nearly meridionally"; at one "side" of spore a capsule "appears in the act of escaping through a rent" in the shell.
1*d*. Fragment of shell in which the striæ appear to correspond to ridges encircling the shell.
2. Kidney tubule, inclosing 3 spores, showing capsules and sporoplasm, the latter structure being represented in 1 spore as divided into 2 lateral halves. (An error; see p. 270.) Pfitzner's alcoholic safranin (after Ohlmacher; camera lucida; Leitz pantachromatic 3 mm., oc. 4. ×1).
3. Diagrammatic figure of spore; *a*, shell; *b*, sporoplasm; *c*, capsule; *d*, posterior extremity of ridge and spore; *e*, ridge; *f*, anterior extremity of ridge and spore; *g*, filaments, much shortened; *a*, *b*, *c*, are on the left side of spore; *e* on the right. (After Whinery. × 1).
Fig. 4. *Ceratomyxa sphærulosa*. Spore showing hollow-cone valves, vertical ridge, and valve-junction plane, capsules, and (*spo.*) the unilateral sporoplasm, and (*x*) pale corpuscles of indeterminate nature (after Thélohan. × ½).

PLATE 42.

Figs. 1–10. *Cystodiscus immersus* (after Lutz. × 1).
1. Gall bladder of *Bufo aqua* with myxosporidium disks shining through. × 1.
2. Portion of medium-sized specimen with large number of spores. × about 70.
3. The same; the ruptured ectoplasm permitting the exit of the contents in the form of vesicles. × about 70.
4. Ripe spore-pairs.
5. Vertical (?) view of mature spores, showing ridge.
6. Longitudinal (?) view of same.
7. Spore with extruded filaments, showing the striæ of the shell.
8. Spore with valves separated.
9. Developmental condition of spore.
10. Mature spore; contents made plain by carmine; containing micrococcoid granules. × about 600.
Figs. 11–13. *Cystodiscus ?? diploxys* (after Balbiani).
11, 12. Spherical cysts in process of spore formation (× 1). × 85.
13. Spores from the cysts (× ⅔). × about 1500.
13*a*. Vertical view.
13*b*, *c*. Transverse views.

PLATE 43.

Figs. 1–5. *Myxidium lieberkühnii.*

1. Myxosporidia (after Lieberkühn. × 1).

1*a*. Showing the granule-free, pronged end by which attachment is effected, and a pansporoblast containing 2 spores. × 330.

1*b*. Myxosporidium which has mostly broken up into pansporoblasts. × 900.

2. Specimen covered with transverse wrinkle-like elevations; at one end some pseudopodia (after Bütschli. × $\frac{3}{2}$). × 160.

3. Three successive stages in the development of clear ectoplasmic pseudopodia at one end of a large myxosporidium (after Bütschli. × 1).

4. Small myxosporidium attached to a nucleated bladder cell (after Bütschli. × 1).

5. Strongly amœboid-branched specimen (after Bütschli. × $\frac{3}{2}$). × about 90.

PLATE 44.

Figs. 1–5. *Myxidium lieberkühnii* (after Bütschli. × 1).

1*a*, *b*. Large forking myxosporidia; *a*, with fine hair-like ectoplasmic processes.

2. Large myxosporidium, showing interlaminæ between ectoplasm and endoplasm.

3. Portion of border of myxosporidium showing the peculiar canaliculate structure mentioned on p. 285.

4. Part of border of large myxosporidium with branched horn-like ectoplasmic processes.

5*a–d*. Four yellowish fat globules, inclosing hæmatoidin crystals.

PLATE 45.

Figs. 1–3. *Myxidium lieberkühnii* (after Pfeiffer. × 1).

1*a*. Smallest form.

1*b*. Small form with fat globules, hæmatoidin crystals, with only 1 pair of ripened spores; ectoplasm evident.

1*c*. Motile myxosporidium with very strong soap-bubble-like ectoplasm; in its interior a well-preserved red blood corpuscle, with fat globules and hæmatoidin inclusions.

1*d*. Specimen with amœboid pseudopodia.

1*e*, *f*. Large forms with scattered spores.

1*g*. Carmine staining after removal of fat by chloroform; the whole endoplasm riddled with nuclei. As yet without spores.

1*h*. Isolated spore × 1200.

2, I. Superficial epithelial layer; 6 healthy epithelial cells with nuclei, and 2 separate strongly hypertrophied cells in which, very soon after infection, the nucleus is destroyed.

2, II*a*. Myxosporidium fallen out of epithelial cell. Still without ectoplasm.

b. Young form, free in urine with peculiar pseudopodioid motile ectoplasmic processes extruded and retracted on a slightly warm stage and many fat globules in the endoplasm.

2, III*a*. Pansporoblast formation; *a*, small myxosporidium with bristle processes.

b. Sexanucleate pansporoblasts, which later form 2 trinucleate sporoblasts; in each sporoblast 2 nuclei form the capsules, the third the sporoplasm (*fide* Pfeiffer).

3. Transverse section of urinary bladder of pike, alcohol-hardened, celloidin-imbedded, hæmatoxylin-stained.

3*a*. Showing, from right to left, the external muscle layer, the internal muscle layer cut transversely, the submucosa, the epithelium with infection in the superficial layers, and free brown-colored myxosporidia containing hæmatoidin and sporoblasts. × 80.

3*b*. Portion of *a*. To the right the monstrously appearing myxosporidia and sporoblasts. × 400.

3*c*. Natural size of the bladder section.

PLATE 46.

Figs. 1–3. *Myxidium lieberkühnii.*

1. Epithelial infection of bladder from fresh and also from hæmatoxylin-stained material (after Pfeiffer. × 1).

1*a*. To the left healthy, to the right slightly hypertrophied epithelia which have lost their nuclei. At the right border, monstrously enlarged epithelia, or rather myxosporidia, with fat and hæmatoidin contents; nucleus obscure. Below to the left an isolated epithelial cell with early infection, and the disrupted epithelial nucleus.

1*b*. Immigration of young myxosporidia into the red blood corpuscles of *Lucius lucius*. Nucleus, where preserved, dark. In the upper row the middle corpuscle shows a multiple infection. Lower row showing not spore formation, but fat globules, nuclei, and hæmatoidin crystals. In the lower right-hand figure the myxosporidium has left the blood corpuscle and developed its hyaline ectoplasm.

2. Myxosporidia (after Balbiani. × 1).

2*a*. Myxosporidium filled with fatty granules without pansporoblasts.

2*b*. Myxosporidium with well-developed spores.

2*c*, *d*. Very young myxosporidia.

3. Pansporoblast containing 2 mature spores (after Lieberkühn. × $\frac{3}{2}$).

PLATE 47.

Figs. 1–5. *Myxidium lieberkühnii.*

1. Spore formation (after Bütschli. × 1).

1*a*. Pansporoblast with nuclei.

1*b*. The pansporoblast has contracted its bulk somewhat, elongated to an oval, and oriented its nuclei preliminary to division.

1*c*. The sexanucleate pansporoblast has divided into 2 spherical trinucleate sporoblasts.

1*d*. The sporoblasts have elongated and oriented themselves and their nuclei.

1*e*, *f*. Showing the development of the capsules independently of the vanishing terminal nuclei. In the center of the spore its nucleus (see p. 287).

2. Developed spore (after Lieberkühn. × $\frac{3}{2}$). × 900.

3. Mature spore (after Bütschli. × 1). Showing outline, bilateral symmetry, capsules, sporoplasm, and nucleus (see p. 287).

4. The same (after Balbiani. × 1).

4*a*, *b*. Most common form of spores with 1 capsule in each wing; *b*, with filaments extruded.

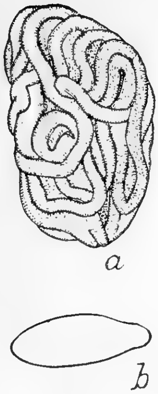
4*c*. Rarer form of spore with 2 capsules in each wing.

5. Spore with filaments extruded (after Bütschli. × 1).

Fig. 6. *Myxidium ? sp.* 102. Showing spore with capsules separated (? in each wing.) (After Leydig. × $\frac{3}{2}$).

INDEX.

This index is intended as a supplement to, and not as a substitute for, the table of contents, tables of distribution, and the tabular key (pp. 138–165), and as a rule subjects embraced in those tables are not indexed. For the species occurring on any host, in any organ, or at any place, see *Distribution*, below. The following are, however, here included: (*a*) All myxosporidian (doubtfully myxosporidian, etc.) generic and specific names, including all synonyms; (*b*) all generic and specific names of hosts which have (in the myxosporidian literature) undergone changes of synonymy; (*c*) such common names of hosts as are well established. Authors included in the Bibliography (pp. 123–129) are omitted; all others cited are indexed.



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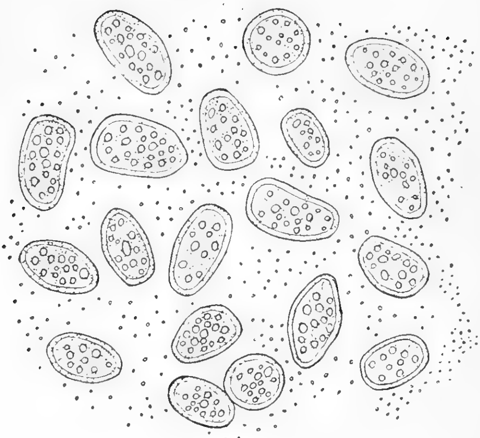

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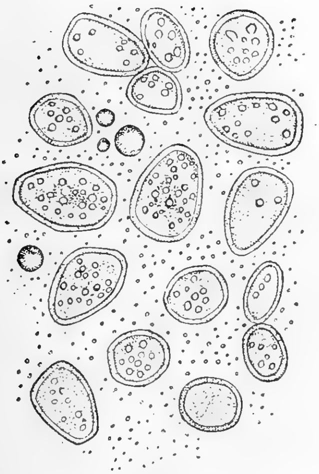

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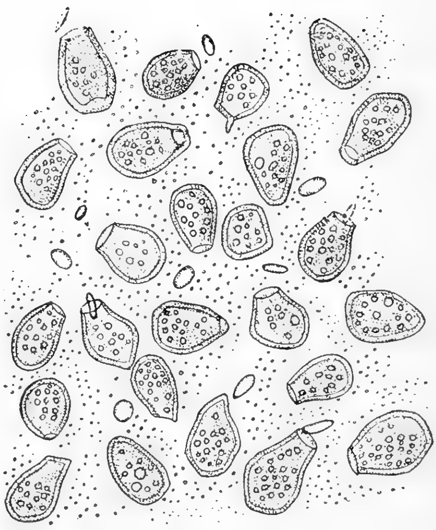

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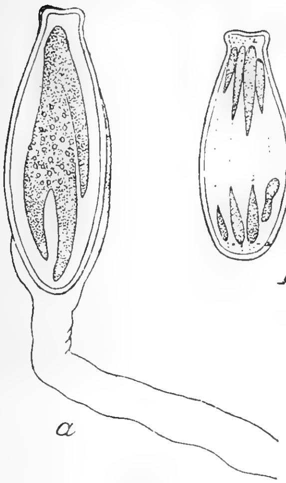

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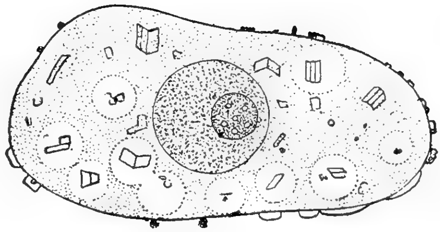

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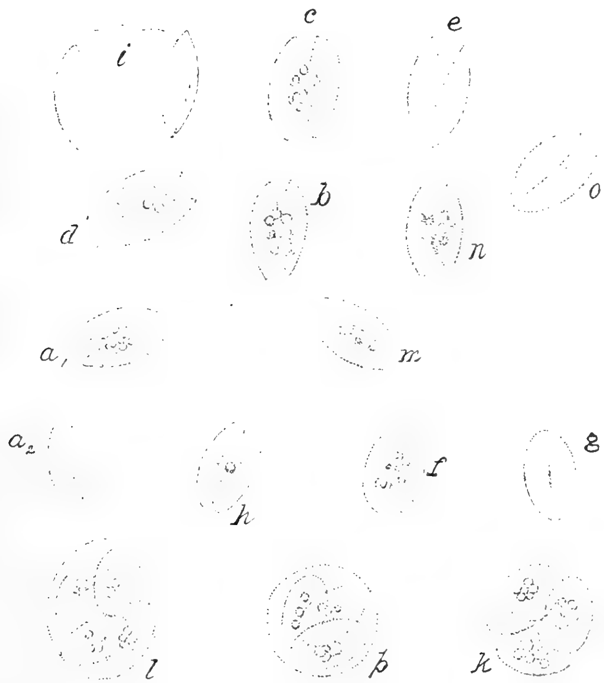

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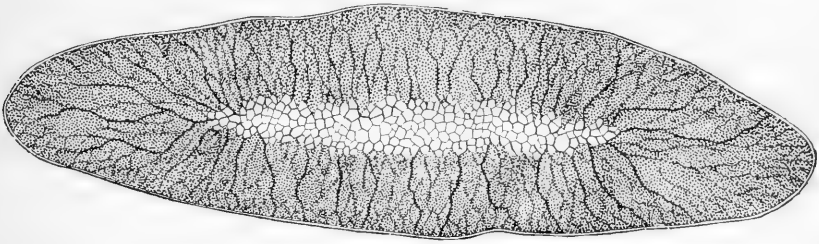

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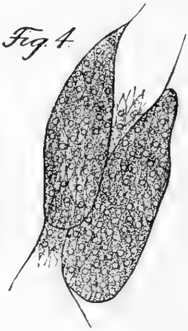

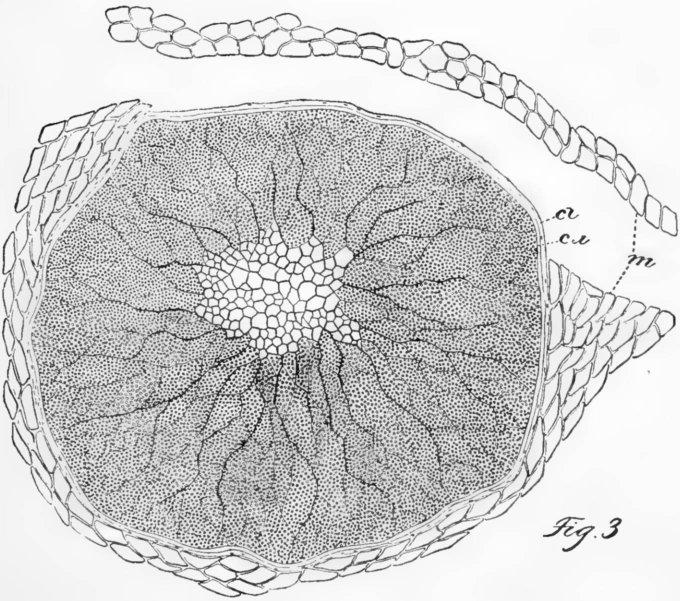

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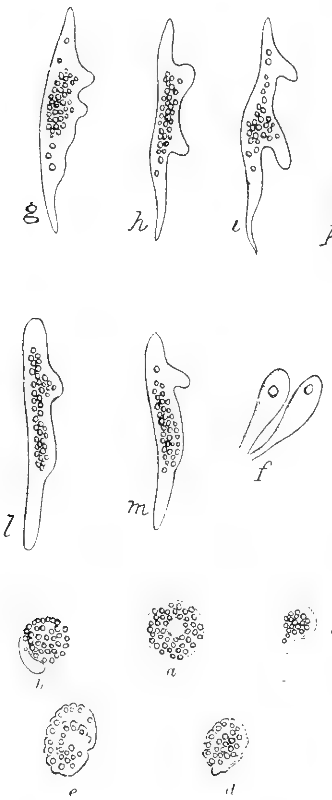

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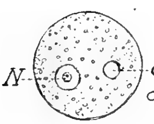

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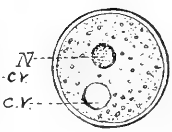

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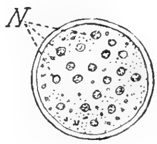

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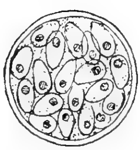
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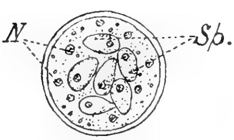

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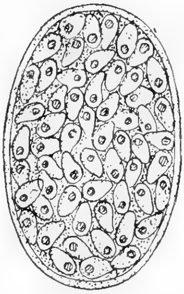

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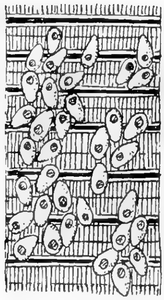

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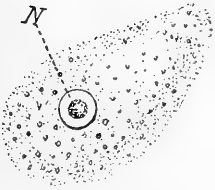

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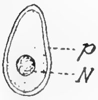

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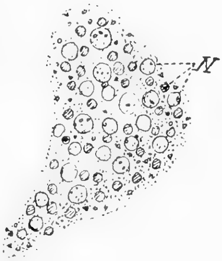

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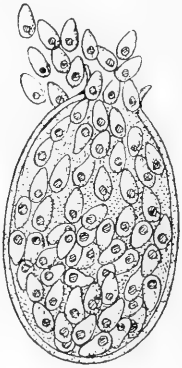

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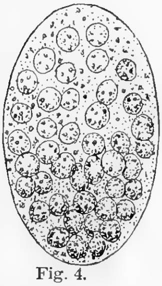

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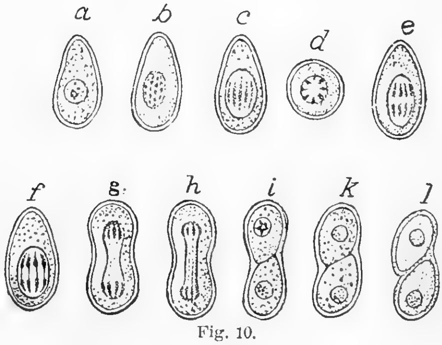

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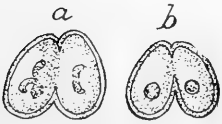

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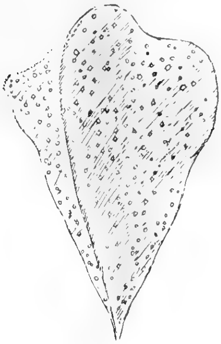

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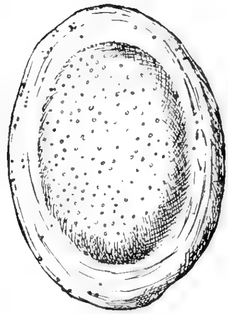

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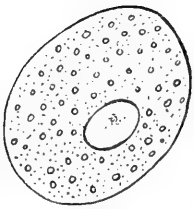

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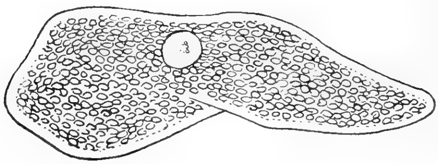

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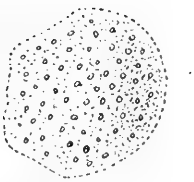

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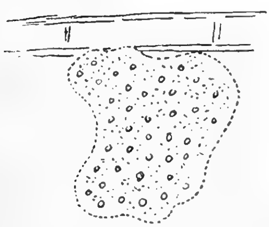

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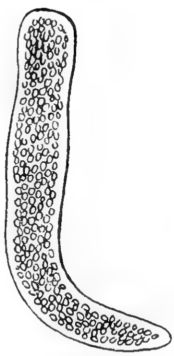

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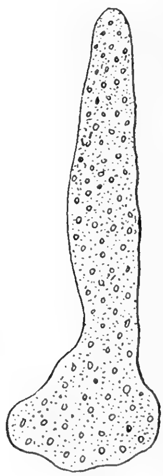

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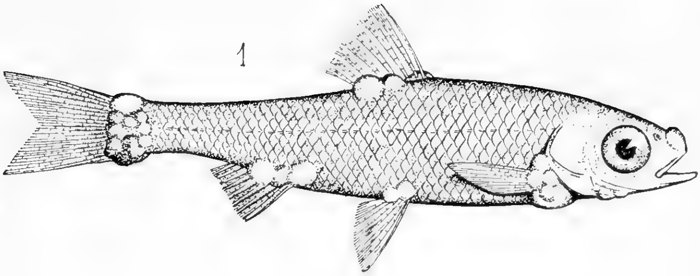

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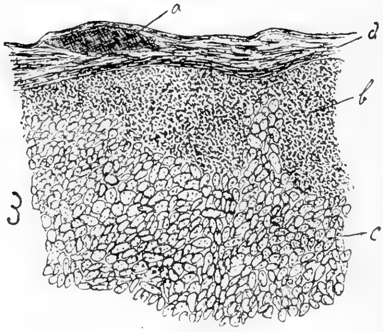

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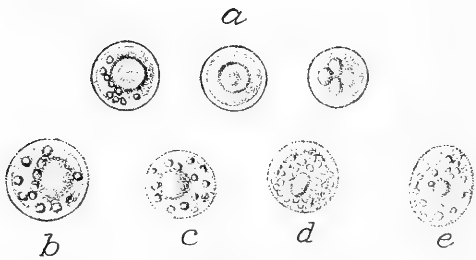

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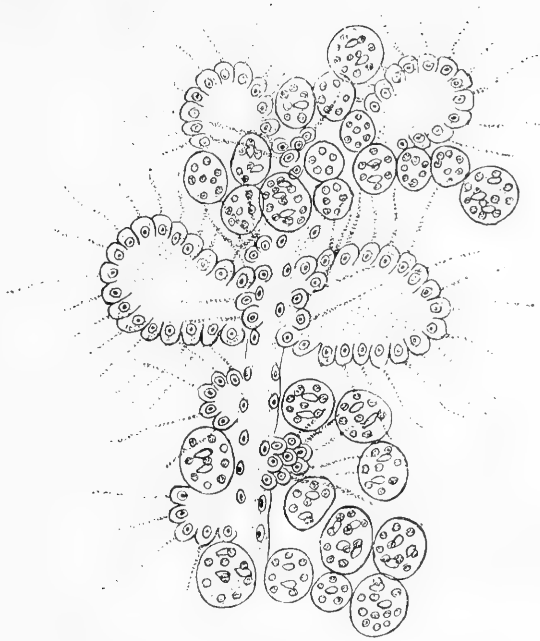

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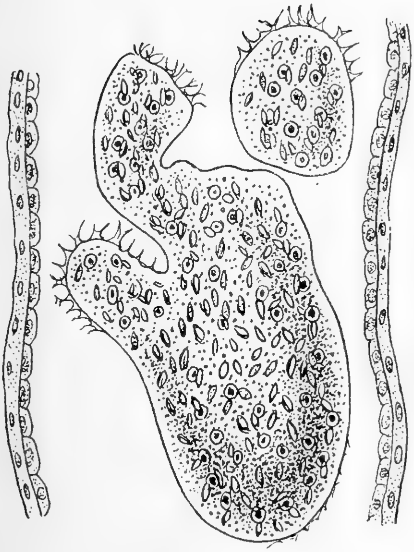

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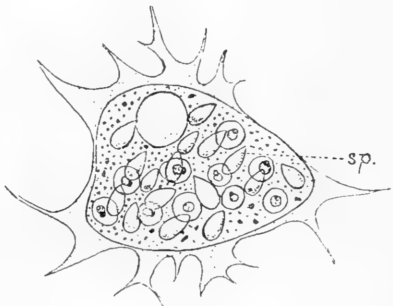

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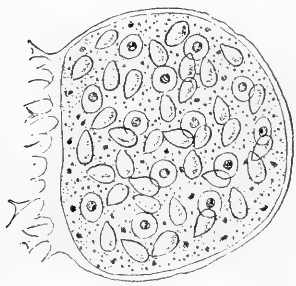

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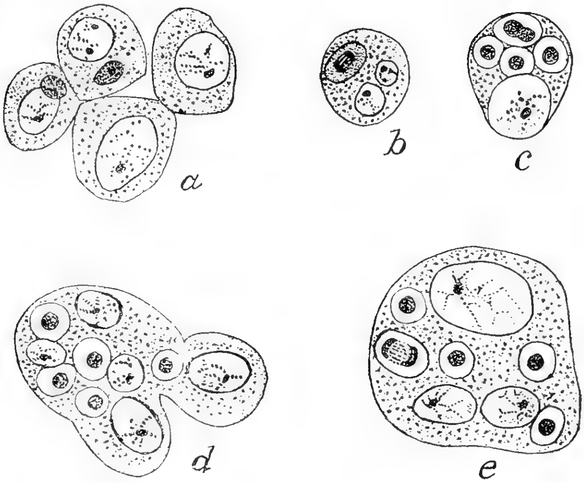

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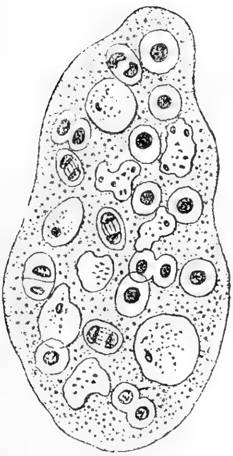

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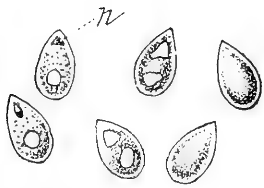

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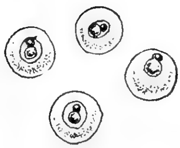

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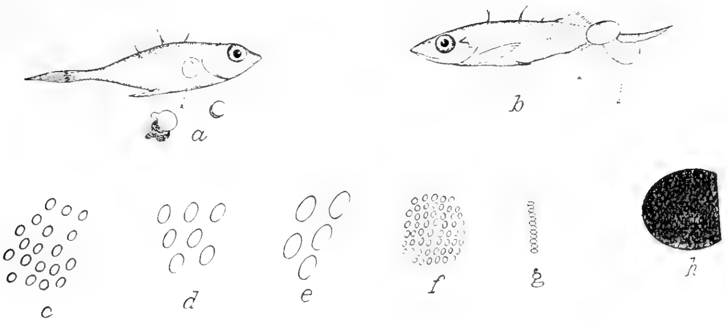

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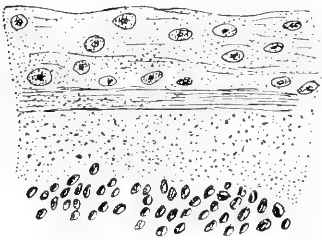

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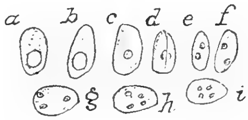

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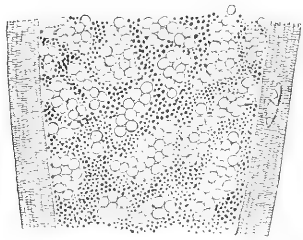

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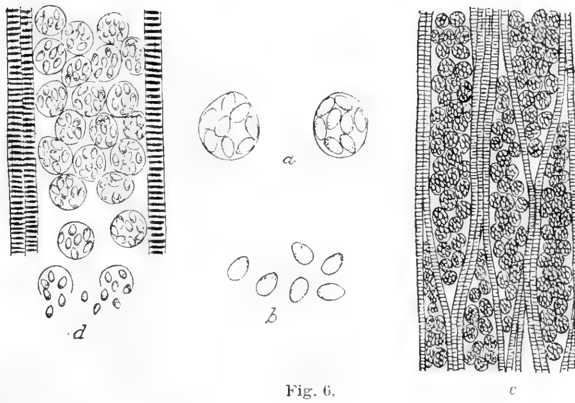

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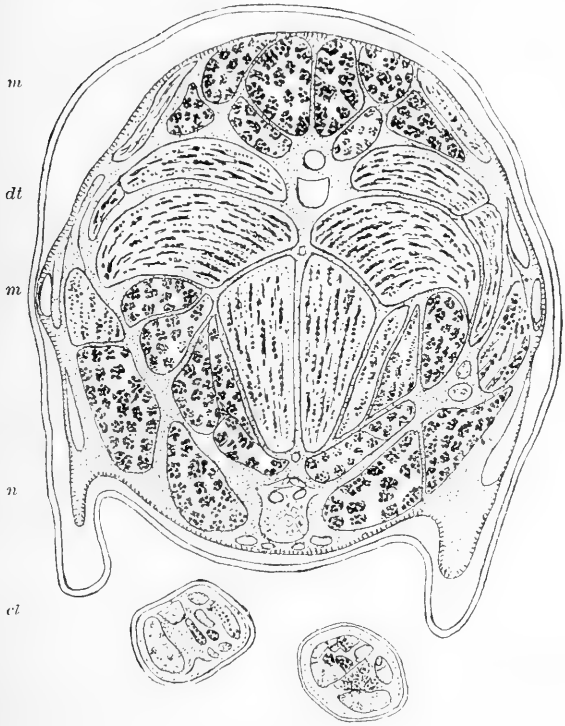

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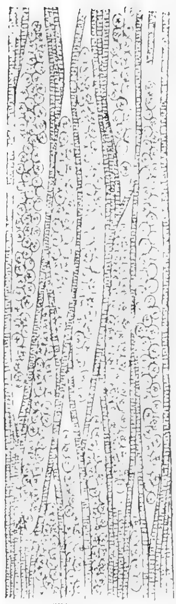

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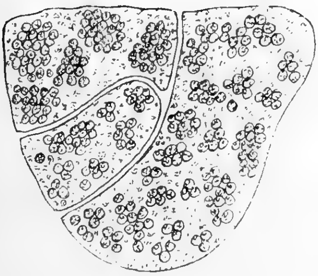

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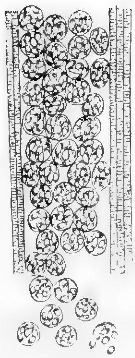

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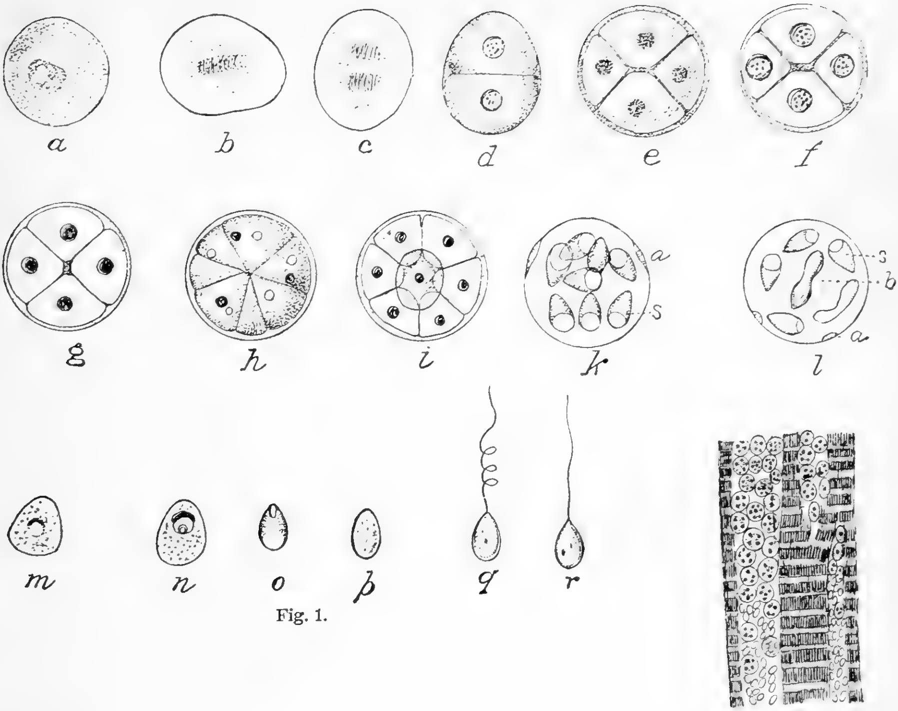

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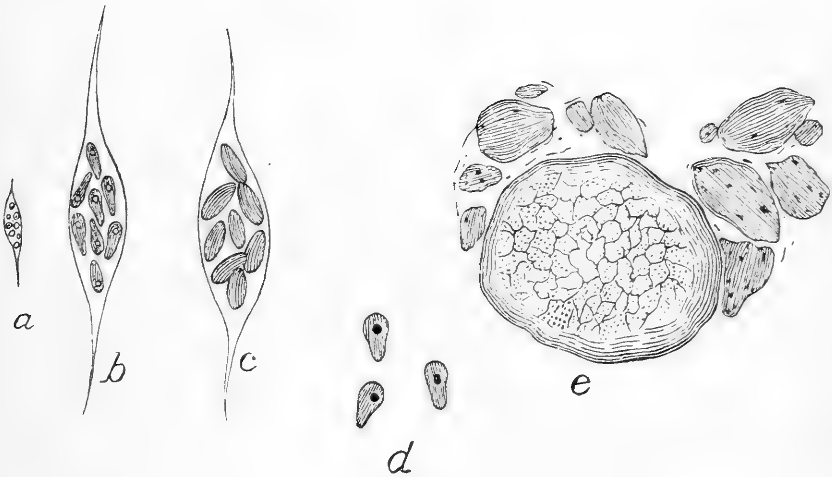

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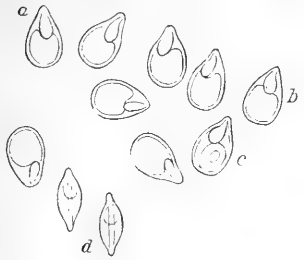

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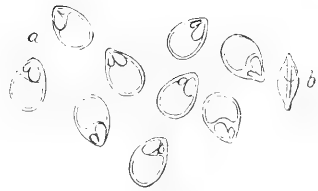

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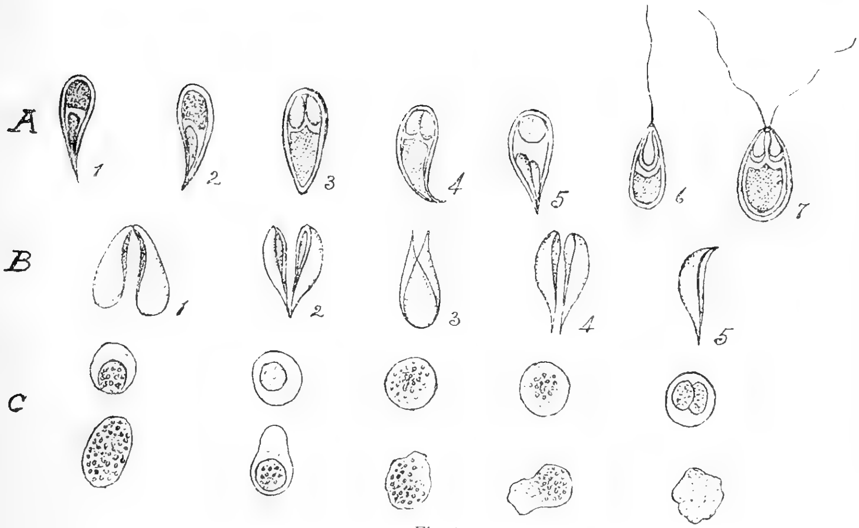

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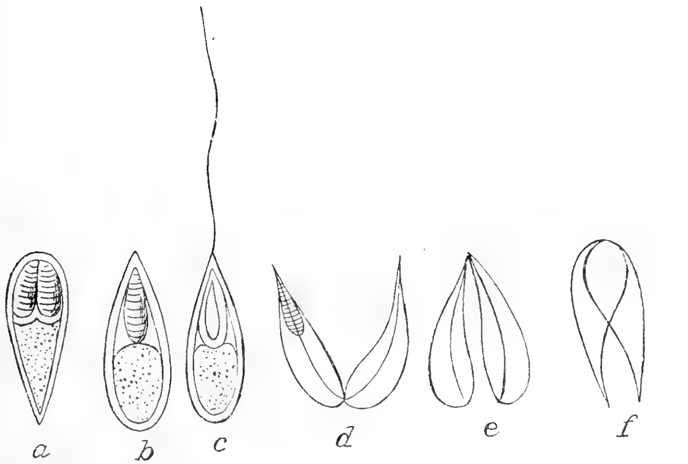

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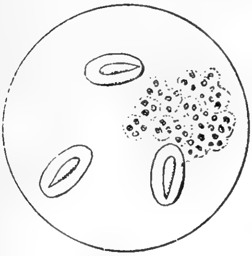

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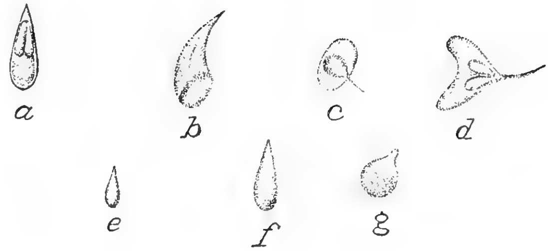

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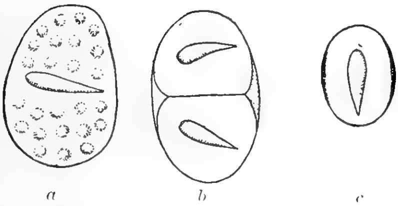

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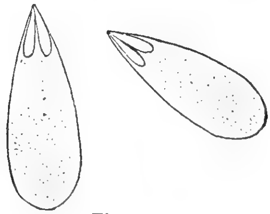

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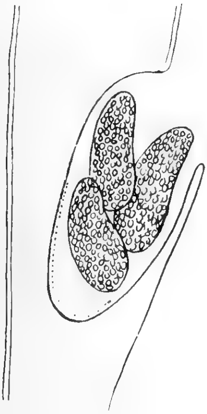

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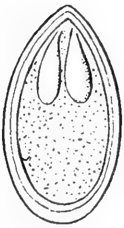

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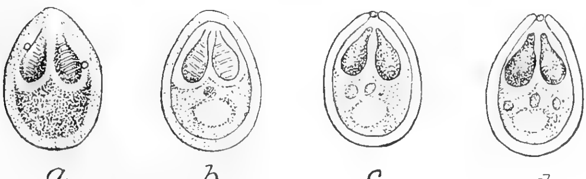

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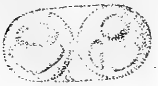
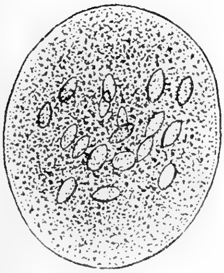


Fig. 1.

a *b* *c*

Fig. 3.



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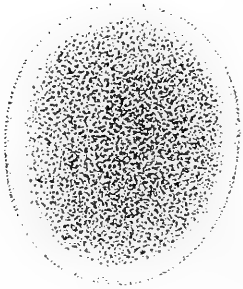

Fig. 2.

a *b* *c*

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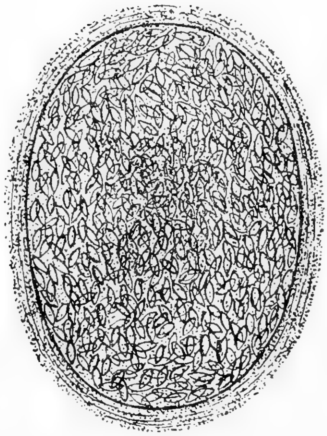

Fig. 5.

a *b* *c*

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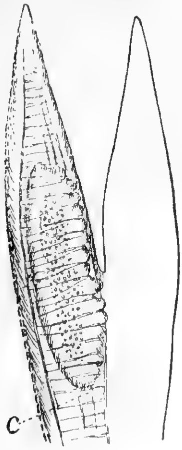

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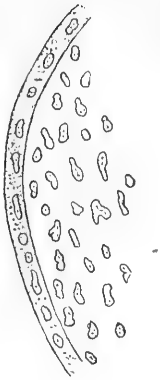

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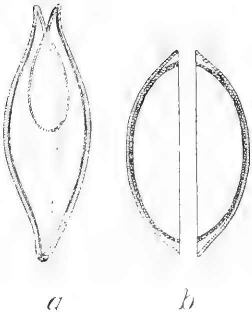

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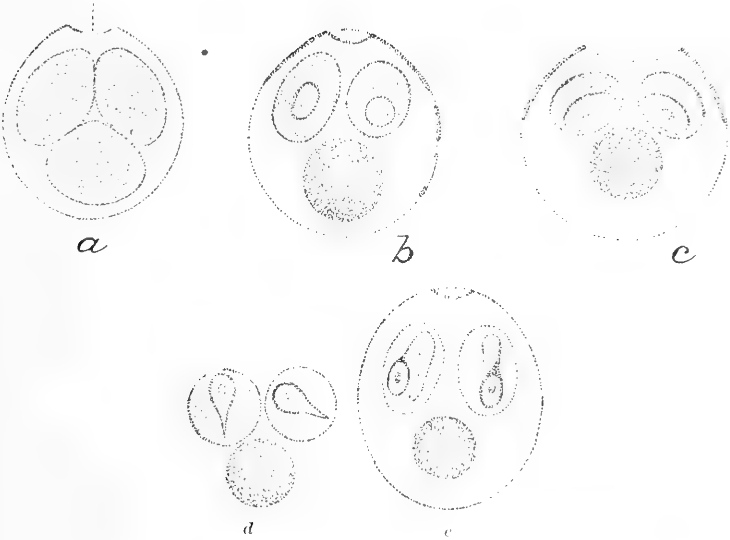

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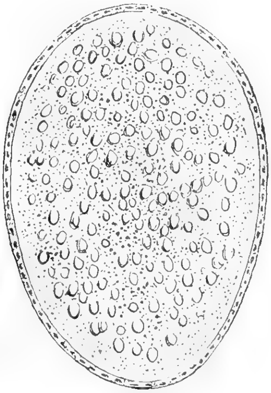

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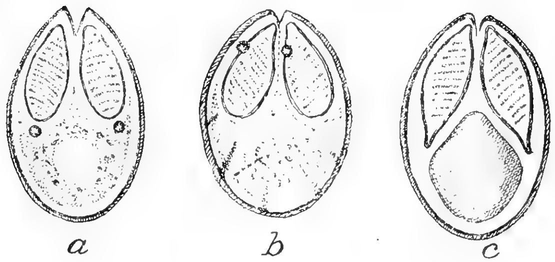

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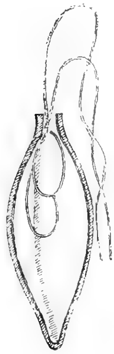
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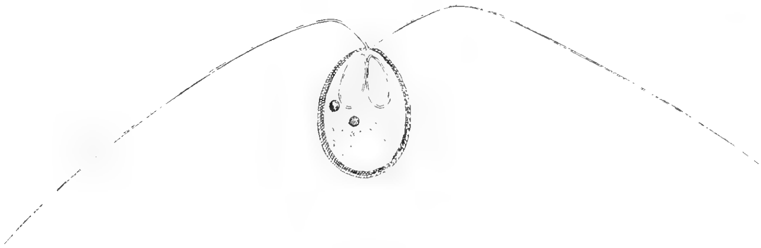
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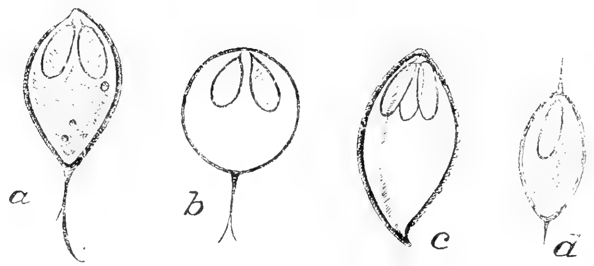


Fig. 4.

Fig 7

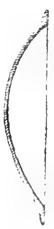


Fig. 5.


Fig. 6.

Fig. 1.

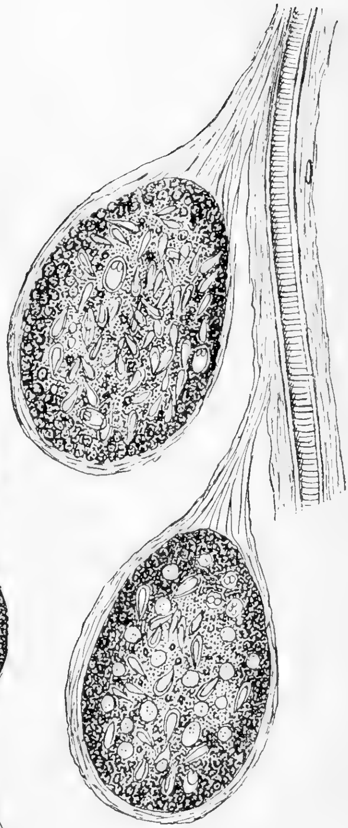
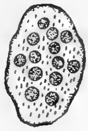


Fig. 2.

Fig. 1



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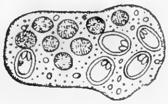

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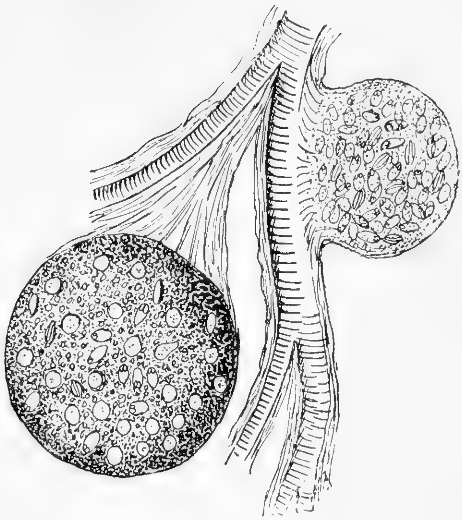

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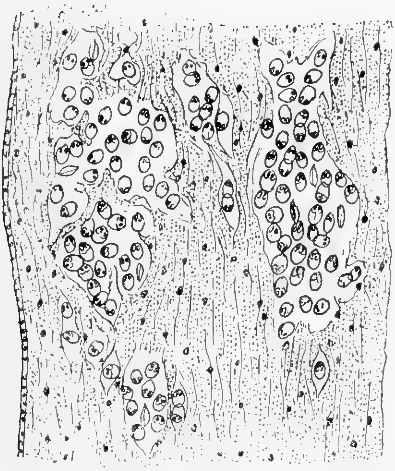

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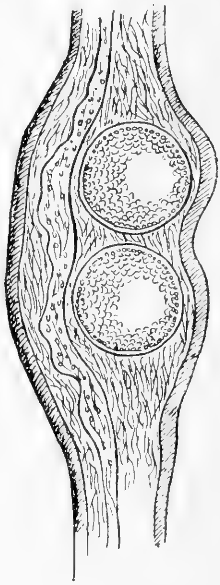

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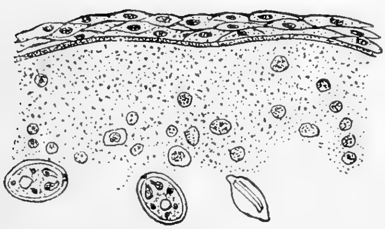

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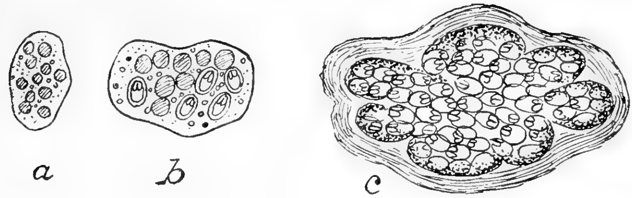

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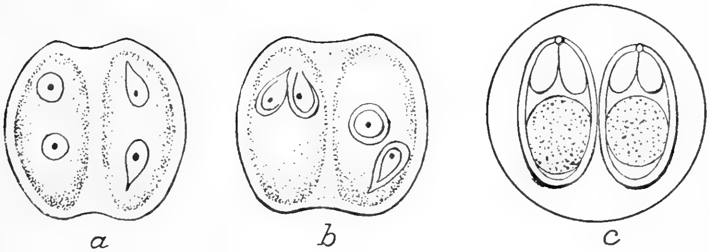

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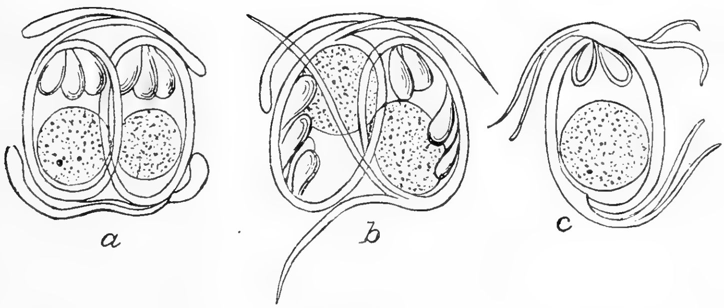

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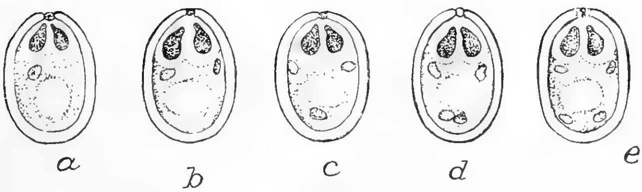

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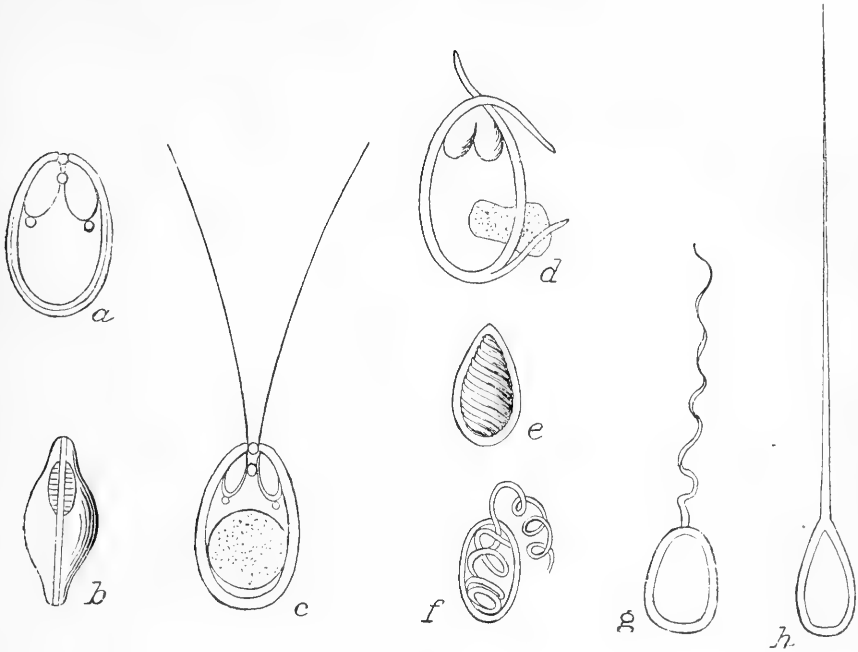

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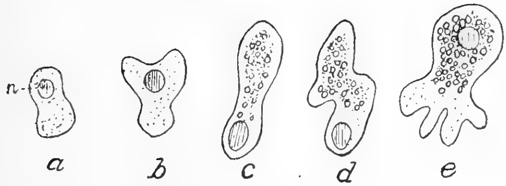

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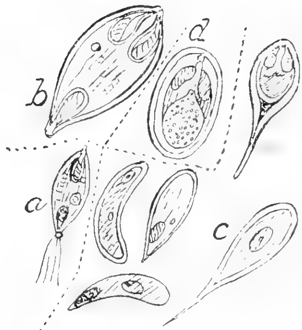

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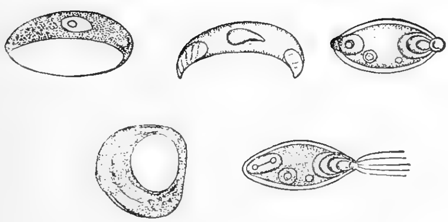

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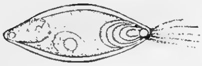

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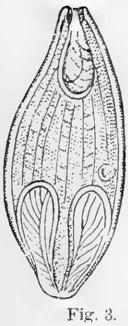

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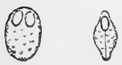

a b

Fig. 4.

Fig. 5.

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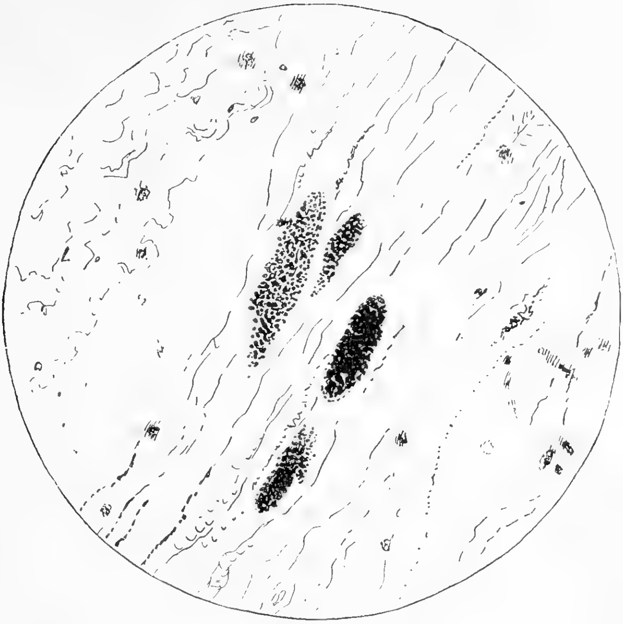

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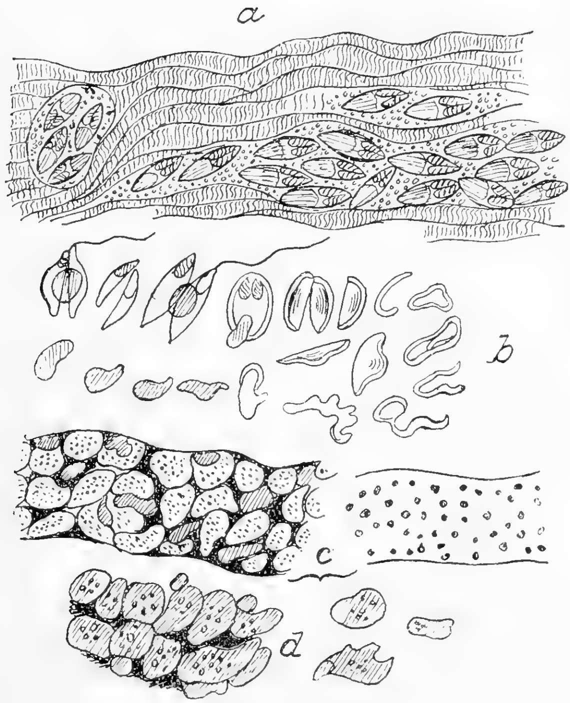

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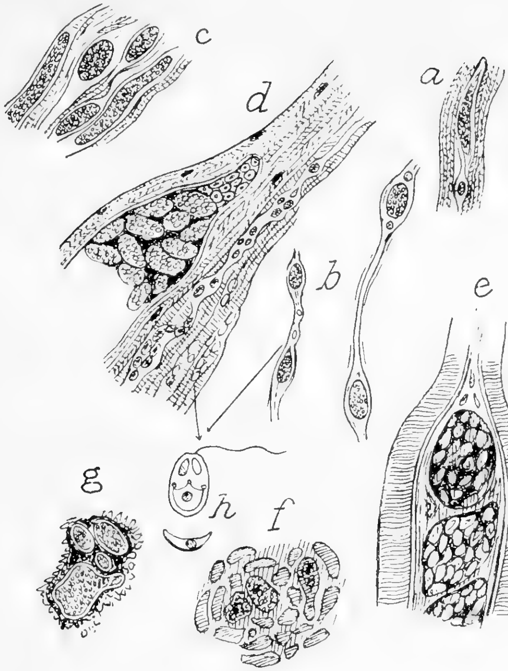

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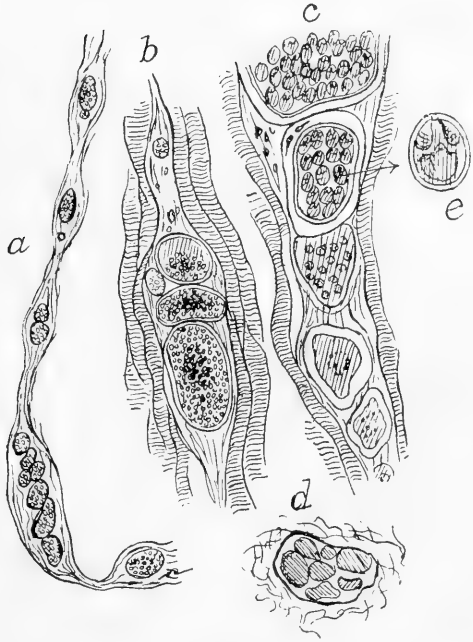

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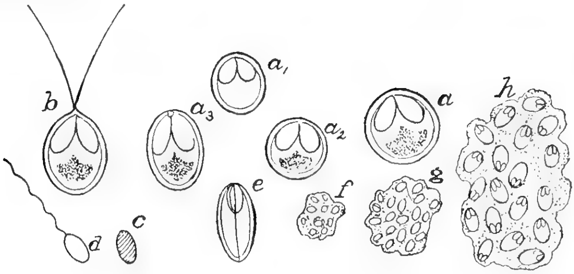

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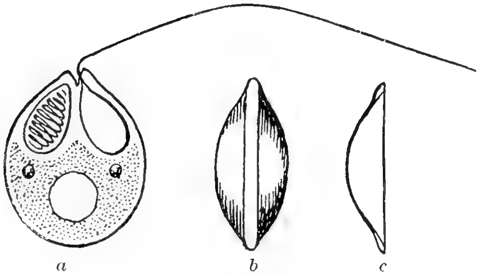

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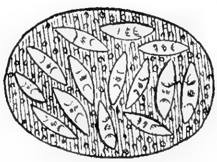

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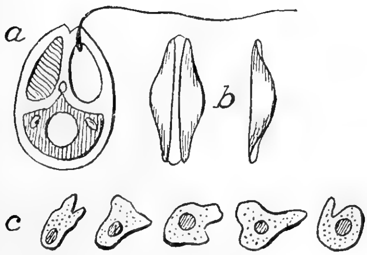

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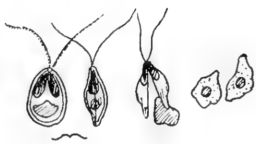

Fig. 6.


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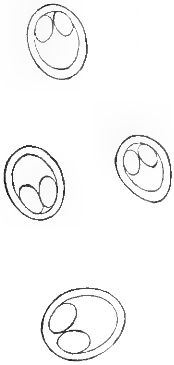
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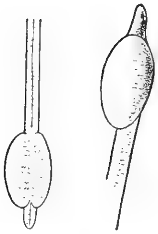
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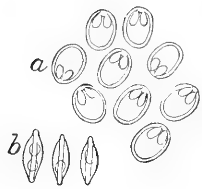

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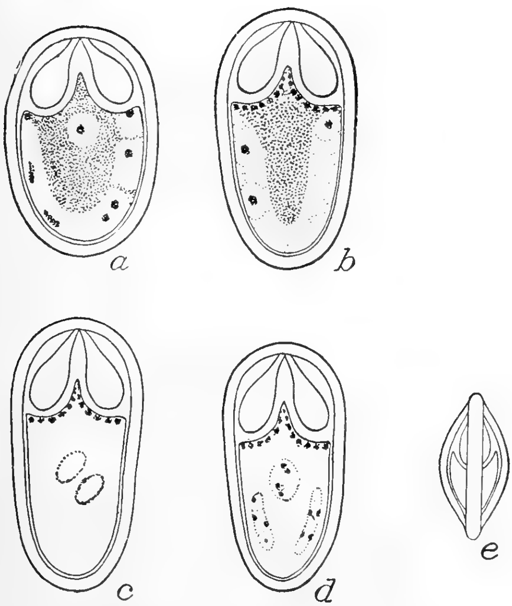

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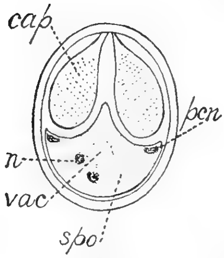

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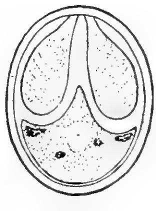
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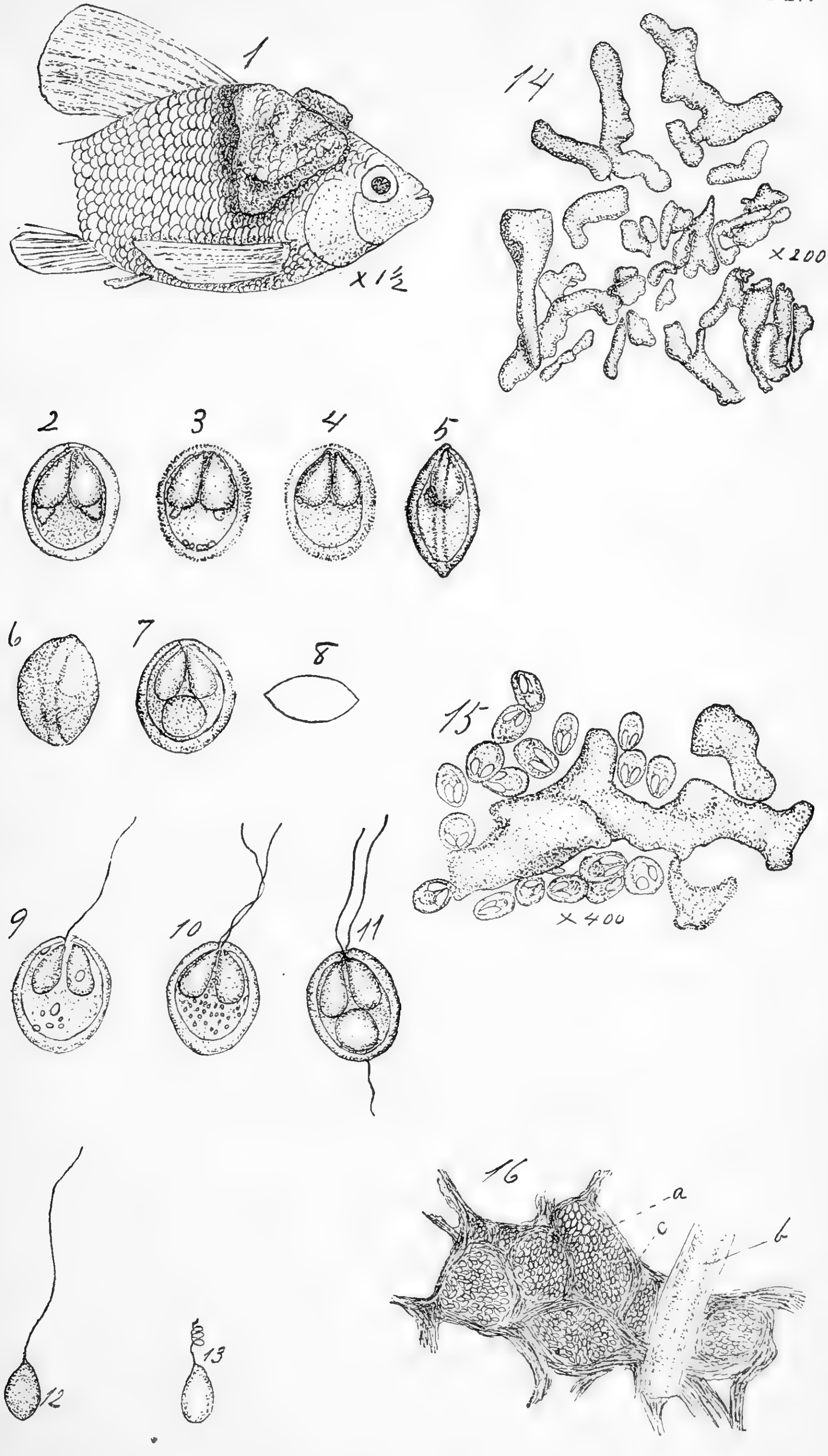
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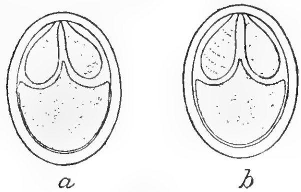

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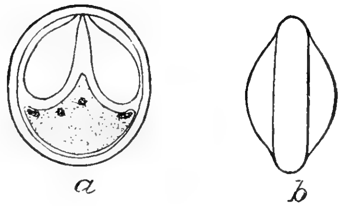

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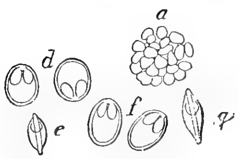

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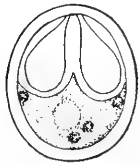

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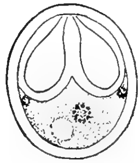

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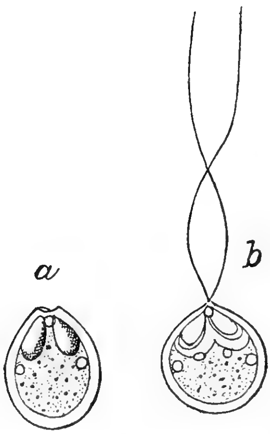

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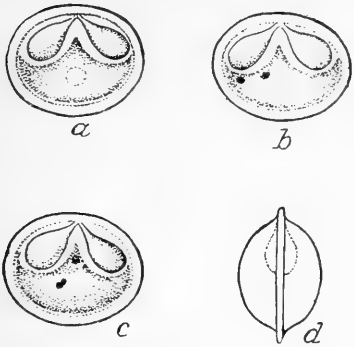

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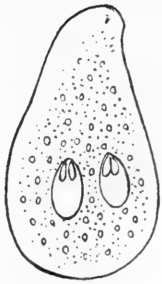

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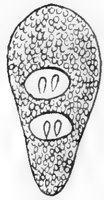

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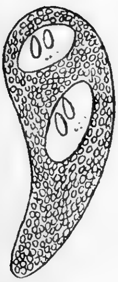

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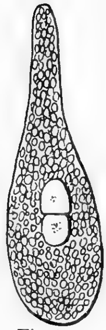

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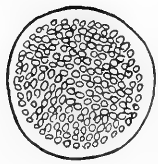

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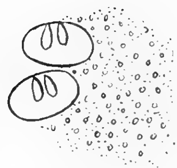

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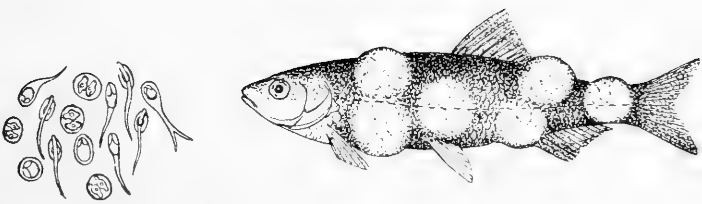

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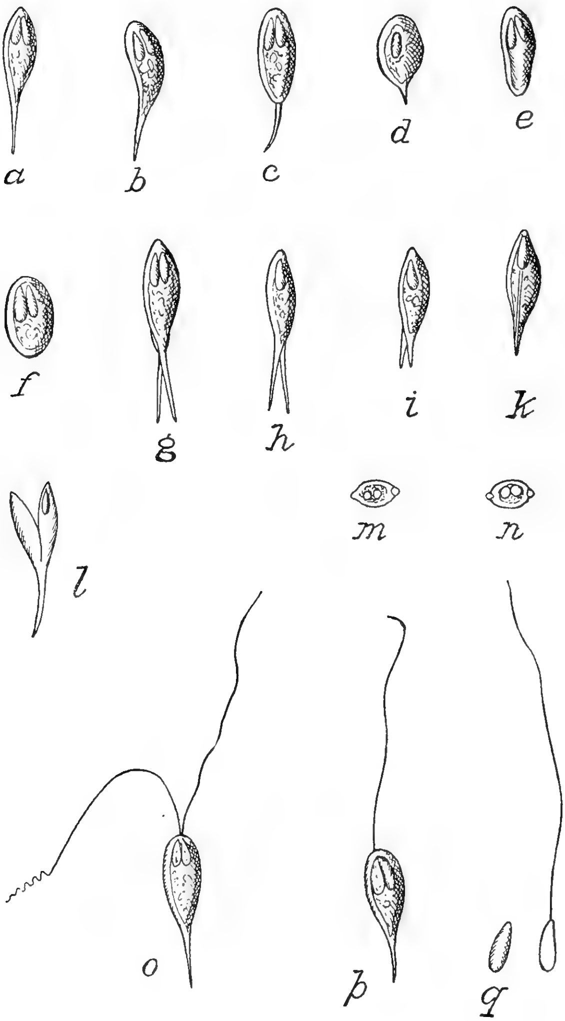

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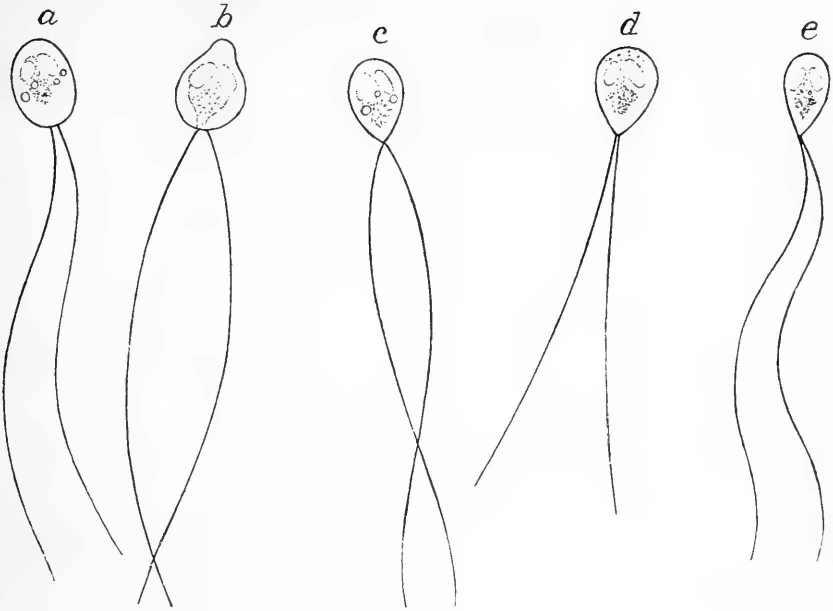

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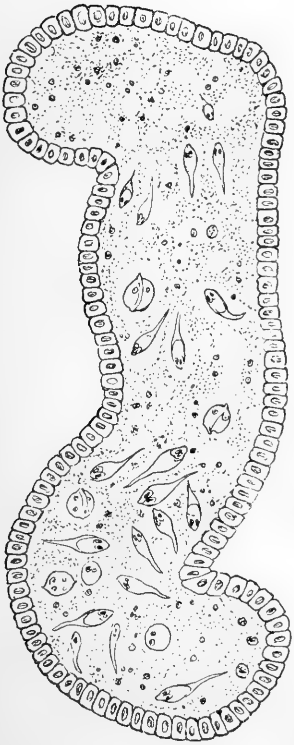
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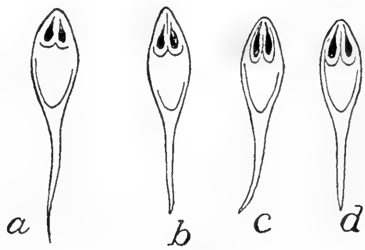

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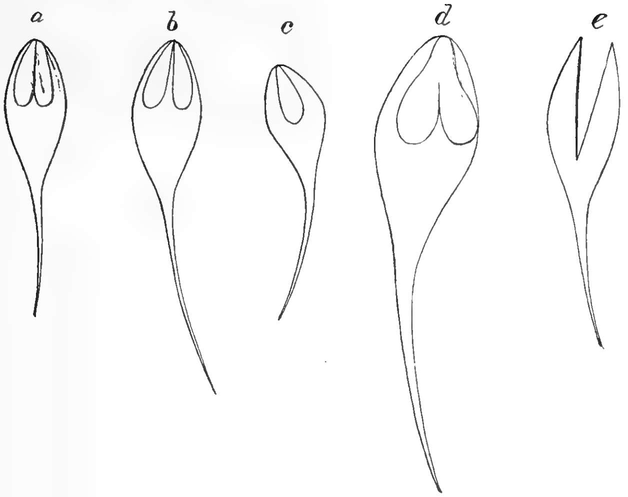

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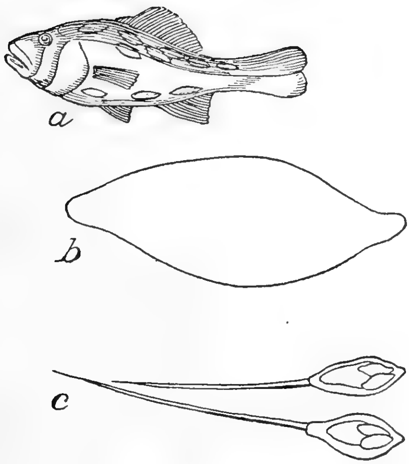

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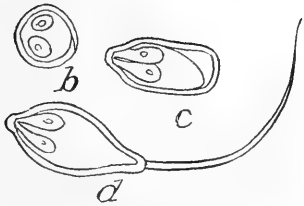

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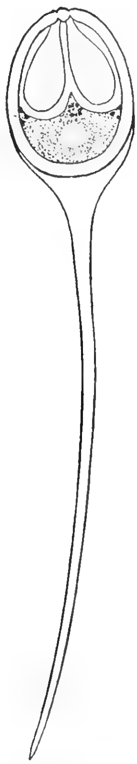

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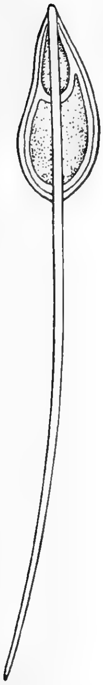
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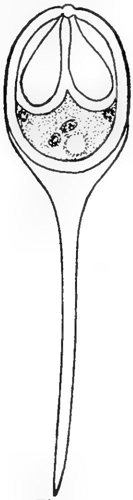
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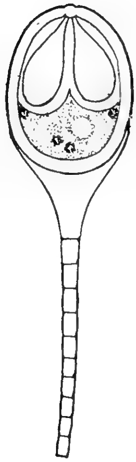
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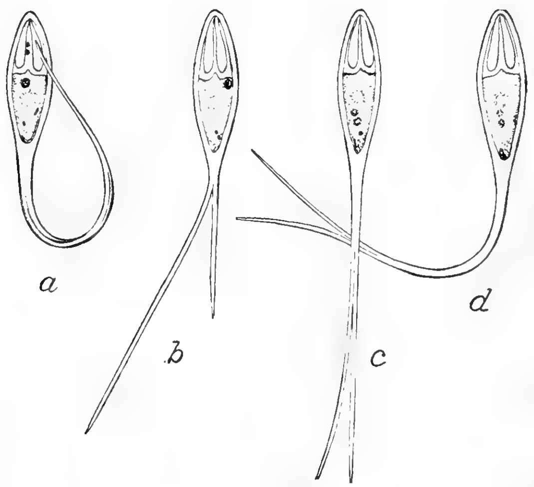

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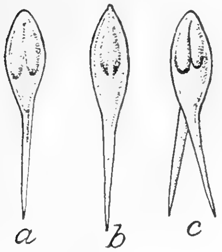

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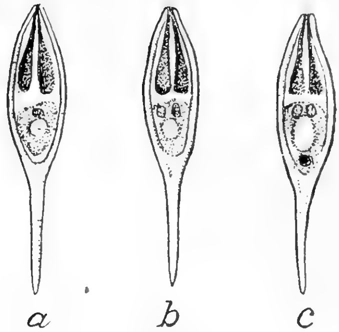

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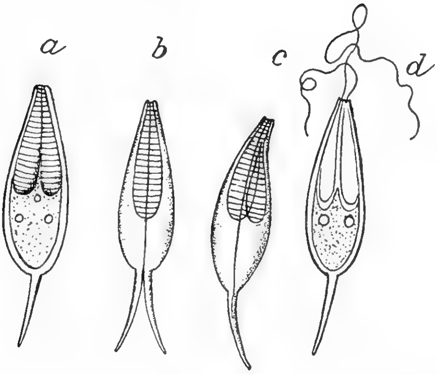

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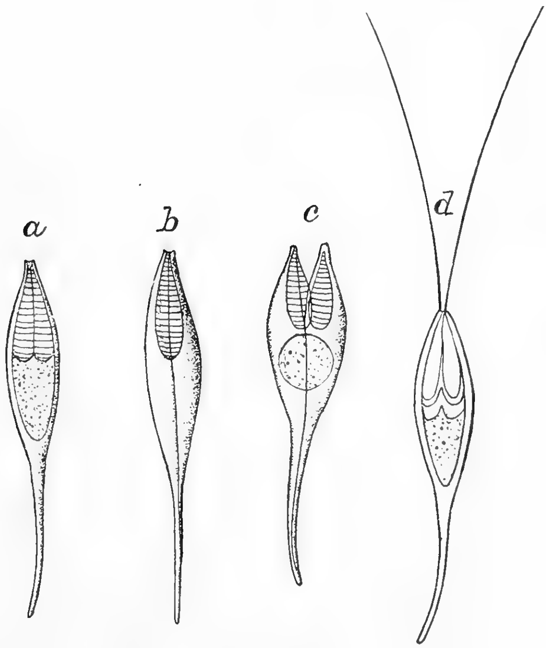

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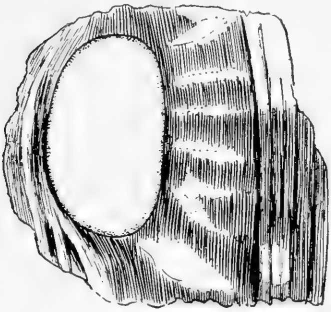

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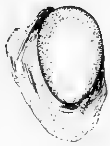

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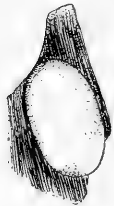

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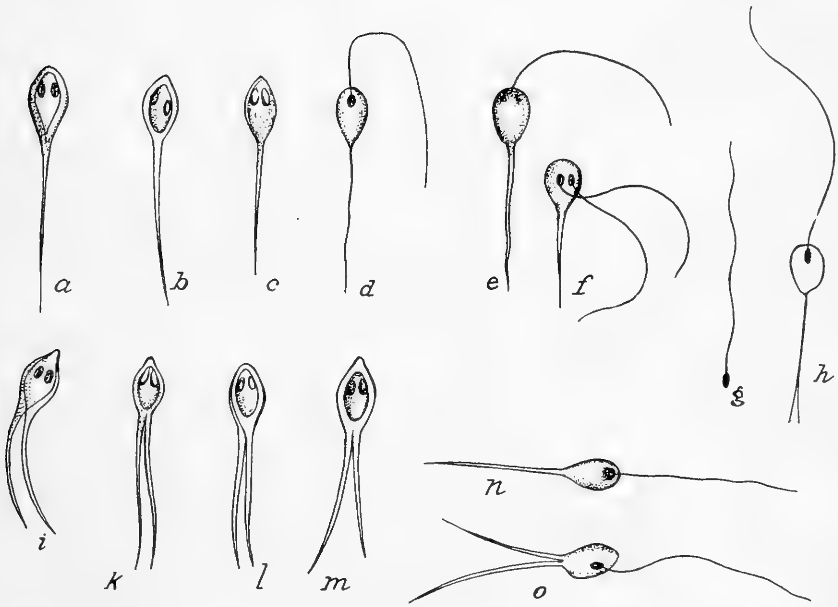

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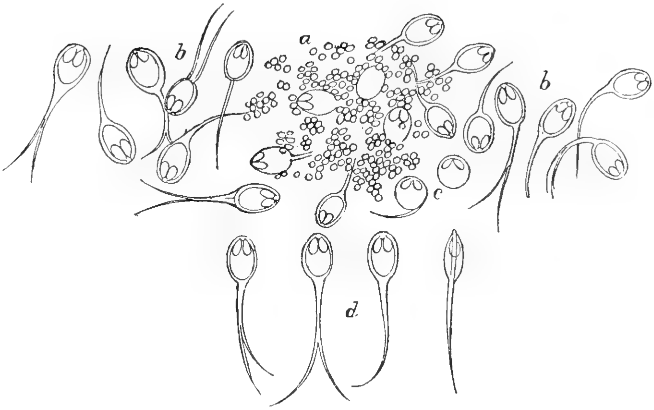

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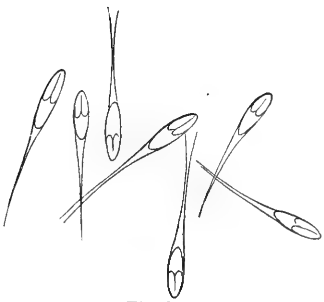

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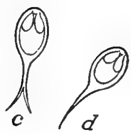

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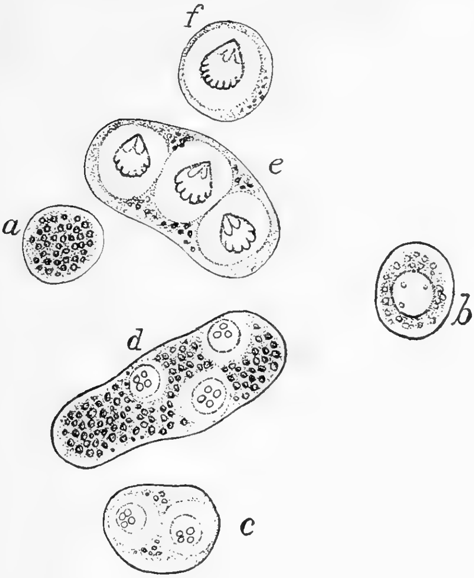

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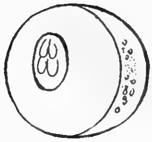

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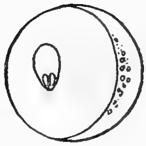

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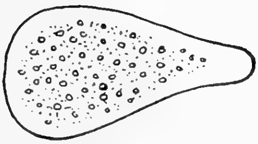

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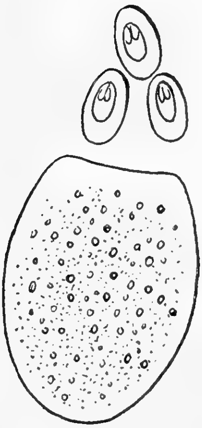

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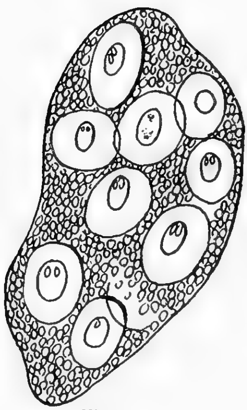

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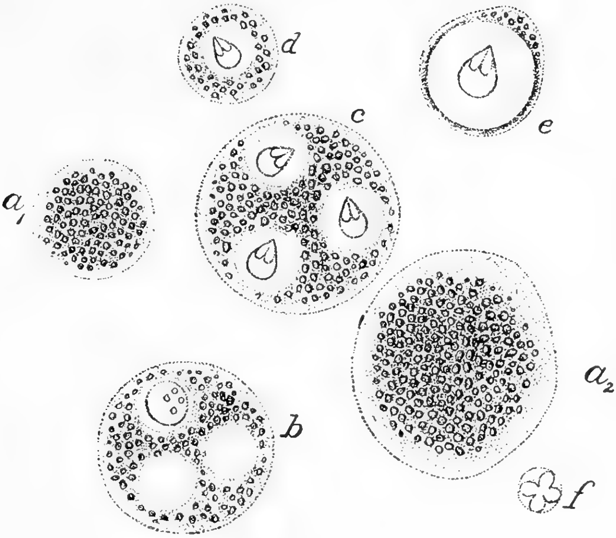

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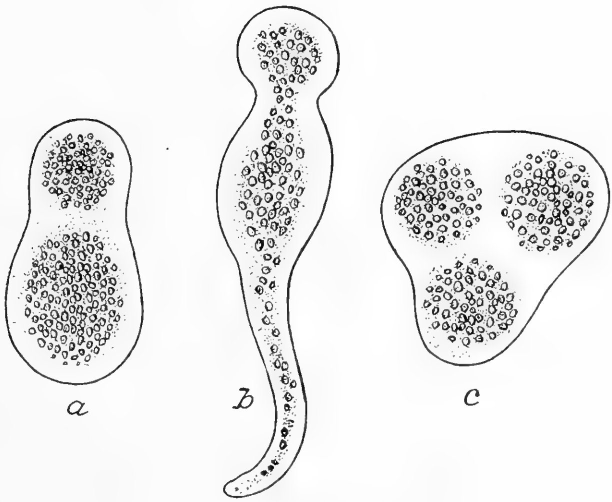

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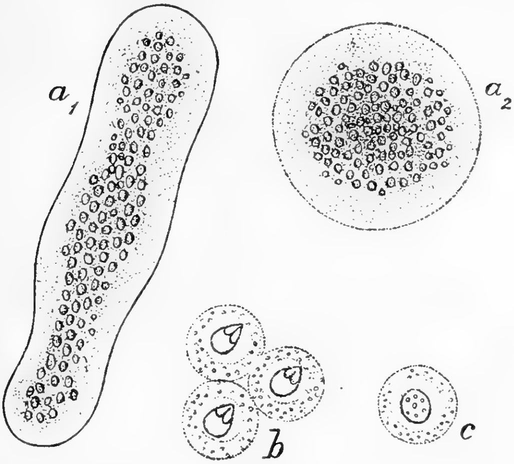

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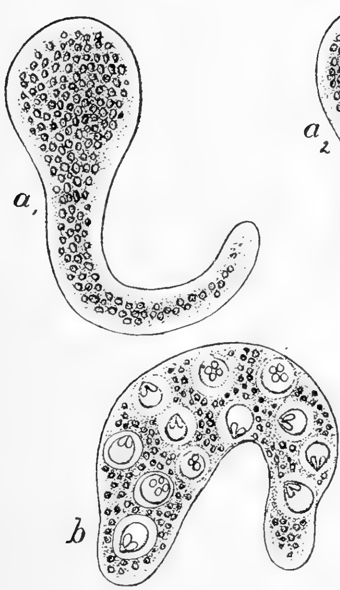

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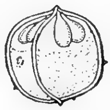

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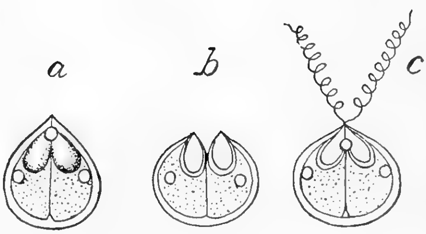

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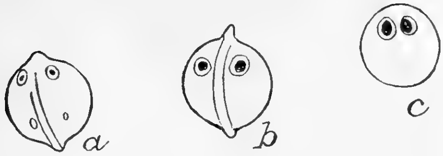

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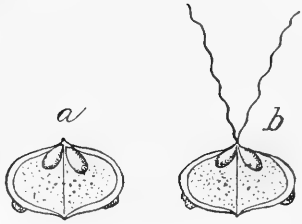

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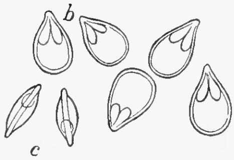

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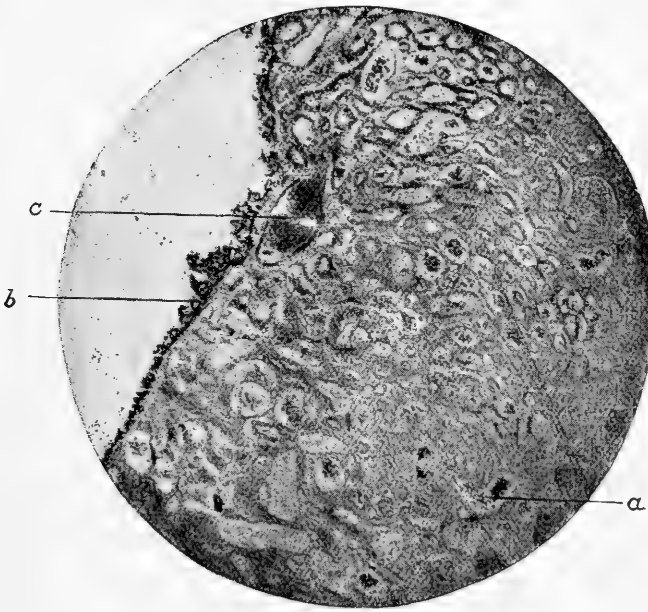

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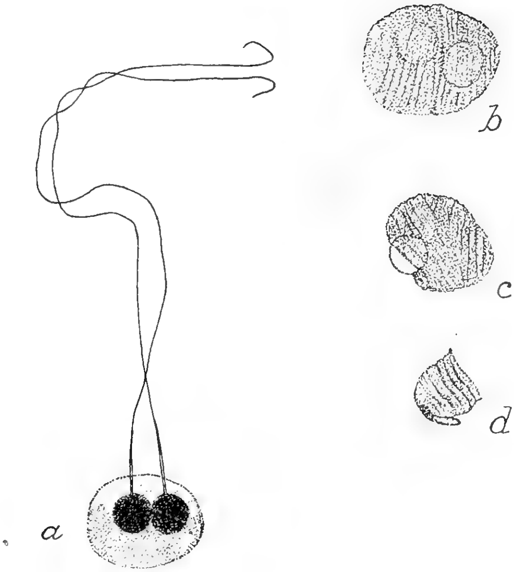

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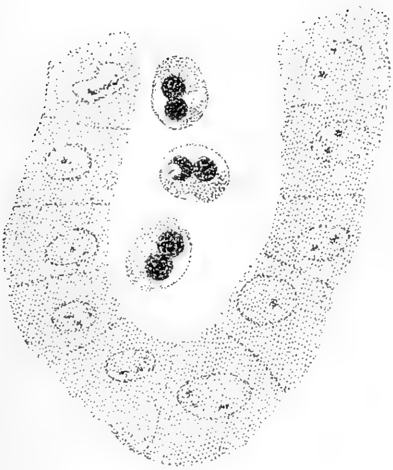

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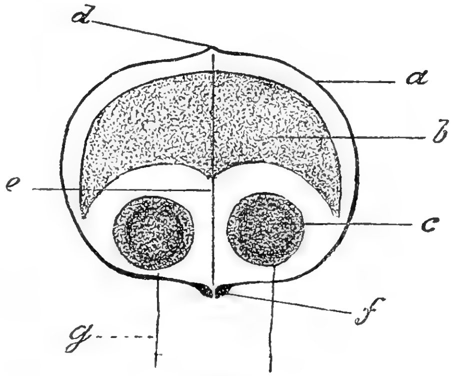

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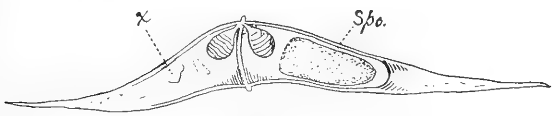

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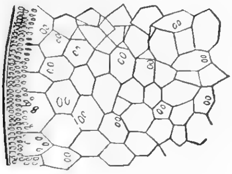
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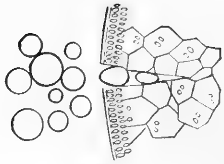
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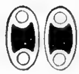
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Fig. 10.


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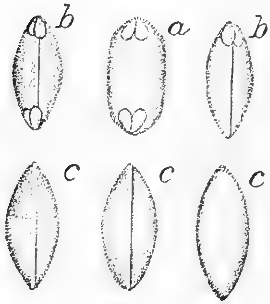

Fig. 13.


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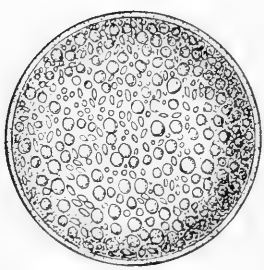
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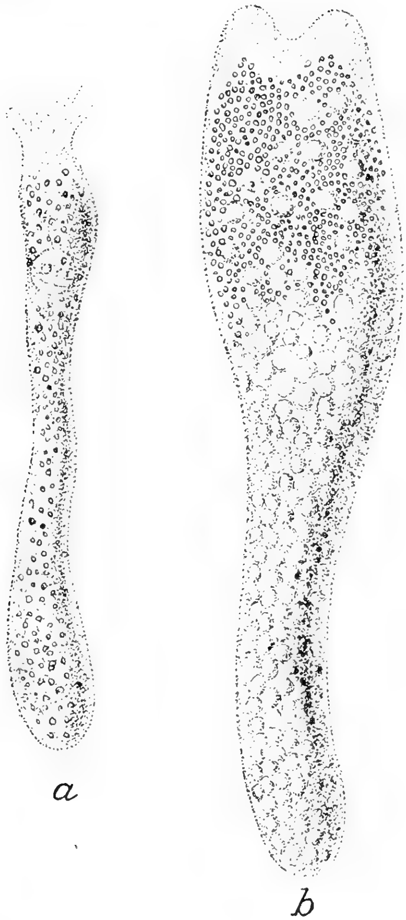

Fig. 1.

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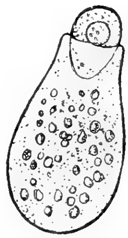

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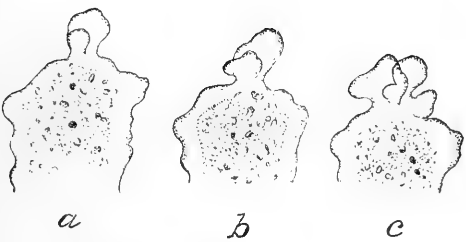


Fig. 3.

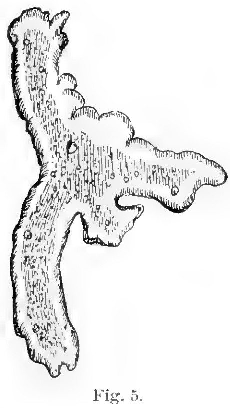


Fig. 5.

PLATE 44.

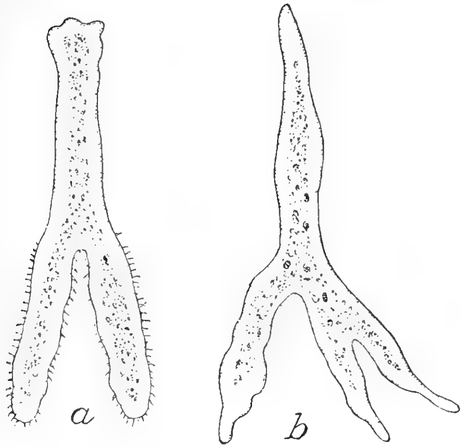


Fig. 1.

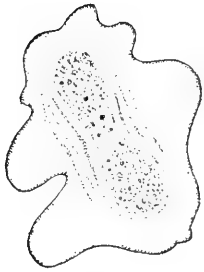


Fig. 2.

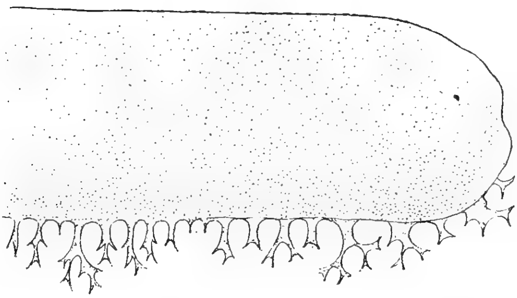
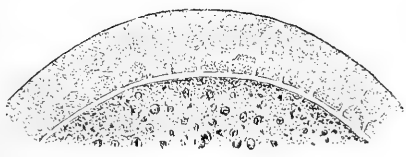


Fig. 4.



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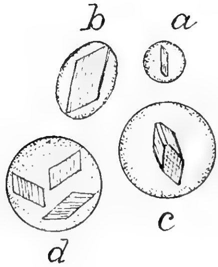


Fig. 5.

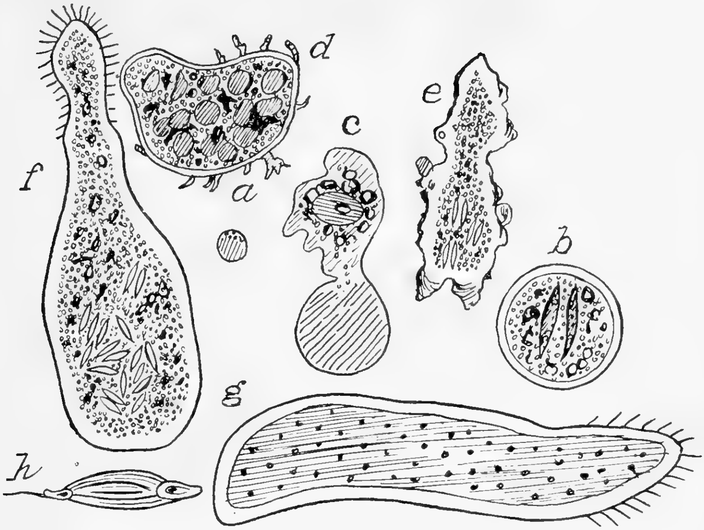


Fig. 1.

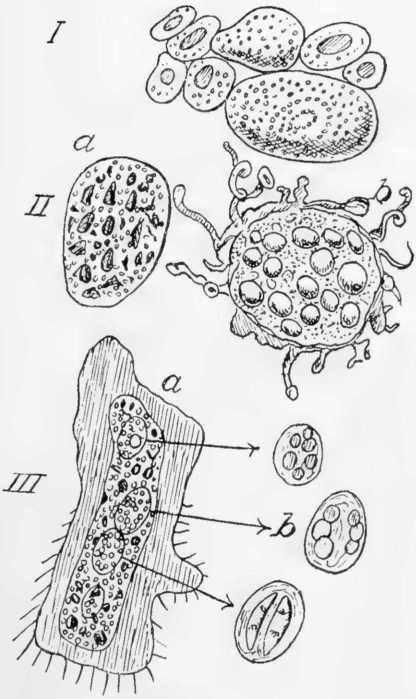
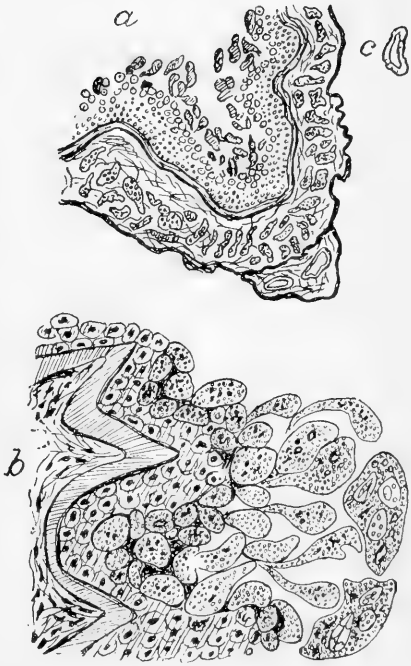


Fig. 2.



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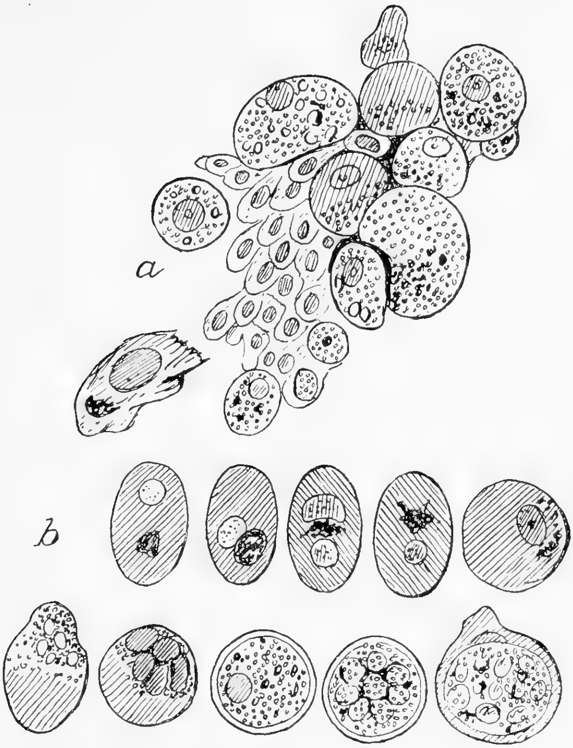

Fig. 1.

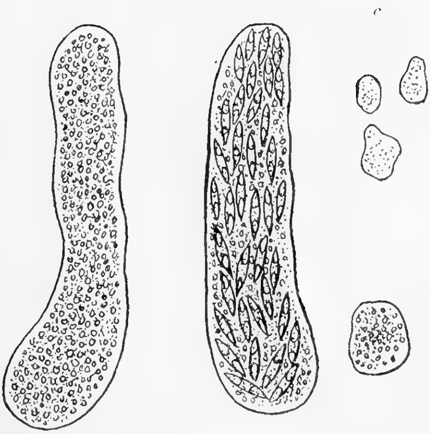

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Fig. 2.

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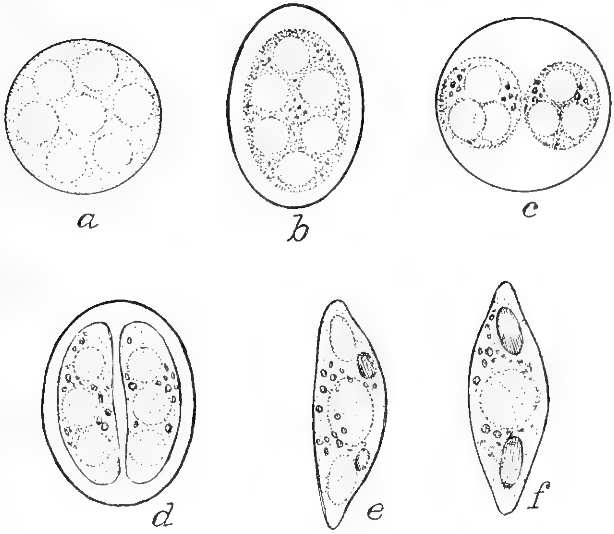


Fig. 1.

Fig. 6

Fig. 2.

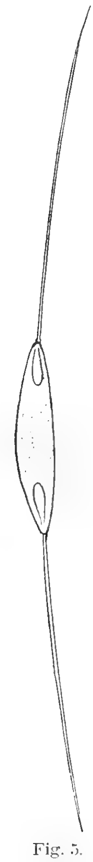
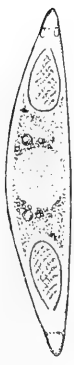


Fig. 5.



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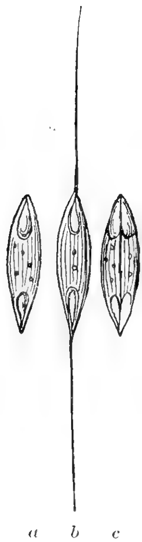

Fig. 4.

3.—A BIBLIOGRAPHY OF PUBLICATIONS IN THE ENGLISH LANGUAGE RELATIVE TO OYSTERS AND THE OYSTER INDUSTRIES.

By Charles H. Stevenson.

INTRODUCTION.

From the period of the Roman Empire to the present time, oysters have occupied a prominent position as a food product; and the growing, harvesting, and marketing of them have given employment to vast numbers of persons and much capital. The subject has consequently afforded an attractive theme for naturalists, historians, government officials, political economists, and miscellaneous writers, and an amazing amount of information in reference thereto has been recorded. This information is so widely distributed through publications and periodicals of almost every description that to the casual inquirer the literature of oysters and the oyster industries appears very meager. In view of the growing attention bestowed on oysters in this country and elsewhere, it is thought that the accompanying compilation of the literature of the subject will supply a need of many persons directly or indirectly interested in oysters and the industries dependent thereon.

Several incomplete bibliographies on this subject have already been published. One of these, consisting of 38 references, 26 of which are to publications in foreign languages, appeared in an appendix to the Report of the Maryland Fish Commission for 1881.* A second list, giving the names of 70 papers in the English language, was published by the Nederlandsche Dierkundige Vereeniging in 1883†; this has been of considerable assistance in the present compilation. In a recent report by the writer on the oyster industry of Maryland‡ there was printed a list of 27 articles relating to the subject of that paper. None of these reference lists, however, furnishes a satisfactory idea of the extent and importance of oyster literature.

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*Report of T. B. Ferguson, a Commissioner of Fisheries of Maryland, January, 1881. Hagerstown, Md., 1881.

† Verslag omtrent Onderzoekingen op de Oester en de Oestercultuur betrekking hebbende uitgebracht door de Commissie voor het Zoologisch Station der Nederlandsche Dierkundige Vereeniging. Leiden, Januari, 1883. 8°, 112 pp.

‡ The Oyster Industry of Maryland. By Charles H. Stevenson. Bulletin U. S. Fish Commission for 1892, pp. 203–297, plates LVI–LXXI, Washington, 1894.

The preparation of a complete bibliography of oysters and the oyster industries was originally contemplated, but the facilities for examining many publications in foreign languages are so unsatisfactory that the present paper has been restricted to works in the English language. It is recognized that such a bibliography must necessarily omit reference to some foreign publications of value. The number of these, however, is much reduced by the enterprise of American scientists and economists in causing most of the important foreign publications to be translated into English. Among the valuable foreign reports which have been translated may be mentioned Voyage d'Exploration sur le Littoral de la France et de l'Italie, by Jean Jacques Coste (Paris, 1861, 4°, 297 pp.), translated in the Report of the U. S. Fish Commission for 1880; Étude sur l'Industrie Huîtrière des États-Unis, by P. De Broca (Paris, 1865, 12°, 266 pp.), translated in the Report of the U. S. Fish Commission for 1873–74 and 1874–75; and Die Auster und die Austernwirthschaft, by Karl Möbius (Berlin, 1877, 8°, 126 pp.), translated in the Report of the U. S. Fish Commission for 1880.

There are, however, several important reports on the anatomy and biology of the oyster that have not yet been translated into English. Among these are several of the publications of the Nederlandsche Dierkundige Vereeniging from 1881 to 1885. The prominent pioneer works on the development of the oyster by Davaine* and Lacaze-Duthiers† are also without English translations.

It is not within the scope of the present compilation to refer to papers dealing only with the nomenclature and classification of oysters, or to encyclopedia articles. Omission has also been made of a very extensive repository of information relative to regulations governing the oyster industries, viz, the session acts of various legislative bodies.

The bibliography here presented contains references to 546 separate publications, the work of over 278 authors. Of these papers, 294 were issued in the United States, 26 in Canada, 176 in England, 25 in Scotland, 10 in Ireland, and 115 in various other countries. Of the American publications, 73 were issued by the U. S. Fish Commission, of which 25 were translations and 48 original articles.

Brief abstracts of important or interesting statements in many of the papers are given, in order to increase the usefulness of the paper.

The compilation is accompanied by a subject index and an author's index to facilitate the finding of references to works on various subjects and the papers of individual writers.

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* C. Davaine: Recherches sur la Génération des Huitres, in Comptes Rendus and Mém. de la Soc. de Biologie, Paris, vol. IV, 1853, pp. 295–339, with 2 plates.

† H. De Lacaze-Duthiers: Mémoire sur le Développement des Acéphales Lamellibranches (Ostrea), in Comptes Rendus de l'Acad. des Sc. Paris, vol. XXXIX, pp. 103 *et seq.* Also, Nouvelles Observations sur le Développement des Huîtres, in Comptes Rendus de l'Acad. des Sc. Paris, vol. XXXIX, pp. 1197 *et seq.*, etc.

BIBLIOGRAPHY OF PUBLICATIONS IN THE ENGLISH LANGUAGE RELATIVE TO OYSTERS AND THE OYSTER INDUSTRIES.

1665—Auzout, M. Shining worms in oysters. <Philosophical Transactions, London, May 7, 1665, No. 12, pp. 203-206.

Within over 240 oysters which the writer examined he discovered a shining substance which, after inspecting with a microscope, he describes as worms; "and these of three sorts; one sort was whitish, having 24 or 25 feet on each side, forked, a black speck on one side of the head and the back like an eel stript of her skin; the second was red, and resembling the common glowworm, found on land, which folds upon their backs, and feet like the former, and with a nose like that of a dog, and one eye in the head; the third sort was speckled, having a head like that of a soal, with many tufts of whitish hair on the sides of it."

1668—Worlidge, J. Systema Agriculturæ; being the Mystery of Husbandry Discovered and Laid Open. London, 1868. 4°, 278 pp.

Describes the uses of oyster shells for agricultural purposes. See 1675.

1669—Sprat, Thomas. The history of the generation and ordering of green oysters, commonly called Colchester oysters. <History of the Royal Society. London, 1669. 4°.

This, the first paper of importance within the scope of this bibliography, is so concise and interesting that it is here transcribed nearly entire, these extracts being from pp. 307-309 of the third edition, published in London in 1722: "In the Month of May the Oysters cast their Spawn (which the Dredgers call their Spat); it is like to a drop of Candle, and about the bigness of a half-penny. The Spat cleaves to Stones, old Oyster-shells, pieces of Wood, and such like things, at the bottom of the Sea, which they call 'Cultch.' 'Tis probably conjectured, that the Spat in 24 hours begins to have a Shell. In the month of May the Dredgers (by the law of the Admiralty Court) have liberty to catch all manner of Oysters of what size soever. When they have taken them, with a knife they gently raise the small brood from the Cultch, and then they throw the Cultch in again, to preserve the ground for the future, unless they be so newly spat that they can not be safely severed from the Cultch, in that case they are permitted to take the stone or shell, etc., that the Spat is upon, one shell having many times 20 spats.

"After the month of May it is Felony to carry away the Cultch, and punishable to take any other Oysters, unless it be those of size (that is to say) about the bigness of a half crown piece, or when the two shells being shut, a fair shilling will rattle between them. The places where these Oysters are chiefly catched are called Pont-Burnham, Malden, and Colnewaters. * * * This Brood and other Oysters they carry to Creeks of the Sea at Brinkel sea, Mersey, Longno, Fringrego, Winenho, Tolesbury, and Salt-coase, and there throw them into the Channel, which they call their Beds or Layers, where they grow and fatten, and, in 2 or 3 years, the smallest Brood will be Oysters of the size aforesaid. Those Oysters which they would have green, they put into Pits about 3 foot deep, in the Salt-marches, which are overflowed only at Spring-tides, to which they have sluices, and let out the Saltwater until it is about 1½ foot deep. These Pits from some quality in the Soil coöperating with the heat of the Sun, will become green, and communicate their color to the Oysters that are put into them in 4 or 5 days, though they commonly let them continue there 6 Weeks or 2 Months, in which time they will be of dark green. To prove that the Sun operates in their greening, Tolesbury Pits will green only in Summer; but that the Earth hath the greater power, Brisklo sea Pits green both Winter and Summer; and for further proof, a Pit within a foot of a greening Pit will not green; and those that did green very well, will in time loose their quality.

"The Oysters when the tide comes in, lie with hollow shell downwards, and when it goes out they turn on the other side; they remove not from their place unless in cold weather, to cover themselves in the Ouse. The reason of the scarcity of Oysters, and consequently of their dearness, is because they are of late years bought up by the Dutch. There are great penalties by the Admiralty Court, laid upon those that fish out of those grounds which the Court appoints, or that destroy the Cultch, or that take any Oysters that are not of size, or that do not tread under their feet, or throw upon the shore, a Fish which they call a Five-finger, resembling a Spur-rowel, because that fish gets into the Oysters when they gape, and sucks them out. The reason why such a penalty is set upon any that shall destroy the Cultch, is because they find that if that be taken away the Ouse will increase, and then muscles and cockles will breed there, and destroy the Oysters, they having not whereon to stick their Spat. The Oysters are sick after they have Spat; but in June and July they begin to mend, and in August they are perfectly well: The Male Oyster is black-sick, having a black Substance in the Fin; the Female white-sick (as they term it) having a milky Substance in the Fin. They are salt in the Pits, salter in the Layers, saltest at Sea." See 1722.

1675—Worlidge, J. Systema Agriculturæ; the Mystery of Husbandry Discovered. The second edition. London, 1675. 4°. See 1681.

Reprint of 1668. See 1681.

1681—Worlidge, J. Systema Agriculturæ, the Mystery of Husbandry Discovered. The third edition, with one whole section added (of fish, carp, trout, and oyster ponds). London. Tho. Dring. 1681. 4°.

Not seen. Title from Verslag omtrent onderzoekingen op de oester en de oestercultuur betrekking hebbende der Nederlandsche Dierkundige Vereeniging, Leiden, 1883, p. 680. See 1698.

1693—Leuwenhoek, Anth. van. Animalcules in muscles and oysters. <Philosophical Transactions, London, January, 1693, No. 196, pp. 593–594.

The animalcules in the oysters were possibly the young oysters. To this famous opponent of the doctrine of spontaneous generation belongs the honor of having discovered the existence of spermatozoa in oysters.

1697—Leuwenhoek, Anth. van. Part of a letter concerning the eggs of snails, roots of vegetables, teeth and young oysters. <Philosophical Transactions, London, December, 1697, vol. XIX, No. 235, pp. 790–799.

Discovered September 3, 1697, in "an English oyster," a grayish stuff which he took to be young oysters; yet in 50 others nothing of the kind was discovered. Hence he surmises "that one oyster bringeth forth its young ones much later than the other."

1698—Worlidge, J. Systema Agriculturæ, the Mystery of Husbandry Discovered. The fourth edition. London, John Taylor, 1698, 4°.

A reprint of 1681. See also 1668.

1720—Rowlands, M. Stocking the river Mene with oysters. <Philosophical Transactions, London, 1720, No. 369, p. 250.

States that the beds in Menai then furnished an abundance of oysters, notwithstanding the fact that none existed in that locality twenty-four years previously, the growth having been started by the personal industry of one planter.

1722—Sprat, Thomas. The history of the generation and ordering of green oysters, commonly called Colchester oysters. <History of the Royal Society. Third edition. London, 1722, pp. 307–309.

A reprint of 1669.

1744—Bartram, J. Some observations concerning the salt-marsh muscle, the oyster banks and the fresh-water muscle of Pensilvania. <Philosophical Transactions, London, 1744, vol. XLVIII, No. 474, pp. 157–160.

Likens the growth of oysters in Pennsylvania to that of "*spuntia*" or Indian fig.

1755—Ellis, John. Corallines on oyster shells. < Philosophical Transactions, London, 1755, vol. XLVIII, part II, pp. 627–633, with two plates.

Classifies the forms and describes the manner in which corallines grow on oyster shells around the British coasts.

1808—Chrisolm, C. On the poison of fish. < Edinburgh Medical and Surgical Journal, Edinburgh, October, 1808, vol. IV, pp. 391–422.

On pp. 400–401 a case is reviewed in which certain persons suffered "cholera and excruciating tormina" after eating of oysters that grew on the copper sheathing of a sunken ship.

1814—Home, Everard. The digestive organs of the oyster. < Home's Lectures on Comparative Anatomy, London, 1814, vol. II, p. 77.

Locates and describes the mouth, stomach, intestines, anus, and adductor muscle of the *Ostrea edulis.*

1827—Home, Everard. The mode by which the propagation of the species is carried on in the common oyster and the large fresh-water muscle. Croonian lecture for 1826. Read November 17, 1826. < Philosophical Transactions, London, 1827, pp. 39–48, plates III–VI.

Discusses with much detail, on pp. 41-44, the anatomy and reproduction of *Ostrea edulis.* The plates indicate the locations of the several organs, and the various stages in the development of the ovaries and young oysters. See 1828.

1828—Home, Everard. Development of the ova of the common oyster. < Home's Lectures on Comparative Anatomy, London, 1828, vol. VI.

A reprint of 1827.

1836—Deshayes, G. P. Conchifera. <Todd's Cyclopedia of Anatomy and Physiology, London, 1836, vol. I.

Treats of the anatomy of the oyster.

1837 a—Garner, Robert. On the nervous system of molluscous animals. < Transactions of the Linnæan Society of London. London, 1837, vol. XVII, pp. 485–501, plate XXIV.

The special feature of this article is the author's reference to the visual powers of oysters. "In *Pecten*, *Spondylus*, and *Ostrea* we find small, brilliant, emerald-like ocelli, which from their structure, having each a minute nerve, a pupil, a pigmentum, a striated body, and a lens, and from their situation at the edge of the mantle, where alone such organs could be useful, and also placed as in *Gasteropoda*, with the tentacles, must be organs of vision."

The question of the ability of oysters to see has also been answered in the affirmative by Will (in Froriep's Neue Notizen, No. 622), who states that there are as many as 30 distinct eyes projecting from the border of the mantle. But Siebold denies that such is the case, and regards the so-called eyes as simply excrescences devoid of optical powers. There can, however, be little doubt that these mollusks are sensitive to light. For further information on this interesting subject see Mitt. aus der Zool. Stat. zu Neapel, vol. VI, 1866; Froriep's Neue Notizen, Nos. 622 and 623; Siebold's Anatomy of the Invertebrata, Boston, 1854, vol. 1, pp. 201-202; and The Eye of Pecten, by Sydney J. Hickson, Studies from the Morphological Laboratory in the University of Cambridge, Part II, 1882, pp. 1–12.

1837 b—Anonymous. The oyster. <Penny Magazine, London, June 24, 1837, vol. VI, pp. 235–238.

A description of the oyster industry of Great Britain with notes on the natural history of the oyster.

1838 a—N—— C. A crustaceous tour; by the Irish Oyster-Eater. < Blackwood's Edinburgh Magazine, Edinburgh, November, 1838, vol. 44, pp. 637–649.

A humorous discussion of the Irish oyster beds and their products.

1838 b—Anonymous. An essay on oysters. <Colburn's New Monthly Magazine, London, 1838, vol. 53, pp. 541 *et seq.*

1839—Parliamentary Paper. Convention between Her Majesty and the King of the French, Defining and Regulating the Limits of the Exclusive Right of the Oyster Fishery on the Coast of Great Britain and France, dated August, 1839. London, 1839.

1841 a—Garner, Robert. On the Anatomy of the Lamellibranchiate Conchifera. <Transactions of the Zoological Society of London. London, 1841, vol. II, pp. 87–102, pl. XIX.

[Communicated December 8, 1835.]

1841 b—Gould, A. A. Report on the Invertebrata of Massachusetts, Comprising the Mollusca, Crustacea, Annelida, and Radiata. Cambridge, 1841, 8°, XIII + 373 pp., 15 plates.

See 1870 *d*.

1843 a—Akerly, Samuel. Shellfish of Richmond County. <Transactions of the New York State Agricultural Society, together with an Abstract of the Proceedings of the County Agricultural Societies for the year 1842. Albany, 1843, vol. II, p. 196.

Refers to the exhaustion of the natural oyster reefs and the development of the planting industry on the south side of Staten Island, New York.

1843 b—Dekay, James E. Zoology of New York, or the New York Fauna; Comprising Detailed Descriptions of all the Animals Hitherto Observed within the State of New York, with Brief Notices of those Occasionally Found Near its Borders, and Accompanied by Appropriate Illustrations. Part VI, Mollusca. Albany: W. & A. White & J. Visscher, 1843, 4°, 271 pp., 40 plates.

Discusses the occurrence and distribution of oysters along the shores of New York State.

1846—Reade, J. B. On the cilia and ciliary currents of the oyster. <Report of the British Association for the Advancement of Science, fifteenth meeting, 1845. London, 1846, pp. 66–67.

Describes the gullet of the oyster as covered with fine, silky hairs or cilia, which by a waving motion cause a current of water to flow towards the mouth, thus supplying the mollusk with food. Also states that the food consists wholly of infusoria.

1849—Forbes, Edward, and **Hanley, Sylvanus.** On the geographical distribution and uses of the common oyster (*Ostrea edulis*). <Edinburgh New Philosophical Journal of Natural Science, Edinburgh, October, 1849, vol. XLVII, No. XCIV, pp. 239–248.

Reprint of part XX of Forbes and Hanley's History of British Mollusca. See 1853.

1850—Perley, M. H. Report on the Sea and River Fisheries of New Brunswick within the Gulf of St. Lawrence and Bay of Chaleur. Fredericton: J. Simpson, Printer to the Queen's Most Excellent Majesty. 1850. 8°, 176 pp.

The oyster resources of New Brunswick are described on pp. 132–133.

1851—Haywarde, Richard. The first oyster-eater. <The Knickerbocker, New York, May, 1851, vol. XXXVII, pp. 385–388.

An archæological discussion.

1852 a—Williams, Thomas. On the structure of the Branchiæ or mechanism of breathing in the Pholades and other Lamellibranchiate mollusks. <Report of the twenty-first meeting of the British Association for the Advancement of Science; held at Ipswich in July, 1851. London, 1852, p. 82.

An abstract of the address delivered.

1852 b—Anonymous. Shellfish, their ways and works. <The Westminster Review, London, February, 1852.

Discusses the "morals" of oysters. See 1852 *c*.

1852 c—Anonymous. The happiness of oysters. <International Magazine, New York, March 1, 1852, vol. V, p. 311.

Extracted from 1852 *b*.

1852 d—Parliamentary Paper. Memorial and Letters Relative to Dredging for Oysters in Deep Water During the Summer Months. London, 1852.

1853—Forbes, Edward, and **Hanley, Sylvanus.** On the geographical distribution and uses of the common oyster (*Ostrea edulis*). <History of British Mollusca, and their Shells. London, 1853, gr. 8°, 4 vols., 198 plates.

Indicates the location of the principal oyster beds of the British coast, including those of Scotland and Ireland, and refers to the existing fishery regulations. Describes the oyster enemies, especially the starfishes, whelks, sponges, and certain annelids. The work also contains many anatomical details. Several other editions have been published.

1854 a—Seibold, C. Th. v. Anatomy of the Invertebrata. Boston: Gould and Lincoln, 1854, 8°, 470 pp.

The Acephala are described on pp. 184-222.

1854 b—Parliamentary Paper. Letters from the Board of Trade of April 28, 1847, to the Commissioners of Customs, and of July 31, 1849, to Messrs. Rayson, Alston and Gibbs, on the Subject of the Oyster Fishery on the East Coast of England. London, 1854.

1855 a—Bush, George. A monstrous oyster shell. <Annals and Magazine of Natural History, London, February, 1855, pp. 91–92, 1 plate.

Describes a very large oyster shell, which somewhat resembled the shell of *Pholas candida*, and discusses its origin.

1855 b—Gray, J. E. A monstrous oyster shell. <Annals and Magazine of Natural History, London, March, 1855, p. 210.

A continuation of the foregoing discussion.

1855 c—Henslow, J. S. A monstrous oyster shell. <Annals and Magazine of Natural History, London, April, 1855, vol. XV, p. 314.

A continuation of the discussion started by Bush. See 1855 *a*.

1856—Eyton, T. C. The oyster and the oyster beds of the British shores. <Edinburgh New Philosophical Society of Natural Science, Edinburgh, October, 1856, vol. IV, No. II, pp. 354–355.

A reprint of 1857 *c*.

1857 a—Carpenter, Philip. Report on the present state of our knowledge with regard to the mollusca of the west coast of North America. <Report of the twenty-sixth meeting of the British Association for the Advancement of Science, held at Cheltenham in August, 1856. London, 1857, pp. 159–368.

Species of *Ostrea* are listed and described.

1857 b—Eyton, T. C. Oyster breeding. <Annual of Scientific Discovery, London, 1857, p. 365.

Calls attention to the effect of the depth of water on the spawning season of oysters and computes the brood of three oysters at 3,000,000.

1857 c—Eyton, T. C. The oyster and the oyster beds of the British shores. <Report of the twenty-sixth meeting of the British Association for the Advancement of Science, held at Cheltenham in August, 1856. London, 1857, pp. 368–370.

Discusses briefly: (1) The oyster beds of England and the laws respecting them; (2) An account of the individual beds from the author's personal observation and inquiries; (3) The natural history of the oyster (*Ostrea edulis*). See 1856 *b*.

1857 d—MacAndrew, Robert. Report on the Marine testaceous molluscs of the northeast Atlantic and neighboring seas, and the physical conditions affecting their development. <Report of the twenty-sixth meeting of the British Association for the Advancement of Science, held at Cheltenham in August, 1856. London, 1857, pp. 101–158.

Lists and describes *Ostrea* on pp. 114 and 135.

1857 e—Parliamentary Paper. Directions for Giving Effect to Certain Rules Made by the Committee of Council for Trade on May 21, 1857, Respecting the Oyster Fisheries in the Seas between the British Isles and France. London, 1857.

1858 a—De Bow, J. D. B. Oyster Trade of Virginia, Baltimore, and Fair Haven. <De Bow's Commercial Review, New Orleans, March, 1858, vol. 24, pp. 259–260.

A statistical review of the industry in each of the three localities mentioned.

1858 b—**Eyton, T. C.** A History of the Oyster and the Oyster Fisheries. London, John Van Voorst. 1858. 8°, 40 pp., 6 plates.

Treats of (1) History and antiquity of the oyster as an article of food. (2) Laws of Great Britain relative to oyster fisheries. (3) Natural history and anatomy of the oyster. (4) Reproduction and growth (*Ostrea edulis*). (5) Enemies of the oyster. (6) List and account of the principal oyster beds of Great Britain. (7) Suggestions for the formation of new oyster beds and the preservation of old ones.

1858 c—**Anonymous.** Essay on oysters. <Irish Quarterly Review, Dublin, 1858, vol. VII, pp. 804 *et seq.*

1859 a—**Pell, Robert L.** Edible fishes of New York. <Transactions of the New York State Agricultural Society, with an Abstract of the Proceedings of the County Agricultural Societies. Albany, 1859, vol. XVIII, pp. 334–397.

The oyster is discussed on pp. 394–396, the principal feature being statistics on the extent of the industry in Maryland in 1858.

1859 b—**Anonymous.** Oyster culture in France. <London Practical Mechanics Journal, London, May, 1859.

Describes briefly the experiments made in oyster-culture by the Government of France in the Bay of St. Brieuc, on the coast of France.

1859 c—**Anonymous.** Oyster manufacture. <Journal of the Franklin Institute, Philadelphia, 1859, vol. 68, pp. 197–198.

Abstract of 1859 *b*.

1860—**Martin, W. C. L.** Traveling oyster beds. <Recreative Science, London, 1860, vol. I, p. 96.

1861 a—**Dickens, Charles** (Editor). Oysters. <All the Year Round, London, March 16, 1861, vol. IV, pp. 541–547.

Discusses the "morals" of the oyster and its edible qualities, with many references to historical celebrities who were fond of them.

1861 b—**Hall, Anna Maria.** Concerning oysters. <St. James Magazine, London, August, 1861, vol. II, pp. 66–74.

A compilation of well-known facts relative to the distribution and abundance of oysters. Also reviews briefly the oyster message of Governor Wise, submitted to the Virginia Legislature in 1860.

1861 c—**Anonymous.** Oysters. <Chambers' Journal, Edinburgh, 1861, vol. 36, pp. 336 *et seq.*

1862 a—**Bertram, James G.** The fisher folk of the Scottish east coast. <Macmillan's Magazine, London, October, 1862, vol. VI, pp. 501–512.

Contains a description of the oystermen of Great Britain and their operations.

1862 b—**Anonymous.** Cultivation of oysters on the west coast of France. <Times, London, November 13, 1862.

Describes the operations of the French Government and the results thereof.

1862 c—**Anonymous.** Kentish oysters. <London Society, London, 1862, vol. III, p. 561.

1863 a—**Fortin, Pierre.** List of the Cetacea, Fishes, Crustacea, and Mollusca, which now inhabit and have inhabited the Canadian shores of the Gulf of St. Lawrence, and are the object of fishing operations, whether on a large or small scale, and which are used as bait, etc. <Annual Report of Pierre Fortin, Esq., Magistrate in Command of the Expedition for the Protection of the Fisheries in the Gulf of St. Lawrence, during the Seasons of 1861 and 1862. Quebec, 1863, pp. 109–124.

1863 b—**Jeffreys, John Gwyn.** *Ostreidæ.* <British Conchology, London, John Van Voorst, 1863, vol. II, pp. 37–48.

Briefly reviews several previous writings on the subject of oysters and their culture.

1863 c—**Masson, David.** Oysters: A gossip about their natural and economic history. <Macmillan's Magazine, London, March, 1863, vol. 7, pp. 401–408.

A compilation relative to the methods of culture then practiced in France and England, with references to many historical celebrities who were fond of oysters.

1863 d—Anonymous. The Oyster; Where, How, and When to Find, Breed, Cook, and Eat it. London, 1863.

See 1863 *f*.

1863 e—Anonymous. Green oysters. <The Field, London, March 14, 1863.

1863 f—Anonymous. The Oyster; Where, How, and When to Find, Breed, Cook, and Eat it. Second edition, with a new chapter, the Oyster Seeker in London. London, Scribner & Co., 1863. 12°, 106 pp.

Discusses very cleverly the following subjects: (1) The oyster season; (2) Ancient history of the oyster; (3) Modern history of the oyster; (4) Natural history of the oyster; (5) Distribution of oysters about the British shores; (6) The cooking of oysters; (7) Medicinal properties of oysters; (8) Distribution of oysters in foreign countries; (9) Oyster pearls; and (10) The oyster shops of London. See 1863 *d*.

1864 a—Buckland, Frank. Spawning oysters. <Times, London, August 3, 1864.

1864 b—Dickens, Charles (Editor). Oysters and oyster culture. <All the Year Round, London, 1864, vol. XI, pp. 161 *et seq*.

1864 c—Esdaile, David. Oyster culture. <Good Words, London, 1864, vol. V, pp. 553–557.

A compilation of information having particular reference to the experiments of M. Coste, prosecuted at the instance of the French Government. States that in 1849 the quantity of oysters consumed in London amounted to 130,000 bushels.

1864 d—Lawson, Henry. Oysters and oyster culture. <Popular Science Review, London, 1864, vol. III, pp. 448–459, one plate.

A review of the knowledge then existing relative to *Ostrea edulis*. Discusses particularly its distribution, anatomy, reproduction, age, enemies, the fishery in Great Britain, the French methods of culture, and the necessities for similar operations on the shores of Great Britain.

1864 e—Pearce, M. Propagation of oysters. Brighton, 1864.

Abstracts of reports relative to the experiments of Coste and Kemmerer.

1864 f—Anonymous. Oyster investigation. <Morning Post, London, August 29, 1864.

An account of the investigations of the Parliamentary commissioners (see 1866 *b*) on the condition of the deep-sea fisheries of Great Britain.

1864 g—Anonymous. New oyster beds. <Sporting Gazette, London, December 24, 1864.

Reports the discovery of new oyster beds in Glenluce Bay, in the district of Galloway, Scotland, and cites the possibilities for further discoveries of a similar nature.

1865 a—Bertram, James G. The Harvest of the Sea. London, John Murray, 1865, 8°.

On pp. 332–381 the following subjects are discussed by the author, the observations having particular reference to *Ostrea edulis:* (1) Proper time for oyster fishing to begin; (2) Description of the oyster; (3) Controversies about its natural history; (4) Spatting of the oyster; (5) Growth; (6) Quantity of spawn emitted by the oyster; (7) Social history of the oyster; (8) Great men who were fond of oysters; (9) Oyster breeding in France; (10) Lake Fusaro and the methods therein; (11) Bœuf's discovery of artificial culture; (12) Oyster farming in the Bay of Biscay; (13) The celebrated green oysters; (14) Marennes; (15) Dr. Kemmerer's plan; (16) Lessons to be gleaned from the French pisciculturists; (17) How to manage an oyster farm; (18) Whitstable; (19) Cultivation of natives; (20) The Colne oyster trade; (21) Scottish oysters; (22) The Pandores; (23) Extent of oyster ground in the Firth of Forth; (24) Dredging; (25) Extent of American oyster beds. See 1868 *b*.

1865 b—Buckland Frank. Oyster culture. <Report of the thirty-fourth meeting of the British Association for the Advancement of Science; held at Bath, in September, 1864. London, 1865, pp. 89–90.

Discusses briefly the natural history and culture of oysters, with notes on the causes of the failure of spat during the preceding seasons.

1865 c—Buckland, Frank. Oyster enemies. <Land and Water Journal, London, 1865, vol. 1.

1865 d—Buckland, Frank. Heaps of oyster shells. <The Field, London, February 4, 1865.

Refers to previous distribution of oysters, as determined by remaining shell heaps.

1865 e—Buckland, Frank. Young oysters. <Times, London, August, 1865.

1865 f—Caird, James; Huxley, T. H.; and Lefevre, G. S. Report of the Commissioners Appointed to Inquire into the Sea Fisheries of the United Kingdom. Vol. II. Minutes of Evidence and Index. London, Parliamentary Paper, 1865, 4°, 1409 pp.

See 1866 *b*.

1865 g—Clark, Henry James. Mind in Nature; or the Origin of Life and the Mode of Development of Animals. New York, 1865, 8°, 322 pp.

The anatomy and the biology of the oyster are discussed on pp. 199–203.

1865 h—Grimshaw, T. W. Supposed cases of poisoning by oysters. <Medical Press, Dublin, October 25, 1865, vol. LIV, p. 372.

Cites an instance in which three persons were made ill from the eating of oysters.

1865 i—Randall, Alex. Opinion in Relation to Taking Oysters in the Chesapeake Bay and its Tributaries, to the General Assembly of Maryland. Annapolis, 1865, 8°, 8 pp.

The opinion of the attorney-general of Maryland in reference to the authority of the State to restrict the taking of oysters to the citizens thereof and to issue licenses therefor.

1865 j—Anonymous. Oyster farming. <Cornhill Magazine, London, January, 1865, vol. XI, pp. 52–61.

An exposition of the methods and results of oyster-culture on the western coast of France and the southern coast of England, with valuable statistical data.

1865 k—Buckland, Frank. Oyster-culture. <The Fisherman's Magazine and Review. London, October, 1865, vol. II, pp. 470–473.

An abstract of address delivered at the thirty-fifth meeting of the British Association for the Advancement of Science. See 1866 *a*.

1866 a—Buckland, Frank. Report on the cultivation of oysters by natural and artificial methods. <Report of the thirty-fifth meeting of the British Association for the Advancement of Science; held at Birmingham in September, 1865. London, 1866, pp. 3–15.

This report of personal observations and experiments discusses the following subjects: (1) The cultivation of oysters by natural means. (2) The cultivation of oysters by artificial means. (3) Experiments in hatching oyster eggs by artificial heat. (4) Experiments on a large scale on the fore shores. (5) The chemical analysis of the oyster. (6) Dredging and its effects. (7) Comparisons of French and English systems of oyster-culture. (8) Experiments in developing oyster-spat. (9) The causes of greenness in oysters.

1866 b—Caird, James; Huxley, T. H., and Lefevre, G. S. Report of the Commissioners Appointed to Inquire into the Sea Fisheries of the United Kingdom. Vol. I. The Report, and Appendix. London, Parliamentary Paper, 1866, 4°, CVII and 72 pp. One map.

After making a very careful and exhaustive inquiry into the condition of the oyster industry of Great Britain, the commission summed up its observations as follows:

"We find that the supply of oysters has very greatly fallen off during the last three or four years. That this decrease has not arisen from overfishing, nor from any causes over which man has direct control, but from the very general failure of the spat, or young of the oyster, which appears, during the years in question, to have been destroyed soon after it was produced. A similar failure of spat has frequently happened before, and probably will often happen again. That the best mode of providing against these periodical failures of the spat is to facilitate the proceedings of those individuals or companies who may desire to acquire so much property in favorably situated portions of the sea bottom as may suffice to enable them safely to invest capital in preparing and preserving these portions of the sea bottom for oyster-culture. * * * That no regulations or restrictions upon oyster fishing, beyond such as may be needed for the object just defined, have had, or are likely to have, any beneficial effect upon the supply of the oysters." See 1865 *f* and 1868 *c*.

1866 c—Knight, Thomas F. Descriptive Catalogue of the Fishes of Nova Scotia. Published by direction of the Provincial Government. Halifax, N. S. Printed by A. Grant, Printer to the Queen's Most Excellent Majesty. 1866, 8°, 54 pp.

The "Edible mollusca of Nova Scotia" are described on pp. 43–54. This portion of the work is really by Willis, for Mr. Knight says: "The author is indebted to J. R. Willis, Esq., of Halifax, for the following ample description of our edible mollusca, which has already been published in a colonial periodical." No trace has been found of the periodical herein referred to.

1866 d—Mearns, J. R. Oysters and dredgers. <Once a Week, London, December 15, 1866, vol. xv, pp. 655–666.

Describes the ancient oyster companies of Faversham and Whitstable, district of Kent, England, their origin and their oyster-grounds.

1866 e—O'Shaughnessey, Arthur W. E. On green oysters. <Annals and Magazine of Natural History, London, September, 1866, vol. XVIII, pp. 221–228.

A review of nearly everything that was known relative to this subject in 1866, with special reference to the papers of Crosse (Journal de Conchyliologie, 1863, vol. XI, p. 221); Cuzent (Comptes Rendus de l'Académie des Sciences, 1863, vol. LVI, pp. 402–403); Chrisolm, C. (Edinburgh Medical and Surgical Journal, 1808, vol. IV, pp. 391–422); Gaillon (Journal de Physique, 1820, vol. 91, pp. 220–225; Bull. Science Soc. Philom., 1820, pp. 129–130; and Fror. Nat., 1821, vol. I, No. 1, pp. 5–7); Valenciennes (Fror. Nat., 1841, vol. XVIII, No. 379, pp. 65–67); Bizio (Ricerche sopra il coloramento in verde delle branche delle Ostriche, Venezia, 1845) and Buckland (The Harvest of the Sea, London, 1865).

1866 f—Parliamentary Paper. The Herne Bay, Hampton and Reculver Oyster Fishery Company. Evidence Taken in a Committee of the House of Lords, April 19 and 20, 1866. London, 1866, 8°.

1866 g—Anonymous. Oysters on the south coast of England and the north coast of France. <Times, London, September 6, 1866.

Discusses and compares the French and the English methods of oyster-culture.

1866 h—Anonymous. The exposition of Arcachon and its object. <Fraser's Magazine, London, September, 1866, vol. 74, pp. 297–308.

Discusses the fisheries exposition of Arcachon, referring particularly and in detail to the advance made in methods of oyster-culture in the bay of Arcachon.

1866 i—Anonymous. Touching the oyster. <Once a Week, London, August 4, 1866, vol. xv, pp. 124–126.

Refers to the scarcity and high prices for oysters in England and the necessities for better methods of obtaining a continuous supply. See 1866 *j*.

1866 j—Anonymous. Touching the oyster. <Every Saturday, Boston, September 1, 1866, vol. II, pp. 244–246.

An abstract reprint of 1866 *i*.

1867 a—Buckland, Frank. On oyster cultivation. <Report of the thirty-sixth meeting of the British Association for the Advancement of Science; held at Nottingham, August, 1866. London, 1867, pp. 70–71.

An abstract of the address delivered, which discussed particularly the development and movements of oyster-spat, and the chemical constituents of oysters.

1867 b—Chambers, W. and R. An oyster-island: Oyster fisheries on Ile de Ré <Chambers' Journal, Edinburgh, April 27, 1867, vol. 44, pp. 257–260.

Oysters formerly grew naturally about the shores of this island, situated on the west coast of France, and which is so celebrated for its salt and oyster products; but the increased consumption or other causes led to the depletion and finally to the destruction of the natural beds. In March, 1858, the present system of oyster-culture was inaugurated by a poor stonemason, named Hyacynthe Bœuf. This paper describes the experiments of Bœuf and those of Jean Jacques Coste, which followed the former, and notices with much detail the general methods of culture practiced at the date of its publication.

1867 c—Dickens, Charles (Editor). Oyster nurseries. <All the Year Round, London, July 27, 1867, vol. 18, pp. 116–118.

Discusses oyster enemies, the scarcity of oysters, and the necessities for the formation of oyster-cultural stations on the shores of Great Britain, the operations in France being the basis of the latter portion of the paper.

1867 d—Fellows, F. W. Oyster culture. <American Naturalist, Salem, 1867, vol. 1, pp. 196–202.

A short compilation on the generation and natural history of oysters, with particular reference to the results of the investigations of Coste and Davaine.

1867 e—Fellows, F. W. Oyster-culture in France. <American Naturalist, Salem, 1867, vol. 1, pp. 346–351.

A compilation from various French publications relative to the methods of oyster-culture practiced in the imperial or model stations (*parcs*) in the bay of Arcachon.

1867 f—Lobb, Harry. Successful Oyster Culture. London, 1867, 8°.

1867 g—Lovell, Matilda Sophia. The Edible Molluscs of Great Britain and Ireland, with Receipts for Cooking Them. London, Reeve & Co., 1867, 8°, 207 pp., 12 plates.

Ostreidæ are discussed on pp. 68–97.

1867 h—Pennell, H. Cholmondeley. Report to the Board of Trade upon the State and Progress of the Roach River Oyster Fishery. Parliamentary Paper, London, 1867.

1867 i—Pennell, H. Cholmondeley. Report to the Board of Trade upon the Orders Applied for under "The Oyster and Mussel Fisheries Act, 1866," with Reference to the River Blackwater, by "The Blackwater Oyster Fishing Company (Limited)," "The Malden Oyster Fishery Company," and "The Fish and Oyster Breeding Company." Parliamentary Paper, London, 1867.

1867 j—Parliamentary Paper. Return of Applications Made to the Board of Public Works in Ireland for licences to Form and Plant Oyster Beds, with Dates, etc.; also of the Expense Incurred by the Board of Works in Ireland with Reference to the Sea and Oyster Fisheries for 1864, 1865, and 1866. Dublin, 1867.

1867 k—Parliamentary Paper. Copies of Application to the Board of Public Works in Ireland of the Right Hon. John Wynne, to Plant Oyster Beds in Sligo Bay; Proceedings Taken Thereon, and Report Relative to the Same. Dublin, 1867.

1867 l—Parliamentary Paper. Report by the Board of Trade of their Proceedings under the Oyster and Mussel Fisheries Act, 1866. London, 1867.

1867 m—Anonymous. Oysters and oyster-culture. <Edinburgh Review, Edinburgh, 1867, vol. 127, pp. 43 *et seq.*

1867 n—Anonymous. Oyster-culture on the south coast of England and north coast of France. <Times, London, October 15, 1867.

1867 o—Anonymous. The Oyster fisheries. <North British Review, Edinburgh, March, 1867, vol. 46, pp. 190-222.

An important compilation on the oyster, with particular reference to its natural history, and its gastronomical status among the Ancients. Also reviews the report of the Parliamentary commission of 1866. See 1866 *b*.

1867 p—Knight, Thomas F. Shore and Deep Sea Fisheries of Nova Scotia. Published by Direction of the Provincial Government. Halifax, N. S., printed by A. Grant, Printer to the Queen's Most Excellent Majesty. 1867, 8°, VI+113 pp.

Discusses the oyster fisheries of Nova Scotia from an economical and political point of view.

1868 a—Arnold. Oysters in brackish water. <Quarterly Journal of Science, London, 1868, vol. XIX, p. 237, and vol. XXI, pp. 15-19.

Describes an instance in which oysters grew in a small pond in which the saltness of the water was scarcely one-sixth that of the sea.

1868 b—Bertram, James G. The Harvest of the Sea. Second edition. London, 1868, 8°, 519 pp., with 50 illustrations.

Reprint of 1865 *a*.

1868 c—Caird, James; Huxley, T. H., and Lefevre, G. S. Report of the Commissioners Appointed to Inquire into the Sea Fisheries of the United Kingdom. Presented by command, 1866. London, 1868. 8°, 179 pp., one map.

A reprint of the report contained in 1866 *b*.

1868 d—Calder, J. E. Oyster-culture: a Compilation of Fact. Tasmania, 1868, 8°, 3 plates.

1868 e—Dallas, E. S. British oysters at Rome. <Once a Week, London, February 29, 1868, vol. XVIII, pp. 186-190.

Reviews much of the existing information relative to the consumption of British oysters by the Romans and speculates as to their methods of obtaining them.

1868 f—Dallas, E. S. French oyster nurseries. <Once a Week, London, September 19, 1868, vol. XIX, pp. 231-235.

Describes the imperial stations or *parcs* in the bay of Arcachon, France, and the methods therein employed, with references to the necessity for similar procedures on the British coast.

1868 g—Dempster, Henry. The Deck-welled Fishing-boat, and Fisheries and Fish-market Reform: being Dialogues on those Important Subjects, with full Information on the Oyster Question. Glasgow, 1868, 8°.

1868 h—de Vere, Schele. Mine oyster. <Putnam's Magazine, New York, October, 1868, vol. II, pp. 418-431.

A compilation and discussion of the natural history of the oyster.

1868 i—Pennell, H. Cholmondeley. Report made to the Board of Trade on the Oyster and Mussel Fisheries of France, and the Applicability of the French System to British Waters. Parliamentary Paper, London, 1868.

1868 j—Anonymous. Oysters, and the oyster fisheries. <Edinburgh Review, Edinburgh, January, 1868, No. CCLIX, pp. 22-39.

Reviews and comprises much of the valuable material contained in the following publications: "A history of the oyster and the oyster fisheries;" by T. C. Eyton, London, 1858. "Voyage d'Exploration sur le Littoral de la France et de l'Italie;" par M. Coste, Paris, 1861. "The Oyster, where, how, and when to find, breed, cook, and eat it;" London, 1863. "The Harvest of the Sea;" by James G. Bertram, London, 1865. "Report of the Commissioners appointed to inquire into the sea fisheries of the United Kingdom;" London, 1866, and "Successful Oyster Culture;" by Harry Lobb, London, 1867.

1868 k—Parliamentary Paper. Sea Fisheries Act, 1868. Part III. Oyster and Mussel Fisheries. Board of Trade Regulations for the Instruction and Guidance of Persons applying for Fishery Orders under Part III of the Sea Fisheries Act, 1868 (31 and 32 Vict., chap. 45). London, 1883. 4°, 12 pp.

1869 a—Buckland, Frank. On the progress of oyster and salmon cultivation in England. <Report of the British Association for the Advancement of Science, thirty-eighth meeting, held at Norwich in August, 1868. London, 1869, pp. 90-91.

Attributes the failure of spat along the British coasts during the preceding six years to the cold weather and the rough water prevalent throughout the spawning season.

1869 b—Jeffreys, John Gwyn. Ostrea edulis. <British Conchology, London, John Van Voorst, 1869, vol. V, pp. 165-166.

Refers to several writings in which this species is discussed.

1869 c—K——, W. The oyster trade in the United States. <The Field, London, May, 1869, vol. 33, p. 388.

Reviews three consular reports emanating from the British Foreign Office, relative to the oyster industry of Chesapeake Bay, Louisiana, and New England waters.

1869 d—"Ostrea." Artificial oyster culture. <The Field, London, February 13, 1869, p. 139.

1869 e—Pennell, A. Francis. Oyster culture. <Times, London, January 29, 1869.

1869 f—Wilcocks, J. C. Oyster fisheries. <The Field, London, 1869.

Describes the location of certain oyster beds on the coast of Great Britain and cites the probabilities for discovering new areas.

1869 g—Anonymous. Oysters. <Broadway, London, 1869, vol. v, pp. 405 *et seq.*

1870 a—Blake, J. A.; Francis, Francis; Hart, G. W., and Brady, T. F. Report of the Commission Appointed to Inquire into the Methods of Oyster Culture in the United Kingdom and France, with a View to the Introduction of Improved Methods of Cultivation of Oysters into Ireland. Dublin, Her Majesty's Stationery Office, 1870. 8°, 51 pp., with appendices, pp. 55–102, and 10 plates.

This commission was appointed in October, 1868, and was directed to visit the principal oyster regions of France, England, and Ireland, to consult the best-informed authorities on the oyster industry, to ascertain, so far as possible, the causes which had led to failures in the oyster fishery and to suggest the remedy. The report discusses the natural history of the oyster, the various branches of the oyster industry, including an interesting epitome of Coste's experiments and the results thereof, and concludes with the following recommendations:

1. All regulations with regard to close time around the Irish coast should be strictly maintained.

2. The inspectors of Irish fisheries should have power, whenever they determine to reserve a bank or any portion thereof from public dredging for the purpose of recovery, to make such arrangements as may seem desirable for keeping the restricted part free from weeds and vermin.

3. There should be procurable at each coast-guard station, at a small cost, general information as to oyster-culture and simple instructions as to the best modes of proceeding.

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6. Facilities should be afforded to the coast population to acquire the use of small portions of foreshore, or sea bottom, for oyster cultivation, and to obtain loans on satisfactory security for the preparation of same, and for the purchase of oysters, collectors, etc.

1870 b—Brady, Thomas F. Digest of the Acts of Parliament and the By-Laws at present in force in Ireland for the Regulation of the Oyster Fisheries, to which is added an Abstract of the Law Enabling certain Persons to Form or Plant Bait Beds. Appendix to Report of the Commissioners Appointed to Inquire into the Methods of Oyster Culture in the United Kingdom and France, with a View to the Introduction of Improved Methods of Cultivation of Oysters into Ireland. Dublin, 1870, pp. 155–165.

1870 c—Davidson, Hunter. Report upon the Oyster Resources of Maryland to the General Assembly. Annapolis, William Thompson of R., 1870. 8°, 20 pp.

1870 d—Gould, A. A. Report on the Invertebrata of Massachusetts. Second edition, edited by W. G. Binney. Boston, 1870. 8°, VIII+524 pp., 12 plates and many wood cuts.

See 1841 *b*.

1870 e—Knight, T. F. Oyster culture in France. <Proceedings and Transactions of the Nova Scotian Institute of Natural Science, for 1867, 1868, 1869, 1870. Vol. II, part II, pp. 42–51. Halifax, 1870.

A group of facts obtained from two authorities: (1) A pamphlet in French, by J. L. Soubeiran, secretary of the Imperial Society of Acclimatization of France, 1866. (2) The Harvest of the Sea, by James G. Bertram, 1865.

1870 f—Pennell, H. Cholmondeley. Report to the Board of Trade upon the State of the Oyster Fisheries in the Rivers Blackwater and Roach. Parliamentary paper, London, 1870.

A detailed report on the operations of an oyster company in each of the rivers mentioned.

1870 g—Sullivan, W. K. Composition of the Soils of Oyster Grounds. Appendix to Report of the Commissioners Appointed to Inquire into the Methods of Oyster Culture in the United Kingdom and France, with a View to the Introduction of Improved Methods of Cultivation of Oysters into Ireland. Dublin, 1870, pp. 166–176.

Because of the small amount of attention which this subject has received and the difficulty in obtaining or consulting copies of this report, the conclusions of Prof. Sullivan (who was a chemist rather than a naturalist) are here quoted in full:

1. The influence of the soil upon the breeding and growth of oysters is complicated by: temperature, especially during the spawning season; sudden alternations of heat and cold due to currents; alternation of depth of water, especially as regards whether the maximum of sun-heat and light concords with low water during the spawning season; velocity of tide; angle of inclination of shore, etc.

2. The soil of oyster-grounds may be made up of materials of any of the great classes of rocks, arenaceous, argillaceous, or calcareous, provided they contain more or less of a fine flocculent highly hydrated silt, rich in organic matter, which indicates that Diatomaceæ, Rhizopoda, Infusoria, and other minute creatures abound.

3. The character and abundance of such organisms in a locality seem to be the true test of a successful oyster-ground.

4. Although oysters do undoubtedly assimilate copper from water where mine-water containing traces of that metal flows into the sea in the neighborhood of the oyster beds, the copper is chiefly, if not exclusively, confined to the body of the oyster, and does not appear to reach the mantle or beard. That the so-called green oysters of Essex, Marennes, and other places, on the other hand, are green-bearded and contain no copper, nor can the most minute trace of copper be detected in the soil of the oyster-grounds where such green-bearded oysters are produced.

1871 a—Lord, J. Keast. Oysters. <Leisure Hour, London, September 16, 1871, vol. XX, pp. 581–582.

Discusses oyster seasons from a gastronomical point of view.

1871 b—W——, E. P. Oysters in Ireland. <Nature, London, December 14, 1871, vol. V, pp. 128, 129.

A review of 1870 *a*.

1872 a—Bertram, James G. Touching oysters. <St. Paul's Magazine, London, 1872, vol. 12, pp. 473 *et seq*.

1872 b—Browne, Orris A. Report to the Auditor of Public Accounts on the Oyster Beds of Virginia. Richmond, Shepperson & Graves, 1872. 8°, 21 pp.

A statement of the duties performed by the Virginia oyster inspector during the preceding year, with reference to the general condition of the oyster industry and recommendations to the State Legislature. Also contains many extracts from the "Report of the commission appointed to inquire into the methods of oyster-culture in the United Kingdom and France, with a view to the introduction of improved methods of cultivation of oysters into Ireland," Dublin, 1870; and other papers. See 1877 *c*.

1872 c—Davidson, Hunter. Report on the Oyster Fisheries: Potomac River Shad and Herring Fisheries, and the Water Fowl of Maryland to his Excellency the Governor, and other Commissioners of the State O. P. Force, January 1, 1872. Annapolis, S. S. Mills, L. F. Colton & Co., 1872. 8°, 48 pp.

One of the most comprehensive of the early reports on the oyster industry of Maryland, especially rich in statistical data.

1872 d—Parliamentary Paper. Return of Particulars of all Inquiries and Examinations Held by the Inspector Appointed by the Board of Trade under "The Oyster and Mussel Fisheries Act, 1866," and "The Sea Fisheries Act, 1868," in Each Year 1868 to 1872; of the Names, Duties, and Salaries of the Persons Employed, etc. London, 1872.

1873 a—Saunders, Silbert. Development of oyster spat. <Quarterly Journal of Microscopic Science, London, 1873, vol. XIII, pp. 439–440.

Summary of a popular lecture delivered July 10, 1873, before the East Kent Natural History Society.

1873 b—Timmons, William E. Report of the Commander of the Oyster Fisheries and Water-Fowl of Maryland, to his Excellency the Governor, and the Commissioners of the State Oyster Police Force, January 1, 1874. Annapolis, Wm. T. Iglehart & Co., 1873, 8°, 11 pp.

Discusses the general condition of the oyster fishery of Maryland in 1873, with recommendations for further legislation.

1873 c—Verrill, A. E. Report upon the invertebrate animals of Vineyard Sound and the adjacent waters, with an account of the physical characteristics of the region. <Report U. S. Fish Commission, 1871–72. Washington, 1873, vol. II, pp. 295–778.

Enumerates and describes, on pp. 472–478, the animals found inhabiting oyster-beds in brackish waters off the southern coast of New England.

1874 a—Chambers, William. Sea fish and oysters. <Chambers' Journal, Edinburgh, January 17, 1874, vol. 51, pp. 43–46.

A review of James G. Bertram's "Harvest of the Sea," London, 1865, with original observations.

1874 b—Lockwood, Samuel. The natural history of the oyster. <Popular Science Monthly, New York, No. 31, November, 1874, pp. 1–20, and No. 32, December, 1874, pp. 157–173.

An illustrated popular article; one of the most interesting contributions from this well-known naturalist. See 1879 *i*.

1874 c—McCrady, John. Observations on the food and the reproductive organs of *Ostrea virginiana*, with some account of the *Bucephalus culculus*, nov. spec. <Proceedings of the Boston Society of Natural History, December 3, 1873, Boston, 1874, vol. XVI, pp. 170–192.

Concludes that *Ostrea virginiana* (the American species) is hermaphrodite. Also states that the food of oysters along the South Carolina coast consists largely of diatoms and sporules of algæ.

1874 d—Whiteaves, J. F. Report on further deep-sea dredging operations in the Gulf of St. Lawrence, with notes on the present condition of the marine fisheries and oyster beds of part of that region. <Sixth Annual Report of the Department of Marine and Fisheries, for the year ending the 30th June, 1873. Printed by order of Parliament. Ottawa, T. B. Taylor, 1874. pp. 178–204 of appendices.

This report is devoted principally to the oyster industry of the Gulf of St. Lawrence, the observations being based on an examination of the oyster beds of Northumberland Straits and of the coast of New Brunswick. See 1874 *e* and 1874 *f*.

1874 e—Whiteaves, J. F. Notes on the marine fisheries, and particularly on the oyster beds, of the Gulf of St. Lawrence. <Canadian Naturalist, 1874, vol. VII, pp. 336–349.

An abridged reprint of 1874 *d*.

1874 f—Whiteaves, J. F. Report on Deep-Sea Dredging Operations in the Gulf of St. Lawrence, with Notes on the Present Condition of the Marine Fisheries and Oyster Beds of Part of that Region. Ottawa, printed by T. B. Taylor, 1874, 8vo, 30 pp.

A reprint of 1874 *d*.

1875—Buckland, Frank. Report on the Fisheries of Norfolk, especially Crabs, Lobsters, Herring, and the Broads. House of Commons, London, August 11, 1875. 8°, 84 pp., 4 plates.

Contains numerous references to the oyster fisheries along the coast of Norfolk, England, on pp. 21–23 and 42–45.

1876 a—De Broca, P. On the oyster industries of the United States. <Report U. S. Fish Commission, 1873–74 and 1874–75. Washington, 1876, vol. III, pp. 271–320.

Translated from Étude sur l'industrie huîtrière des États-Unis, faite par ordre de S. E. M. le Compte de Chasseloup Laubat, ministre de la marine et des colonies. Suivie de divers aperçus sur l'industrie de la glace en Amérique, les bateaux de pêche pourvus de glacières, les réserves flottantes à poisson, la pêche du maquereau, etc. Par M. P. De Broca, lieutenant de vaisseau, directeur des mouvements du port du Havre. Nouvelle édition, augmentée de divers documents et de notes. Paris, 1865, 12mo, 2 pl., 266 pp. This, the first extensive report on the economic and commercial phases of the oyster industry in the United States, is based on an investigation made in the summer of 1862 by the author, acting under instructions from the French Government.

1876 b—Francis, Francis. The breeding of the oyster. <The Field, London, November 18, 1876.

1876 c—Francis, Francis. The breeding of the oyster. <The Field, London, December 2, 1876.

1876 d—Hamilton, Lord Claud; Lefevre, G. Shaw; Stanhope, Edward (and others). Report from the Select Committee on Oyster Fisheries; together with the Proceedings of the Committee, Minutes of Evidence, Appendix, and Index. House of Commons, London, July 7, 1876. 4°, xx + 334 pp.

This committee was appointed to inquire "the reasons for the present scarcity of oysters on the British coasts." The report of the committee is briefly summed up as follows: There are not, in consequence of the increasing demand and consequent high price, so many full-grown oysters left to spat as there ought to be, hence the scarcity. The paper contains 3,941 questions and answers relative to oysters and the oyster industry of Great Britain.

1876 e—Kent, Saville. Reproduction of oysters. <The Field, London, April 22, 1876.

1876 f—Lavoine, Napoleon. Oyster fishery in the Gulf of St. Lawrence. <Report of the Commissioner of Fisheries, for the year ending 31st December, 1875. Ottawa, printed by Maclean, Rogers & Co., 1876, pp. 53–54.

A brief review of the condition of the industry in 1875.

1876 g—Lockyer, J. N. Our oyster fisheries. <Nature, London, August 3, 1876, vol. XIV, p. 285.

Reviews briefly the report of the British parliamentary "select committee on the oyster fisheries" of 1876.

1876 h—Woods, W. Fell. The breeding of the oyster. <The Field, London, November 25, 1876.

1876 i—Parliamentary paper. Report of Inspectors Appointed by the Board of Trade, under the 45th Section of "The Sea Fisheries Act, 1868," to Inquire into the State of the Fisheries Established under Orders made by the Board, in Pursuance of part 3 of the Above Named Act. London, 1876.

Describes the oyster fisheries of Blackwater (Essex), Bosham, Boston Deeps, Emsworth, Emsworth Channel, Firth of Forth, Greshernish, Hamble, Holy Loch, Langston, Lynn Deeps, Paglesham, Roach River, and Swansea.

1876 j—Anonymous. Oysters: native and foreign. <Whittaker's Journal of Amusing and Instructive Literature, London, 1876.

1876 k—Anonymous. The oyster. <Saturday Review, London, August 26, 1876, vol. XLII, pp. 260–261.

Reviews and deprecates the necessity for the report of the "select committee on the oyster fisheries" of 1876. See 1876 *d*.

1877 a—Bouchon-Brandely, G. Oyster Culture on the Shores of the Channel and of the Ocean. Parliamentary paper, London, 1877.

Translated from Journal officiel de la République Française, of January 22, 1877.

1877 b—Brooks, W. K. The affinity of the Mollusca and Molluscoida. <Proceedings Boston Society of Natural History, February 2, 1876. Boston, 1877, vol. XVIII, pp. 225–236.

1877 c—Browne, Orris A. Report on the oyster beds of Virginia. <Annual Report of the Fish Commissioner of the State of Virginia for the year 1877. Richmond, 1877, 8°, pp. 26–43.

An abridgment of 1872 *b*.

1877 d—Dyer, W. T. Thiselton. Greening of oysters. <Nature, London, September 6, 1877, vol. XVI, p. 397.

Refers to the green color being particularly common in the oysters in the vicinity of Croisic, and attributes it to certain diatoms in the food of the oyster, especially *Novicula fusiformis* Grunow, var. *ostrearia*.

1877 e—King, John T. Oysters. <The Mirror, Baltimore, January 13, 20, and 27, and November 1, 1877.

A compilation on the natural history of oysters and on the oyster industry of the Chesapeake Bay.

1877 f—Lockyer, J. N. Oyster culture. <Nature, London, October 11, 1877, vol. xvi, pp. 499–500.

A brief review of Die Auster und die Austernwirthschaft, by Karl Möbius, Berlin, 1877. See 1883 *u*.

1877 g—Page, John R. Oyster-beds and oyster culture in Virginia. <Annual Report of the Fish Commissioner of the State of Virginia for the year 1877. Richmond, 1877, pp. 23–25.

A brief discussion of the area and location of the oyster beds of Virginia, with reference to their injurious effects on the agricultural interests of the tide-water counties of the State. Recommends individual ownership of oyster beds.

1877 h—Richardson, James. American oyster culture. <Scribner's Monthly, New York, December, 1877, vol. xv, pp. 225–238.

Touches upon the natural history of the oyster and describes the origin and development of the oyster-planting industry in the western part of Connecticut, with references to the industry in other American localities.

1877 i—Woods, W. Fell. Letters on Oyster Fisheries; the Causes of Scarcity; the Remedies, etc. Reprinted from the "Field," London. Edward Bumpus, 1877. 8°, 44 pp.

These letters appeared in the "Field," London, in 1876, and were intended to controvert evidence which had been given before the "Select Committee on Oyster Fisheries," of 1876.

1877 j—Beale, Anne. Oyster dredging. <Good Words, London, November, 1877, vol. xix, pp. 756–759.

A popular account of a visit to certain oyster beds on the shores of Great Britain.

1877 k—Jones, J. Matthew. Mollusca of Nova Scotia. <Proceedings and Transactions of Nova Scotian Institute of Natural Science, 1877, vol. iv, part iii, pp. 321–330.

1877 l—Anonymous. The lobster, crab and oyster fisheries. <The Quarterly Review, London, October, 1877, No. 288, vol. cxliv, pp. 474–498.

An abstract publication and review of the following: (1) Report from the Select Committee on Oyster Fisheries; together with the Proceedings of the Committee, Minutes of Evidence, Appendix and Index. Ordered by the House of Commons to be printed, July 7, 1876. (2) Report on the Fisheries of Norfolk, especially Crabs, Lobsters, Herrings, and the Broads. By Frank Buckland, Inspector of Salmon Fisheries. Presented by Her Majesty's Command. Ordered by the House of Commons to be printed, August 11th, 1875. (3) Report on the Crab and Lobster of England and Wales, of Scotland and Ireland. Presented to both Houses of Parliament. By Command of Her Majesty. 1877.

1878 a—Bledsoe, A. T. The oyster at home. <Southern Review, Baltimore, October, 1878, vol. xxiv, pp. 385–404.

A popular discussion of the oyster fishery of the Chesapeake Bay, with brief abstracts from Guide pratique de l'ostreiculteur et procédés d'élevage et de multiplication des races marines comestibles. By Félix Fraiche, Paris, 1865. 12°, 174 pp.

1878 b—Chambers, W. and R. French oyster nurseries. <Chambers' Journal, Edinburgh, August 3, 1878, vol. lv, pp. 516–518.

Describes the oyster industry of Arcachon, Ile d'Oléron, Cancale, Vannes, and Auray, on the French coast, and discusses the possibilities for application of the methods of those localities to the shores of Great Britain.

1878 c—Hayes, Jos. Report on the Principal Oyster Fisheries of France; with a short Description of the System of Oyster Culture pursued at some of the most Important Places, from Inspections made in September and October, 1877. Presented to both Houses of Parliament by command of Her Majesty. Dublin, 1878. Royal 8°, 28 pp., 3 maps.

Reports on the oyster fisheries of (1) Courseulles sur Mer, (2) Grand Camp, (3) St. Vaast de la Hogue, (4) Granville, (5) Cancale, (6) Brest, (7) Auray, (8) Vannes, (9) Les Sables D'Olonne, (10) Ile de Ré, (11) Ile D'Oléron, (12) Marennes, (13) La Tremblade, (14) La Verdon, and (15) Arcachon.

1878 d—King, John T. The Anatomy, Propagation and Cultivation of the Oyster. Washington, D. C. Harvey & Holden, 1878, 12°, 32 pp.

A popular summary of well-known facts relative to the natural history of the oyster, with notes on the oyster industry of Chesapeake Bay. See 1879 *h*.

1878 e—Lockyer, J. N. Oyster beds of the Chesapeake Bay. <Nature, London, October 17, 1878, vol. XVIII, p. 653.

Refers to the inauguration by the U. S. Coast Survey of an investigation of the oyster beds of James River, Virginia, and of Tangier and Pocomoke Sounds, Maryland and Virginia.

1878 f—Smith, E. A. Ostrea assuming the sculpture of another shell (*Trochus maculatus*) to which it adheres. <Proceedings Zoological Society, London, 1878, p. 730, pl. XLVI, fig. 12.

1878 g—Winther, G. On the geographical distribution of the common oyster. <Annals and Magazine of Natural History, London, March, 1878, 5 ser., vol. I, pp. 185–189.

Abstract translation of Om vore Haves Naturforhold med Hensyn til konstig Oestersavl og om de i den henseende anstillede Forsög. Kopenhagen, 1876. Nordisk Tidskrift for Fiskeri. Discusses briefly *Ostrea edulis* and the oyster areas of Europe.

878 h—Woodward, S. P. Manual of the Mollusca, third edition, with appendix by R. Tate. London, 1878, 8°, with numerous plates and woodcuts.

,878 i—Parliamentary paper. Report to the Board of Trade upon Four Applications made under "The Sea Fisheries Act, 1868," for Orders for the Establishment of an Oyster Fishery in the River Blackwater. London, 1878.

1878 j—Anonymous. Society of Oyster Culturists of Morbihan. Dublin, 1878.

Explanatory pamphlet for the International Exposition of 1878.

1879 a—Brooks, W. K. Preliminary observations on the development of the Marine Prosobranchiate Gasteropods. <Chesapeake Zoological Laboratory, Scientific Results of the Season of 1878. Baltimore, 1879, pp. 121–142, one plate.

1879 b—Brooks, W. K. Abstract of observations upon the artificial fertilization of oyster eggs and the embryology of the American oyster. <American Journal of Science, New Haven, December, 1879, vol. XVIII, pp. 425–427.

A concise statement of the observations published in the report of the commissioners of fisheries of Maryland, dated January, 1880. See 1880 *b*.

1879 c—Brooks, W. K. Propagating oysters. <Science News, 1879, vol. I, pp. 249–251.

A brief citation of the results noted in 1880 *b*.

1879 d—Buckland, Frank, and Walpole, Spencer. Report by Frank Buckland, Esq., and Spencer Walpole, Esq., Inspectors of Fisheries for England and Wales, and Commissioners for Sea Fisheries on the Sea Fisheries of England and Wales. London. Her Majesty's Stationery Office, 1879. 8°, 282 pp., 1 map.

Contains numerous brief references to the oyster beds along the coast of England and Wales.

1879 e—Gray, Barry. Oysters and oyster eaters. <The Sea World, New Haven, November 17, 1879, vol. I, No. 14.

1879 f—Hopson, W. B. Catching oysters by steam power. <The Sea World, New Haven, August 4, 1879, vol. I, No. 1.

1879 g—Hurlbutt, A. M. On the structure of the blood corpuscles of the oyster. <Medical Press, New York, 1879, vol. XXIX, pp. 23–30.

The results of a microscopical examination with a lens of 1,200 diameters.

1879 h—King, John T. Wonders and Food Luxuries of the Sea. The Anatomy, Propagation, Habits, Food, and Cultivation of Oysters, Clams, Crabs, Lobsters, Fish, and Maninose, and their Migrations. Baltimore, 1879, 16°, 152 pp.

The data relative to the oyster are largely a modification of a paper published in 1878. See 1878 *d*.

1879 i—Lockwood, Samuel. The natural history of the oyster. <The Sea World, Branford, Conn., vol. I, Nos. 2–7, August 18–September 24, 1879.

A reprint of 1874 *b*.

1879 k—Möbius, Karl. How can the cultivation of the oyster, especially on the German coasts, be made permanently profitable? <Report U. S. Fish Commission, 1877. Washington, 1879, vol. V, pp. 875–884.

Translated by Herman Jacobson from circular No. 3 of the Deutsche Fischerei-Verein, Berlin, March 21, 1877. Describes the location and character of the natural oyster-grounds of Germany, the reasons for there being no oysters on the barren grounds, and the methods for and difficulties of utilizing the latter.

1879 l—Patterson, Carlile P. Investigations of Oyster Beds: Questions to Oystermen. Washington, 1879. Royal 8°, 21 pp.

Contains 187 questions relative to the oyster beds, oysters, and the oyster industries. This publication was issued for distribution to the Chesapeake oystermen, to aid in the investigation, the results of which are noted in 1882 *j*.

1879 m—Robinson, John A. Abstract of laws regarding oyster fishing in the several States from Maine to Virginia, inclusive, except Connecticut. <The Sea World, New Haven, October 15, 1879, vol. I, No. 9.

Cites briefly the regulations of these States, under the following captions: (1) By whom private rights of cultivation may be granted. (2) To whom licenses may be granted. (3) Extent of area granted. (4) Form of conveyance. (5) Conditions on which land may be granted. (6) Fees for granting private oyster beds and taxes thereon. (7) Forfeitures of planting grounds. (8) Special licenses for oystering. (9) Dredging licenses and prohibitory provisions. (10) Special provisions.

1879 n—Simmonds, P. L. Oysters and other edible mollusca. <The Commercial Products of the Sea. New York, 1879, 8°, VIII + 484 pp.

1880 a—Balfour, Fr. M. A Treatise on Comparative Embryology. London, 1880. 8°, vol. I.

Treats of Lamellibranchiata on pp. 214–223.

1880 b—Brooks, W. K. Development of the American oyster. <Appendix to Report of the Commissioners of Fisheries of Maryland. January, 1880. pp. 1–81, 10 plates.

Describes the first successful attempt to propagate the *Ostrea virginiana*, and is the standard authority on the anatomy and development of this species. See 1880 *c*.

1880 c—Brooks, W. K. The development of the oyster. <Studies from the Biological Laboratory, Johns Hopkins University, Baltimore, 1880, No. IV, pp. 1–106, 10 plates.

A reprint of 1880 *b*.

1880 d—Brooks, W. K. The acquisition and loss of a food yolk in molluscan eggs. <Studies from the Biological Laboratory, Johns Hopkins University, Baltimore, No. IV, pp. 107–116, one plate.

1880 e—Brooks, W. K. Observations upon the artificial fertilization of oyster eggs and on the embryology of the American oyster. <Annals and Magazine of Natural History, London, January, 1880, Fifth series, vol. V, pp. 82–83.

A reprint of 1879 *b*.

1880 f—Brooks, W. K. Biology of the American oyster. <North Carolina Medical Press, Wilmington, January, 1880, pp. 253–258.

A brief summary of 1880 *b*.

1880 g—Buckland, Frank. The oyster's food, young, and foes. <The Sea World and Fishing Gazette, New York, October 12, 1880, vol. II, No. 9.

1880 h—Buckland, Frank. Oyster culture in China. <The Sea World and Fishing Gazette, New York, November 23, 1880, vol. II, No. 15.

1880 i—Goode, G. Brown. Bulletin of the U. S. National Museum. Exhibits of the Fisheries and Fish Culture of the United States of America, Made at Berlin in 1880. Prepared under the direction of G. Brown Goode, Deputy Commissioner. Washington, 1880, 8°, 263 pp.

The exhibit of oysters and methods of cultivating oysters is catalogued on pp. 43-49.

1880 j—Hopson, W. B. Oysters and oyster culture. <The Sea World, New York, May 11, 1880, vol. I, No. 39.

1880 k—Hopson, W. B. The oyster supply in Connecticut. <The Sea World, New York, January 20, 1880, vol. XXI, No. 49.

1880 l—Hopson, W. B. The oyster trade of New York City. <The Sea World, New York, September 7, 1880, vol. II, No. 4.

1880 m—Hore, J. P. The Deterioration of Oyster and Trawl Fisheries of England: its Cause and Remedy. By J. P. Hore and Edward Jex. London, Elliot Stock, 1880. 8°, 128 pp.

On pp. 1–51 is given a brief review of the oyster industry of Great Britain from early in the seventeenth century to 1880. The author attributes the depletion of the beds to (1) overdredging; (2) annihilation of the parent stock; (3) the want of an effectual close season; (4) to impediments under the present state of the law to artificial cultivation. This paper is particularly valuable because of the abstracts from manuscript documents of the seventeenth century preserved in the public record office of Great Britain.

1880 n—H.——, M. C. The green color of oysters. <Nature, London, October 7, 1880, vol. XX, p. 549.

1880 o—McDonald, Marshall. Report upon the Fisheries and Oyster Industries of Tidewater Virginia with Recommendations of such Legislation as is Necessary to Regulate the Same and Derive a Revenue from Them. Made in Obedience to a Joint Resolution of the General Assembly by M. McDonald, Commissioner of Fisheries of Virginia. Richmond, 1880. 8°, 20 pp.

1880 p—Macleay, William (President). Legislative Assembly. New South Wales. Fisheries Inquiry Commission. Report of the Royal Commission, Appointed on the 8th of January, 1880, to Inquire into and Report upon the Actual State and Prospect of the Fisheries of this Colony; together with Minutes of Evidence, and Appendices. Ordered by the Legislative Assembly to be Printed, 13th May, 1880. Sydney: Thomas Richards, Government Printer, 1880. 4°, 42 + 128 + 21 pp.

Contains numerous brief references to the oysters and the oyster fisheries of New South Wales, strongly urges immediate legislation for the protection of the fishery, and suggests the formation of oyster farms under the control of inspectors.

1880 q—Macleay, William (President). New South Wales. Fisheries of New South Wales. Report of the Royal Commission, Appointed on the 8th of January, 1880, to Inquire into and Report upon the Actual State and Prospect of the Fisheries of this Colony. Sydney: Thomas Richards, Government Printer. 1880, Royal 8°, 110 pp.

This is a reprint of the first 42 pages of 1880 *p*, and contains the report proper of the Commission.

1880 r—Power, Alfred. Ode to an oyster. <Colburn's New Monthly Magazine, London, June, 1880, vol. 117, pp. 670–671.

1880 s—Ryder, John A. On the course of the intestine in the oyster (*Ostrea virginiana*). <American Naturalist, Philadelphia, September, 1880, vol. XIV, pp. 674–675.

1880 t—Winslow, Francis. Extracts from report of investigations of the oyster beds in Tangier and Pocomoke sounds and parts of the Chesapeake Bay, conducted during portions of the years 1878 and 1879. <Appendix to Report of the Commissioners of Fisheries of Maryland, January, 1880, pp. 103–220.

A preliminary and abridged publication of 1882 *j*.

1880 u—Anonymous. The oyster season: An epicure analyzing the animal and intellectual properties of the bivalve. <The Sea World, New York, September 14, 1880, vol. II, No. 5.

1880 v—Anonymous. The oyster. <Chambers' Journal, Edinburgh, 1880, vol. 59, pp. 59 *et seq.*

1880 w—Anonymous. Mine oyster. <The Sea World, New Haven, February 9, 1880, vol. 1, No. 26.

A description of the oyster industry of Louisiana.

1881 a—Brady, Thomas F. Oyster Fisheries, Ireland. Digest of the Acts of Parliament and the By-Laws at Present in Force in Ireland for the Regulation of the Oyster Fisheries, to which is added a List of the Licenses Granted for Oyster Beds, and an Abstract of the Law Enabling Certain Persons to Form or Plant Bait Beds. Dublin, Her Majesty's Stationery Office, 1881. 8°, 43 pp.

1881 b—Dickens, Charles (Editor). Something about oysters. <All the Year Round, London, March 26, 1881, vol. 46, pp. 534–537.

Discusses oysters gastronomically.

1881 c—Ferguson, T. B. The oyster. <Report of T. B. Ferguson, a Commissioner of Fisheries of Maryland, January, 1881. Hagerstown, 1881. pp. CV–CXIV.

Cites the scientific investigations that had been made toward the preservation of the Maryland oyster industry.

1881 d—Harding, Charles W. Prize Essay, National Fisheries Exhibition, Norwich, 1881, on the Utilization of Localities in Norfolk and Suffolk suitable for the Cultivation of Mussels and other Shell Fish. Norwich, 1881. 4°, 4 pp.

1881 e—Ingersoll, Ernest. The Oyster Industry. U. S. Fish Commission, Washington, 1881. 4°, 252 pp., 22 plates.

This paper, the most voluminous and comprehensive yet published relative to the oyster industry of America, contains a description of the industry in each of the United States, a compilation of notes on the natural history of *Ostrea virginiana*, and a "glossary of terms or oysterman's dictionary."

1881 f—Ryder, John A. An account of experiments in oyster culture and observations thereto, made at St. Jerome's Creek, Maryland, during the summer of 1880. <Appendix A to Report of a Commissioner of Fisheries of Maryland, January, 1881, Hagerstown, 1881. pp. 1–64.

Discusses the anatomy and food of the oyster (*Ostrea virginiana*) and the faunæ of oyster beds, and describes certain methods for breeding oysters in confinement. See 1884 *s*.

1881 g—Shanks, W. F. G. Oysters and oyster culture. <Lippincott's Magazine, Philadelphia, May, 1880, vol. XXVII, pp. 479–492.

An important discussion of the oyster industry of the Atlantic coast of the United States, with a review of the cultural methods employed in France.

1881 h—Winslow, Francis. Deterioration of American oyster beds. <Popular Science Monthly, New York, November and December, 1881, vol. XX, pp. 29–43 and 145–156.

Discusses the deterioration of the reefs in the Chesapeake Bay, particularly those of Tangier and Pocomoke sounds, and suggests methods for restoring them to their former condition of abundant productiveness. The second chapter is devoted to the "natural history of the oyster with especial reference to the process of reproduction and the conditions influencing its rate of increase."

1881 i—Winslow, Francis. An account of an experiment in artificially fertilizing the ova of the European oyster (*Ostrea edulis*). <Appendix to Report of a Commissioner of Fisheries of Maryland, January, 1881. Hagerstown. 1881, pp. 65–75.

Describes the development of *Ostrea edulis* from the earliest phases.

1881 j—Anonymous. Advent of the oyster. <American, Philadelphia, 1881, vol. II, p. 324.

1882 a—Brocchi, P. Oyster Culture on the Shores of the Channel and of the Ocean. Parliamentary paper, London, 1882.

Translated by T. H. Farrer from Journal Officiel de la République Française, November, 1881, pp. 6181–6186. See 1884 *c* and 1884 *d*.

1882 b—Horst, R. On the development of the European oyster (*Ostrea edulis* L.). <Quarterly Journal of Microscopical Science, London, October, 1882, vol. XXII, pp. 341–346, 1 plate.

Abstract from Tijdschrift der Nederlandsche Dierkundige Vereeniging, 1882, vol. VI.

1882 c—Lockyer, J. N. The oyster industry of the United States. <Nature, London, November 9, 1882, vol. XXVIII, pp. 39–40.

A review of 1881 *e*.

1882 d—Pike, R. G.; Hudson, W. M., and Woodruff, G. N. Report of the Commissioners of Shell-Fisheries of Connecticut. Presented to the Legislature, January session, 1882. Hartford, 1882, 8°, pp. 37–132, 2 maps.

This first report of the Connecticut Shellfish Commission describes the organization of the Commission, the area and location of the natural oyster-grounds of the State, the areas of ground preëmpted, and the methods of culture pursued in the State. The appendix contains the State laws regulating the oyster industries. One of the maps indicates the location of the oyster-grounds, both public and private, and the other contains a sketch of the triangulations executed in 1881 in connection with the oyster surveys.

1882 e—Ryder, John A. Notes on the breeding, food, and green color of the oyster. <Bulletin U. S. Fish Commission, vol. I, 1881. Washington, 1882, pp. 403–419.

Reviews the history of investigations in the subjects noted and gives many original observations. See 1882 *f*, 1882 *g*, and 1883 *af*.

1882 f—Ryder, John A. Notes on the breeding, food, and cause of green color of the oyster. <Transactions of the American Fish-Cultural Association, Eleventh Annual Meeting. New York, 1882, pp. 57–79.

Reprint from Bulletin U. S. Fish Commission, vol. I, 1881. Washington, 1882, pp. 403–419. See 1882 *e*.

1882 g—Ryder, John A. Notes on the breeding, food, and cause of green color of the oyster. <Forest and Stream, New York, May 25, 1882, and June 1, 1882, vol. XVIII, pp. 331–332 and pp. 349–351.

Abstract of 1882 *e*.

1882 h—Ryder, John A. A summary of recent progress in our knowledge of the culture, growth, and anatomy of the oyster. <Forest and Stream, New York, November 30, 1882, vol. XIX, pp. 351–352.

1882 i—Walpole, Spencer. Report on the manner in which the Herne Bay, Hampton, and Reculver Oyster Company are Cultivating the Oyster Grounds within the Limits of the Fishery granted them by "The Herne Bay Fishery Act, 1864." Parliamentary paper, London, 1882.

1882 j—Winslow, Francis. Report on the oyster beds of the James River, Va., and of Tangier and Pocomoke Sounds, Maryland and Virginia. <Appendix No. 11, Report U. S. Coast and Geodetic Survey, 1881. Washington, 1882. 4°, 87 pp., 3 maps.

A report on the delineation of the oyster beds of the localities cited in the title, with notes on the tides and currents, density of the waters, characteristics and abundance of the oysters, effects of ice and gales, with general notes on the condition of the fishery. The three maps indicate the locations of the oyster beds. See 1879 *l* and 1880 *t*.

1882 k—Anonymous. Success in oyster culture. <Forest and Stream, New York, September 14, 1882, vol. XIX, p. 121.

A description of the experiments made by Prof. Henry J. Rice in the summer of 1882. See 1883 *aa*.

1883 a—Anderson-Smith, W. Oyster Culture in Scotland. Selection of the Prize Essays of the International Fisheries Exhibition, Edinburgh, 1882. London, Blackwood, 1883.

1883 b—Anderson-Smith, W. Various Methods of Oyster Culture. Selection of the Prize Essays of the International Fisheries Exhibition, Edinburgh, 1882. London, Blackwood, 1883.

1883 c—Atwater, W. O. Report of progress of an investigation of the chemical composition and economic values of fish and invertebrates used for food. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 231–286.

Contains an account of analyses of oysters, including description of samples, tabular statements of results, and methods of analyses; also summarizes the more immediately practical results of the work, especially in its relations to the nutritive values of the samples analyzed, the detailed account of the more abstract investigations being reserved for another report. See 1885 *a*.

1883 d—Bouchon-Brandely, G. A report on oyster-culture in the Mediterranean. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 907–930.

Translated from pp. 45–103 of Rapport au Ministre de l'Instruction publique sur la Pisciculture en France et l'Ostréiculture dans la Méditerranée, par M. Bouchon-Brandely. Paris, 1878. Extrait du Journal Officiel des 16, 17 et 18 Mai, 1878. Small 8°, 103 pp.

Discusses the methods and conditions of oyster-culture as prosecuted at Lake Fusaro, Tarente, Toulon, Peninsula of Giens, Berre, Caronte, Thau, Leucate, and Agay.

1883 e—Bouchon-Brandely, G. Report relative to the generation and artificial fecundation of oysters. <Bulletin U. S. Fish Commission, 1882. Washington, 1883, vol. II, pp. 319–338.

Translated by John A. Ryder from Rapport relatif à la génération et à la fécondation artificielle des huîtres, adressé au Ministre de la Marine et des Colonies, par M. Bouchon-Brandely. Journal officiel de la République Française. December 16 and 17, 1882, pp. 6762–6764 and 6778–6782.

This is at present the standard authority on the embryology and biology of *Ostrea angulata*, or Portuguese oyster. See 1883 *f*.

1883 f—Bouchon-Brandely, G. The Generation and Artificial Fecundation of Oysters. Parliamentary paper, London, 1882.

Another translation of the preceding paper.

1883 g—Coste, Jean Jacques. Report on the oyster and mussel industries of France and Italy. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 825–884.

Extracted and translated from pp. 89–193 of Voyage d'Exploration sur le littoral de la France et de l'Italie. Deuxième édition. Paris, 1861. 4°, 297 pp. This well-known report pictured the success of the oyster-cultural processes of Italy and strongly urged their introduction on the French coast, and resulted in the institution, under the patronage of Napoleon III, of a series of experimental measures, which have finally resulted in the present important oyster industry on the coasts of France. The following subjects are discussed in the translation: (1) Artificial oyster beds of Lake Fusaro. (2) Green oysters of Marennes. (3) Mussel weirs of the Bay of Aiguillon. (4) Condition of the oyster beds along the coasts of France, and the necessity of restocking them. (5) Artificial oyster beds created in the Bay of Saint-Brieuc. (6) Restocking of the Basin of Arcachon. (7) Appliances suitable for the reception of oyster spat.

1883 h—Cox, James C. On the edible oysters found on the Australian and the neighboring coasts. <Proceedings Linnæan Society of New South Wales, Sydney, 1883, vol. VII, pp. 122–134 and pp. 555–560.

Describes thirteen species occurring on those coasts, with notes on the oyster beds and the oyster industry.

1883 i—De Bon, M. Report on the condition of oyster culture in France in 1875. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 885–906.

Translated from Notice sur la Situation de l'Ostréiculture en 1875; précédée d'un Rapport adressé au Ministre de la Marine et des Colonies, par M. De Bon. (Extrait de la Revue Maritime et Coloniale.) Paris, 1875. 8°, 27 pp. In addition to describing the condition in 1875, this report sketches the history of oyster-culture in France from its origin.

1883 j—Fraiche, Félix. A practical guide to oyster culture, and the methods of rearing and multiplying edible marine animals. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 753–824.

Translated by H. J. Rice from Guide Pratique de l'Ostréiculteur et Procédés d'Élevage et de Multiplication des Races Marines Comestibles, par M. Félix Fraiche. Paris, E. Lacroix, 1865, 12°, 174 pp., 25 woodcuts. Discusses the natural history of the common European oyster (*Ostrea edulis*) and other mollusks, cites the history of oyster-culture in France, and describes with much detail the methods of culture pursued in that country.

1883 k—Hausser, A. E. Oyster culture in Morbihan. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 943–1000.

Translated from L'Industrie Huîtrière dans le Morbihan. Rapport adressé au nom de la Commission du concours de Vannes, par A. E. Hausser, Paris, 1876, 12°, 152 pp.

The methods of culture practiced at Morbihan, France, in 1875, are described with great minuteness. The principal subject-captions are as follows: Breeding parks in general, collectors, liming, formation of breeding parks, removal of young oysters from the collectors, their preservation, enemies of the oyster, parks for raising and fattening oysters, and measures required to insure the prosperity of oyster-culture.

1883 l—Hoek, P. P. C. Results of the investigations relative to the oyster and its cultivation at the end of the first year of these investigations. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 1001–1036.

Translated by Herman Jacobson from Overzicht van den stand van het onderzoek de oester en haar cultuur betreffende aan het einde van het eerste onderzoekingsjaar. In 1880 the Netherlands Zoological Association devoted its attention to investigations respecting the minute anatomy and the biology of the oyster, and an account of the general outline and results of that work appears in this paper.

1883 m—Hoek, P. P. C. Researches on the generative organs of the oyster (*Ostrea edulis*). <Bulletin U. S. Fish Commission, 1882. Washington, 1883, vol. II, pp. 343–345.

Translated by John A. Ryder from Recherches sur les organes génitaux des huîtres, par M. P. P. C. Hoek. Comptes rendus des séances de l'Académie des Sciences, Paris, Novembre 6, 1882. States that the generative organs (of the *Ostrea edulis*) do not consist of localized glands, but extend over nearly the whole of the body mass. They are not separated on either side of the body from the integument. It is the same cul-de-sac which produces at one time the spermatozoa and the ova. See 1890 *a*.

1883 n—Horst, R. A contribution to our knowledge of the development of the oyster (*Ostrea edulis*). <Bulletin U. S. Fish Commission, 1882. Washington, 1883, vol. II, pp. 159–167.

Translated by John A. Ryder from Tijdschrift der Nederlandsche Dierkundige Vereeniging, vol. VI, 1882.

1883 o—Hovey, H. C. Oyster farming in Connecticut waters. <Science, Cambridge, September 14, 1883, vol. II, pp. 376–377.

Abstract of a paper read before the American Association for the Advancement of Science, August, 1883.

1883 p—Hubrecht, Thomas. Oyster Culture and Oyster Fisheries in the Netherlands. One of the Papers of the Conferences held in Connection with the Great International Fisheries Exhibition. London, Clowes & Sons, 1883.

1883 q—Huxley, Thomas H. Oysters. <The Fish Trades Gazette and National Fisheries Record, London, May 26, 1883, vol. I, pp. 5–6.

Abstract of an address on the natural history of the oyster and results of oyster fishing, delivered at the Royal Institution, London, May 11, 1883. See 1883 *r*.

1883 r—Huxley, Thomas H. Oysters and the oyster question. <The English Illustrated Magazine, London, October, 1883, and November, 1883, vol. I, pp. 47–55, and pp. 112–121.

A lecture delivered at the Royal Institution, London, on May 11, 1883, with additional notes. Describes, in a popular manner, the minute anatomy and the biology of *Ostrea edulis*, and reviews the oyster industry of Europe, with notes on the efficiency of certain regulations. Concludes that the abundance or scarcity of oysters depends on causes that can not be materially affected by restrictive legislation. All such legislation is in itself objectionable, inasmuch as it creates new offenses and tends to make the administration of justice odious, and the burden of proof is always on those who advocate it to show that its utility is so great and manifest as to outweigh the inconvenience.

1883 s—Lockwood, Samuel. Natural history of the oyster. <American Monthly Microscopical Journal, Boston, January, 1883, vol. IV, pp. 7–8.

Abstract of a popular address delivered by the author before the New York Microscopical Society, December 15, 1882.

1883 t—Lockyer, J. N. Oysters, oyster fishing, and oyster culture at the Fisheries Exhibition. <Nature, London, August 30, 1883, vol. XXVIII, pp. 415–416.

Recites briefly the exhibits made in these lines by various countries at the London Fisheries Exhibit, 1883.

1883 u—Möbius, Karl. The oyster and oyster-culture. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 683–752.

Translated by H. J. Rice, from Die Auster und die Austernwirthschaft; von Karl Möbius, Berlin, 1877, 8°, 126 pp. Discusses the following branches of the subject, especial reference being made to the Schleswig-Holstein oysters: (1) The sea flats. (2) Oyster banks and oystering. (3) The reproduction of the oyster. (4) Why oysters are not found over all portions of the sea flats. (5) Artificial oyster-breeding in France. (6) Attempts to introduce the French system of oyster-breeding into Great Britain. (7) Can the French system of artificial oyster-breeding be carried on in the waters of the German coast? (8) Can natural oyster-beds be enlarged, and can new beds be formed, especially along the German coast? (9) Growth and fecundity of the oyster. (10) An oyster-bed is a *biocönose* or a social community. (11) Concerning the increase in the price of oysters and in the number of consumers, and the decrease in the number of oysters. (12) The chemical constituents and flavor of oysters. (13) The objects and results of oyster-culture.

1883 v—Osborn, Henry L. The structure and growth of the shell of the oyster. <Studies from the Biological Society of Johns Hopkins University, Baltimore, 1883, vol. II, pp. 427–432, with 1 plate.

1883 w—Pike, R. G.; Hudson, W. M., and Woodruff, Geo. N. Second report of the Shellfish Commissioners of the State of Connecticut, to the General Assembly, January session, 1883, Middletown, Conn., 1883, 8°, 44 pp., 1 map.

A record of the proceedings of the Commission in 1882, with official designations of the several natural oyster beds under the exclusive jurisdiction of the State, and the State laws relating to shell fisheries enacted in 1882. The map shows the triangulation work executed in 1882.

1883 x—Rasch, H. H. On the reason for an extraordinarily rich production of oysters in a natural basin. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 1037–1044.

Translated by Tarleton H. Bean from Nordisk Tidsskrift for Fiskeri, 1880, pp. 49–58.
The natural basin consisted of a small lake situated a few feet higher than the open sea close outside of it, and which could receive salt water from the sea only during severe storms.

1883 y—Renaud, J. An account of the Portuguese and French oysters (*Ostrea angulata* and *Ostrea edulis*) cultivated in the Bay of Arcachon. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 931–938.

Translated from Notice sur l'Huitre Portugaise et Française cultivée dans la Baie d'Arcachon, Arcachon, 1878, 4°, 33 pp.

1883 aa—Rice, H. J. Experiments in oyster propagation. <Transactions of the American Fish-Cultural Association, twelfth annual meeting, New York, 1883, pp. 49-56.

Describes a process by means of which he was enabled to propagate the *Ostrea virginiana* and retain the young oysters alive for fourteen days. See 1883 *ab*.

1883 ab—Rice, H. J. Experiments in oyster propagation. <Forest and Stream, New York, August 9, 1883, vol. XXI, pp. 28-29.

An abstract of 1883 *aa*.

1883 ac—Ryder, John A. Preliminary notice of some points in the minute anatomy of the oyster. <Bulletin U. S. Fish Commission, 1882. Washington, 1883, vol. II, pp. 135-137.

1883 ad—Ryder, John A. The microscopic sexual characteristics of the American, Portuguese, and common edible oyster of Europe compared. <Bulletin U. S. Fish Commission, 1882. Washington, 1883, vol. II, pp. 205-215.

1883 ae—Ryder, John A. Note on the organ of Bojanus in *Ostrea virginica*. <Bulletin U. S. Fish Commission, 1882. Washington, 1883, vol. II, pp. 345-347.

1883 af—Ryder, John A. On the green color of the oyster. <American Naturalist, Philadelphia, January, 1883, vol. XVII, pp. 86-88.

Report on the continuation of the observations noted in 1882 *e*.

1883 ag—Ryder, John A. Rearing oysters from artificially fertilized eggs, together with notes on pond culture. <Bulletin U. S. Fish Commission, 1883. Washington, 1883, vol. III, pp. 281-294.

Describes the experiments made by the author in the summer of 1882 at St. Jerome Creek, St. Mary County, Maryland. For journal of operations see 1884 *r*.

1883 ah—Ryder, John A. Rearing oysters from artificially impregnated eggs. <Science, Cambridge, February 23, 1883, vol. I, pp. 60-62.

An abstract of 1883 *ag*.

1883 ai—Ryder, John A. Rearing oysters from artificially impregnated eggs. <New Zealand Journal of Science, July, 1883, vol. I, pp. 455-459.

An abstract of 1883 *ag*.

1883 aj—Ryder, John A. On the mode of fixation of the fry of the oyster. <Bulletin U. S. Fish Commission, 1883. Washington, 1883, vol. III, pp. 383-387, 9 figs.

1883 ak—Ryder, John A. Oyster culture in Holland. <Science, Cambridge, July 20, 1883, vol. II, p. 79.

A review of Varslag omtrent onderzoek op de oester en de oestercultuur betrekking hebbende. Aflevering i. Leiden, 1883, 8°, 253 pp., 5 plates.

1883 al—Ryder, John A. The protozoan parasites of the oyster. <Science, Cambridge, June 22, 1883, vol. I, pp. 567-568.

Reviews a paper by M. Cortes on the protozoan parasites or commensals of *Ostrea edulis*.

1883 am—Ryder, John A. The oyster problem solved. <Forest and Stream, New York, August 30, 1883, vol. XXI, p. 90.

Cites briefly the results of the author's experiments at Stockton, Maryland, in the summer of 1883. See 1883 *an*.

1883 an—Ryder, John A. Rearing oysters from artificially fertilized eggs at Stockton, Maryland. <Science, Cambridge, October 5, 1883, vol. II, pp. 463-464.

An account of experiments made by the author during the summer of 1883.

1883 ao—Sole, Mary. Oysters and oyster fisheries. <The Fish Trades Gazette and National Fisheries Record, London, July 28, 1883, vol. I, pp. 209-210.

Argues the desirability of improved regulations for the formation of oyster-cultural companies in England.

1883 ap—**Winslow, Francis.** Catalogue of the Economic Mollusca and the Apparatus and Appliances used in their Capture and Preparation for Market, Exhibited by the United States National Museum at the Great International Fisheries Exhibition, London, 1883. Washington, 1883, 8°, 86 pp.

On pp. 14–41 the author discusses the biology of *Ostrea virginiana* and the oyster industry in the United States, with statistics of the business, the latter being abstracted from 1881 *c*; and on pp. 62–85 is given a list of the materials exhibited by the U. S. National Museum for illustrating the oyster and the oyster industry.

1883 aq—**Winslow, Francis.** Chesapeake oyster beds. <Science, Cambridge, September 28, 1883, vol. II, pp. 440–443.

A review of 1882 *j*.

1883 ar—**Anonymous.** Progress in oyster culture. <The Scotsman, Edinburgh, October 29, 1883, p. 6.

1883 as—**Anonymous.** Artifical oyster rearing. <Chambers' Journal, Edinburgh, 1883, vol. LX, pp. 602.

1883 at—**Anonymous.** Oysters in China. <Special catalogue of the Chinese collection of exhibits for the International Fisheries Exhibition, London, 1883.

Describes the methods of oyster-culture on the coasts of China.

1883 au—**Anonymous.** The United States at the Fisheries Exhibition. <Engineering News, London, September 14, 1883, vol. XXXVI, pp. 229–230.

A brief review of an address delivered by G. Brown Goode at the Great International Fisheries Exposition, London, 1883.

1883 av—**Anonymous.** The Oyster Epicure: Collation of Authorities on the Gastronomy and Dietetics of the oyster. New York, White, Stokes and Allen, 1883, 12°, 61 pp.

The following branch subjects are discussed: (1) When in season; (2) How to eat it; (3) How to serve it; (4) What to drink with it; (5) How many to eat; (6) How to open it; (7) Roasted in its own shell; (8) Which to choose, and where; (9) Dietetics of the oyster; (10) Famous oyster-eaters.

1883 aw—**Bouchon-Brandely, G.** Oyster culture in France. <The Fish Trades Gazette and National Fisheries Record, London, June 2, June 9, and June 16, 1883, vol. I, pp. 30–31, 64, and 92–93.

A reprint of 1883 *d*.

1883 ax—**Bouchon-Brandely, G.** On the sexuality of the common oyster (*O. edulis*) and that of the Portuguese oyster (*O. angulata*). Artificial fecundation of the Portuguese oyster. <Bulletin U. S. Fish Commission, 1882. Washington, 1883, vol. II, pp. 339–341.

Translated by John A. Ryder from De la sexualité chez l'huître ordinaire (*O. edulis*) et chez l'huître portugaise (*O. angulata*). Fécondation artificielle de l'huître portugaise. Comptes rendus hebdomadaires des Séances de l'Académie des Sciences. Vol. XCV, No. 5 (31 Juillet, 1882), pp. 256–259. Paris, 1882.

1883 ay—**Faber, G. L.** The Fisheries of the Adriatic and the Fish Thereof. London, 1883, Royal 8°, 292 pp.

1883 az—**Seal, Matthew** (Chairman). Royal Commission on the Fisheries of Tasmania. Report of the Commissioners, together with General and Critical Observations on the Fisheries of the Colony; Classified Catalogue of all the known species; Abstract of the Minutes of Proceedings of the Commission; Evidence taken before Commissioners; Statistics, etc. Tasmania: William Thomas Stoutt, Government Printer, Hobart, 1883. 4°, LXVI+86 pp.

Contains numerous brief references to the oysters and the oyster industries of Tasmania, and the regulations governing the taking of oysters.

1883 ba—**Hoek, P. P. C.** Oyster culture in the Netherlands. <Report U. S. Fish Commission, 1880. Washington, 1883, vol. VIII, pp. 1029–1035.

Translated from Circular No. 2, 1879, of the Deutsche Fischerei-Verein.

1883 bb—Möbius, Karl. On experiments, begun in 1880, to plant American oysters in the Western Baltic, and the usefulness of continuing these experiments, with the aid of the German Fishery Association. < Bulletin U. S. Fish Commission, 1883. Washington, 1883, vol. III, pp. 213–217.

Translated by Herman Jacobson, from Circular No. 2, 1883, of the Deutsche Fischerei-Verein, Berlin, April 30, 1883.

1883 bc—Anonymous. International Fisheries Exhibition, 1883. Official Catalogue. London: William Clowes & Sons, Limited, 1883. 8°, XCI + 382 pp.

Refers to the exhibits of oysters and the methods of oyster-culture made by various countries.

1884 a—Anson, C. V., and Willett, E. H. Oyster Culture. Prize Essay issued in connection with the Great International Fisheries Exhibition. London, Clowes & Sons, 1884. 8°.

1884 b—Bouchon-Brandely, G. Report to the Minister of the Marine relative to oyster-culture upon the shores of the British Channel and the ocean. < Report U. S. Fish Commission, 1882. Washington, 1884, vol. X, pp. 673–724.

Translated by Marshall McDonald from report published in the Journal Officiel de la République Française, January 22, 24, 25, and 26, 1877.

1884 c—Brocchi, P. Report on the condition of oyster culture in France in 1881. <Bulletin U. S. Fish Commission, 1884. Washington, 1884, vol. IV, pp. 97–111.

Translated from Journal Officiel de la République Française, November 8, 1881, pp. 6181–6186. A very interesting and important statistical paper by a zoologist thoroughly conversant with the industry. See 1882 *a* and 1884 *d*.

1884 d—Brocchi, P. Report on the condition of oyster-culture in France in 1881. <Report U. S. Fish Commission, 1882. Washington, 1884, vol. X, pp. 725–739.

A reprint of 1882 *a*, which is another translation of the original of 1884 *c*.

1884 e—Brooks, W. K.; Wardell, J. T., and Legg, W. H. Report of the Oyster Commission of the State of Maryland, January, 1884. Annapolis, 1884, 4°, 183 pp., 4 maps, 13 plates.

This commission was authorized and directed by the general assembly of Maryland to "examine the condition of the oyster beds of the State and report the same to the next general assembly, with such recommendations as will conduce to the protection of this important industry." The report discusses the results of an examination of the oyster beds, the causes for their exhaustion, the necessary procedures for their improvement, the methods and possibilities of oyster planting, with particular reference to the practices in France, the oyster industry and oyster regulations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, and Virginia, and recommendations for the improvement of the industry in Maryland, with a minority report by W. H. Legg, stating his objection to some points of the report. The maps represent portions of the Chesapeake Bay. See 1884 *f*.

1884 f—Brooks, W. K.; Wardell, J. T., and Legg, W. H. Report of the Oyster Commission of the State of Maryland, January, 1884. Baltimore, 1884, 4°, 193 pp., 4 maps, 13 plates.

A reprint of 1884 *e*.

1884 g—Goode, G. Brown. The oyster industry of the world. <Transactions of the American Fish-Cultural Association, thirteenth annual meeting. New York, 1884, pp. 146–148.

Presents an approximation of the oyster products of the world. See 1884 *h*.

1884 h—Goode, G. Brown. The oyster industry of the world. <Bulletin U. S. Fish Commission, 1884. Washington, 1884, vol. IV, pp. 468–469.

A reprint of 1884 *g*.

1884 i—Greene, Albert R. Shell fisheries of Rhode Island: public hearing by the joint special committee of the general assembly. <Providence Journal, Providence, Rhode Island, March 5, 1891.

1884 j—Hoek, P. P. C. Oyster Culture. Prize essay issued in connection with the Great International Fisheries Exhibition. London, Clowes & Sons, 1884, 36 pp., 3 plates.

1884 k—Hovey, Horace C. Oyster farming in Connecticut. <Proceedings of the American Association for the Advancement of Science, thirty-second annual meeting, held at Minneapolis, August, 1883. New York, 1884, pp. 460–466.

1884 l—Hudson, William M. The shell fisheries of Connecticut. <Transactions of the Fish-Cultural Association, thirteenth annual meeting. New York, 1884, pp. 124–146.

Considers the relations existing between the State and the public and private oyster areas in Long Island Sound within the boundaries of Connecticut, with especial reference to legislation affecting the oyster industry.

1884 m—Lockwood, Samuel. An oyster on a crab. <American Naturalist, Philadelphia, February, 1884, vol. XVIII, p. 200.

Describes a female *Cancer irroratus* (Say), one-fourth full-grown, and with the caudal flaps distended with eggs, carrying attached to the right side of its carapace an oyster 2½ inches in length and 2 inches in width.

1884 n—Pike, R. G.; Hudson, W. M., and Woodruff, G. N. Third Report of the Shell Fish Commissioners of the State of Connecticut to the General Assembly, January session, 1884. Middletown, Conn., 1884. 8°, 40 pp.

Contains the official designation of the natural beds under the exclusive jurisdiction of the State, and refers to the general condition of the oyster industry of Connecticut in 1883.

1884 o—Puysegur, M. On the cause of the greening of oysters. With a supplementary note on the coloration of the blood corpuscles of the oyster, by John A. Ryder. <Report U. S. Fish Commission, 1882. Washington, 1884, vol. X, pp. 793–805.

Also reviews much of the existing literature relative to this subject. This first part of this article is translated from Notice sur la Cause du Verdissement des Huitres. Paris, Berger-Levrault et Cie, 1880. 8°, 11 pp., 1 plate.

1884 p—Rumpff, Carl. The oyster as a popular article of food in North America. <Bulletin U. S. Fish Commission, 1884. Washington, 1884, vol. IV, pp. 356–358.

Translated by Herman Jacobson from Circular No. 3, 1884, of the German Fishery Association, Berlin, April 4, 1884.

1884 q—Ryder, John A. On a new form of filter or diaphragm to be used in the culture of oysters in ponds. <Bulletin U. S. Fish Commission, 1884. Washington, 1884, vol. IV, pp. 17–31.

The filter described consists of barriers of sand confined between gunny cloth and galvanized wire cloth, which works quite successfully. This article also describes the methods of constructing the oyster ponds or *claires*.

1884 r—Ryder, John A. Journal of operations on the grounds of the Eastern Shore Oyster Company, on Chincoteague Bay, near Stockton, Md., during the summer of 1883. <Bulletin U. S. Fish Commission, 1884. Washington, 1884, vol. IV, pp. 43–47.

This journal contains a daily record of the work, the results of which were published in Bulletin U. S. Fish Commission, 1883, vol. III, pp. 281–294, in a paper entitled "Rearing oysters from artificially fertilized eggs, together with notes on pond culture." See 1883 *ag*.

1884 s—Ryder, John A. An account of experiments in oyster culture and observations relating thereto. <Report U. S. Fish Commission, 1882. Washington, 1884, vol. x, pp. 763–778.

A continuation of an article by this author, published in the report of the Maryland Fish Commissioner for 1881. See 1881 *f*.

1884 t—Ryder, John A. The metamorphosis and post-larval stages of development of the oyster. <Report U. S. Fish Commission, 1882. Washington, 1884, vol. x, pp. 779–791.

1884 u—Ryder, John A. A contribution to the life-history of the oyster (*Ostrea virginica* Gmelin and *O. edulis* Linn.). <The Fisheries and Fishery Industries of the United States. Washington, 1884, sec. 1, pp. 711–758.

Discusses—(1) Outline sketch of the coarser anatomy of the oyster.
(2) The minute anatomy of the oyster.
(3) Sex, sexual products, and differences of the sexual habits of the American and European oysters.
(4) New methods of distinguishing the sexes and of taking the eggs of the oyster.
(5) Rate of growth of *Ostrea virginica*.
(6) The food of the oyster.
(7) On the cause of the green color of the oyster.
(8) Local variations in the form and habits of the oyster.
(9) The oyster crab as a messmate and purveyor.
(10) Physical and vital agencies destructive to oysters.
(11) Natural and artificial oyster banks.

1884 v—White, H. P.; Long, C. W., and Bock, Thos. H. The Local Oyster Law of Somerset County, Codified as Public Local Laws, Article XIX, Sections 91–101, Inclusive. Also Regulations and Designations made by the County Commissioners of said County. Crisfield, Md: From Crisfield Leader Press, 1884. Royal 8°, 6 pp.

1884 w—Winslow, Francis. Report of experiments in the artificial propagation of oysters, conducted at Beaufort, N. C., and Fair Haven, Conn., in 1882. <Report U. S. Fish Commission, 1882. Washington, 1884, vol. x, pp. 741–762.

These experiments, like those of Dr. Brooks in 1879 and of Prof. Ryder and Lieut. Winslow in 1880, resulted in impregnating the egg and maintaining the embryo alive for a short period, after which it died. This report cites the methods and apparatus employed and the influence of the various natural conditions affecting the development of the egg.

1884 x—Winslow, Francis. Memorandum of the present condition and future needs of the oyster industry. <Bulletin U. S. Fish Commission, 1884. Washington, 1884, vol. IV, pp. 233–234.

Briefly refers to the necessity for model oyster farms and continued investigations of the embryological life of the oyster.

1884 y—Winslow, Francis. Notes upon oyster experiments in 1883. <Bulletin U. S. Fish Commission, 1884. Washington, 1884, vol. IV, pp. 354–356.

1884 z—Winslow, Francis. Present condition and future prospects of the oyster industry. <Transactions of the American Fish-Cultural Association, thirteenth annual meeting. New York, 1884, pp. 148–163.

Refers particularly to the Chesapeake region.

1884 aa—Winslow, Francis, and Others. Ownership of oyster grounds. <Transactions of the American Fish-Cultural Association, thirteenth annual meeting. New York, 1884, pp. 241–247.

Recommends the adoption by each State of the principle of individual ownership of oyster-grounds.

1884 ab—Anonymous. Oyster fishery in Connecticut. <Science, New York, March 20, 1884, vol. V, p. 234.

A brief review of the fourth annual report of the Shellfish Commissioners of the State of Connecticut. See 1885 *o*.

1884 ac—Duvar, J. Hunter. Oysters in Prince Edward Island. <Report on the Fisheries of Canada for the year 1883. Ottawa, 1884, pp. 177–180.

A discussion of the condition of the oyster industry of Prince Edward Island during the preceding year, with notes on the inefficiency of the regulations governing the fishery and recommendations for additional restrictions on the public fishery and for encouragement to oyster-culturists.

1885 a—Atwater, W. O. Contributions to the knowledge of the chemical composition and nutritive values of American food fishes and invertebrates. <Report U. S. Fish Commission, 1883. Washington, 1885, vol. XI, pp. 433–500.

A continuation of 1883 *c*. On pp. 486–488 is given a table of percentages of water and nutritive ingredients in 38 specimens of fresh oysters and 3 specimens of canned oysters from various localities in America. See 1888 *a*.

1885 b—Blackford, Eugene G. Report of the Commissioner of Fisheries of the State of New York in charge of the Oyster Investigation. Albany, 1885, 8°, 70 pp.

The first of the three reports of this investigation discusses the decrease of oysters in New York State and the means of increasing the supply, the locations and conditions of the reefs, and the enemies of the oyster, the investigation relating to those beds west of Patchogue on the south side and Port Jefferson on the north side of Long Island.

1885 c—Blackford, Eugene G. Report of the work of an Oyster Investigation with the steamer Lookout. <Bulletin U. S. Fish Commission, 1885. Washington, 1885, vol. V, pp. 52–57.

Describes the conditions of the oyster-grounds at City Island, Perth Amboy, and the south side of Staten Island, Cold Spring Harbor, Hempstead Harbor, Little Neck Bay, Manhasset or Cow Bay, Execution Light-house rock, Port Chester and Rye Beach, Northport Harbor, Princess Bay, and Spuyten Duyvil Creek, all in the State of New York.

1885 d—Blackford, Eugene G. The oyster beds of New York. <Transactions of the American Fisheries Society, fourteenth annual meeting. New York, 1885, pp. 85–89.

Describes briefly the preliminary work in the investigation of the natural oyster beds of New York, begun in 1884, and cites the possibilities for oyster-culture in that State. See 1885 *c*.

1885 e—Blackford, Eugene G. The oyster beds of New York. <Forest and Stream, New York, August 13, 1885, vol. XXV, p. 50.

A reprint of the preceding paper.

1885 f—Brooks, W. K. Oyster farming for North Carolina. <Forest and Stream, New York, April 16, 1885, vol. XXIV, pp. 230–231.

A paper read at the Fishermen's Convention at Raleigh, October 15, 1884.

1885 g—Cunningham, T. J. Resting position of oysters. <Nature, London, October 22 and December 10, 1885, vol. XXXII, p. 597, and vol. XXXIII, p. 129.

Disputes the statements of many well-known malacologists that oysters rest on the convex valve, and advances the theory that they rest on the flat valve because that side is nearly always the cleaner, being more nearly free from worm tubes, hydroids, etc. See 1885 *k*, 1885 *n*, 1885 *s*, 1885 *u*, and 1885 *v*.

1885 h—Garman, Samuel. Protecting the oyster beds from starfish depredations. <Bulletin U. S. Fish Commission, 1885. Washington, 1885, vol. V, pp. 127–128.

Urges the use of divers in the removal of starfish from the oyster beds in Long Island Sound.

1885 i—Hoek, P. P. C. Comparative examination of cultivated and uncultivated oysters, with the view to determine the number which, during the first year, took part in reproduction. <Bulletin U. S. Fish Commission, 1885. Washington, 1885, vol. v, pp. 193–196.

Translated by Herman Jacobson from pp. 481–495 of Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Dell 1. Leiden, E. J. Brill, 1883–84.

These experiments were made in Holland, and, being conducted under very unfavorable circumstances, were, according to the writer, not conclusive.

1885 j—Hopson, W. B. An Essay on the Oyster Industry of the United States. New York: The McWilliams Printing House, 1885. 8°, 78 pp.

Discusses: (1) Oyster cultivation in Connecticut; (2) Experiences in oyster-planting in Connecticut; (3) Enemies of the oyster; (4) Food of the oyster; (5) Anatomy of the oyster; (6) "Drinking oysters"; (7) The oyster trade of Boston and Providence; (8) The Connecticut trade; (9) The oyster trade of New York City; (10) Shipping seed oysters to California; (11) European shipments; (12) Blue points; (13) Rockaways; (14) Shrewsburys; (15) The oyster trade of Delaware Bay; (16) The Baltimore trade; (17) Chesapeake Bay oyster industry; (18) Hints regarding the cooking of oysters.

1885 k—Hunt, Arthur R. Resting position of oysters. <Nature, London, November 5 and December 17, 1885, vol. xxxiii, pp. 8 and 154.

Argues that they rest on the convex side.

1885 l—Mather, Fred. Successful oyster-culture. <Forest and Stream, New York, October 1, 1885, vol. xxv, pp. 190–191.

Describes the experiments of the author in 1885.

1885 m—Möbius, Karl. Report on planting Canadian oysters near the Island of Aaröe, in the Little Belt, November 6, 1884. <Bulletin U. S. Fish Commission, 1885. Washington, 1885, vol. v, pp. 257–260.

Describes the details of the planting of 17 barrels of oysters in November, 1884. The success of the operation was not noted.

1885 n—Möbius, Karl. Resting position of oysters. <Nature, London, November 19, 1885, vol. xxxiii, p. 52.

Replies adversely to T. J. Cunningham's arguments on this subject. See 1885 *g*.

1885 o—Pike, R. G.; Hudson, W. M., and **Bill, J. A.** Fourth Report of the Shell Fish Commissioners of the State of Connecticut, to the General Assembly, January session, 1885. Middletown, Conn., 1885. 8°, 32 pp.

Completes the official designation of the natural oyster reefs under the exclusive jurisdiction of the State of Connecticut. Refers to the proceedings of the commissioners and the general condition of the oyster industry in 1884. Appendix contains the shellfish enactments of 1884.

1885 p—Pike, R. G.; Hudson, W. M., and **Bill, J. A.** Fifth Report of the Shell Fish Commissioners of the State of Connecticut, to the General Assembly, January session, 1886. Middletown, Conn., 1885. 8°, 26 pp.

Contains notes on the procedures of the commissioners and the condition of the oyster industry of Connecticut in 1885, and the shellfish enactments of the State during the same year.

1885 q—Rice, H. J. The propagation and natural history of the American oyster. <Supplement to the Report of the Commissioner of Fisheries of the State of New York, in charge of the Oyster Investigation. Albany, 1885. 8°, pp. 71–137.

A brief summary of the present knowledge regarding the natural history of *Ostrea virginiana*, and its application to the waters of the State of New York. Discusses particularly the distribution of the species, structure of the shell, the coarse anatomy of the animal, the generative organs, seed oysters, food of the oyster, coloration of the oyster, its friends and enemies, artificial propagation, and the methods of obtaining spat.

1885 r—Ryder, John A. The oyster problem actually solved. <Forest and Stream, New York, October 22, 1885, vol. xxv, pp. 249–250.

1885 s—Ryder, John A. Resting position of oysters. <Nature, London, November 26, 1885, vol. xxxiii, pp. 80–81.

Opposes the theory advanced by T. J. Cunningham that oysters rest on the convex side. See 1885 *g*.

1885 t—Ryder, John A. New system of oyster culture. <Science, New York, November 27, 1885, vol. vi, pp. 465–467.

The principles of the new system are as follows:

(1) Oyster embryos diffuse themselves throughout the three dimensions of a body of water, and will affix themselves to collecting surfaces similarly distributed, up to and even above low-water level.

(2) The floating fry will adhere to smooth surfaces as well as rough ones.

(3) The surfaces upon which spatting occurs must be kept as free as possible from sediment and organic growths, in order that the very small mollusks may not be smothered and killed during the most critical period of their lives.

(4) Artificial fertilization of the egg of the oyster is feasible, and will become an important adjunct to successful spat-culture.

(5) The water charged with embryo oysters may be passed through a steam pump without injury.

(6) Oyster fry usually adheres most freely to the under surface of shells or other collectors, because the lower side is cleanest, and most favorable to the survival of the animals.

(7) The spat of the oyster will grow and thrive with comparatively little light.

(8) The specific gravity of the water may range from 1.003 to 1.0235.

(9) The most favorable temperatures of the water for spatting seem to be from 68° to about 80° F.

(10) Spatting will occur just as freely in ponds or tanks with a free circulation as in open water.

1885 u—Stuart-Wortley. The resting position of oysters. <Nature, London, October 29, 1885, vol. xxxii, p. 625.

In this writer's experiments "the young oysters born in tanks rested on the flatter shell when they obtained a flat surface, such as a tile, to adhere to; but when so arranged that they had irregular surfaces to deal with, such as little bundles of twigs, some adhered one way and some another. But where young oysters, nearly two years old, were moved from their original supports, and were compelled to find new ones, they selected the flat shell to rest upon in every instance, except where they were placed on sand, in which case they rested on the convex shell, in order apparently to avoid clogging the mouth of the shell with sand." See 1885 *g*.

1885 v—Turner, W. Resting position of oysters. <Nature, London, November 12, 1885, vol. xxxiii, p. 30.

1885 w—Verrill, A. E. How long will oysters live out of water. <Bulletin U. S. Fish Commission, 1885. Washington, 1885, vol. v, pp. 161–162.

In the instance described the oysters lived ten weeks under very unfavorable circumstances.

1885 x—Winslow, Francis. The North Carolina oyster industry. <Forest and Stream, New York, May 7 and 14, 1885, vol. xxiv, pp. 292, 293, and 332.

A paper read at the Fishermen's Convention, Raleigh, October 16, 1884. Cites instances of the depletion of oyster beds in all parts of the world, reviews the development of the oyster, and outlines the practical application of the information to the water areas of North Carolina.

1885 y—Wood, W. M. Report of operations at St. Jerome station, in laying out oyster ponds, by the steamer *Fish Hawk*, in 1883. <Report U. S. Fish Commission, 1883. Washington, 1885, vol. xi, pp. 1153–1156.

Contains a brief table showing the results of dredging on oyster beds by the steamer *Fish Hawk* in various localities in Maryland from November 15 to 24, 1883.

1885 z Anonymous. Oyster commission of New York. <Forest and Stream, New York, February 26, 1885, vol. xxiv, p. 91.

Reviews the first report of the New York oyster commissioner. See 1885 *b*.

1885 aa—Anonymous. Whitstable oysters. <Chambers' Journal, Edinburgh, 1885, vol. LXII, pp. 481 *et seq.*

1885 ab—Anonymous. Prices of English oysters. <Standard, London, March 19, 1885.

1885 ac—Anonymous. Whitstable and her natives. <London Daily Telegraph, London, August 31, 1885.

Describes the company of free fishermen and dredgers of Whitstable, England.

1885 ad—Anonymous. Oyster-culture in Connecticut. <Forest and Stream, New York, December 17, 1885, vol. XXV, p. 410.

Reviews the Fifth Annual Report of the Shellfish Commissioners of the State of Connecticut. See 1885*p*.

1885 ae—Anonymous. Clinton oyster lands. <New Haven Register, New Haven, September 15, 1885.

An account of the controversy relative to the rights to oyster-grounds in the channel of the Hammonasset River, Connecticut.

1885 af—Harding, Charles W. An Apparatus for Storing, Keeping Alive, and Protecting from the Force of the Sea Edible Molluscs. London. Published and sold at the Patent Office Sale Branch, 1885. 4°, 4 pp., 2 plates.

1885 ag—Ryder, John A. The rate of growth of oysters at Saint Jerome Creek Station. <Bulletin U. S. Fish Commission, 1885. Washington, 1885, vol. V, pp. 129–131.

1886 a—Blackford, Eugene G. Oyster-culture in New York. <Commercial Advertiser, December 28, 1886.

A discourse on the necessity of giving to the oyster-cultivators of New York State some certainty of tenure in the grounds used by them.

1886 b—Bothwell, A. J. On the half shell: a description of oyster fishing. <Review, Brooklyn, N. Y., February, 27, 1886.

1886 c—Buch, S. A. Oyster-culture as seen at the London Fisheries Exhibition. <Report of the U. S. Fish Commission, 1884. Washington, 1886, vol. XII, pp. 913-924.

Translated by Herman Jacobson from Norsk Fiskeritidende, Bergen, October 1884, vol. III, Nos. 3 and 4.

1886 d—Hodson, Thomas S. Long Island oyster beds. <The Sun, Baltimore, August 2, 1886.

1886 e—Hodson, Thomas S. Steam oyster dredges: their work in New England waters. <The Daily American, Baltimore, August 5, 1886.

1886 f—Hodson, Thomas S. Private oyster beds: cultivation needed in Maryland. <The Daily American, Baltimore, August 14, 1886.

Suggests methods for increasing the abundance of the Chesapeake oyster yield.

1886 g—Horst, R. The development of the oyster (*Ostrea edulis* L.). <Report U. S. Fish Commission, 1884. Washington, 1886, vol. XII, pp. 891–911, 2 plates.

Contains an historical résumé of the investigations in this subject, with an account of the individual researches of the author.

1886 h—Mather, Fred. Oyster-culture. <Transactions of the American Fisheries Society, fifteenth annual meeting. New York, 1886, pp. 26–36.

A review of experiments made at Cold Spring Harbor, New York, during the summer of 1885.

1886 i—Mather, Fred. Oyster-culture. <Forest and Stream, New York, July 15, 1886, vol. XXVI, p. 491.

A modified reprint of 1886*h*.

1886 j—Phillips, Thomas. American oysters. <The Fish Trades Gazette and Game and Poultry Trades Chronicle, London, October 30 and November 6, 1886, vol. IV, Nos. 180 and 181.

The English trade in American oysters from the standpoint of a Liverpool oyster dealer.

1886 k—Pike, R. G.; Hudson, W. M., and Bill, J. A. <Sixth Report of the Shell Fish Commission of the State of Connecticut to the General Assembly, January session, 1887. Middletown, Conn., 1886. 8°, 30 pp.

A report of the procedures of the commissioners, the general condition of the oyster industry in the State during the preceding year, and the shellfish enactments of 1885. See 1886 *l*.

1886 l—Pike, R. G.; Hudson, W. M., and Bill, J. A. The oyster industry. <The New Haven Register, New Haven, November 26, 1886.

A reprint of 1886*k*.

1886 m—Verrill, A. E. How long will oysters live out of water. <The Fish Trades Gazette and Poultry Trades Chronicle, London, July 3, 1886, vol. IV, No. 163.

A reprint of 1885*w*.

1886 n—White, William. The American oysters. <Eagle, Brooklyn, September 12, 1886.

A lengthy account of the development and methods of the exportation of American oysters to England.

1886 o—Winslow, Francis. Report on the Waters of North Carolina, with Reference to their Possibilities for Oyster-Culture; together with the Results Obtained by the Surveys directed by the Resolution of the General Assembly, ratified March 11, 1885. Raleigh, 1886. 8°, 151 pp., 2 maps.

Discusses for each water area of the State the character of the bottom, the depth and specific gravity of the waters, the strength and direction of the currents, and the character of the indigenous fauna. The maps indicate the location of the public and private oyster beds and the areas considered suitable for cultivation. See 1889 *n*.

1886 p—Anonymous. Shell fish in Connecticut. <Science, New York, January 15, 1886, vol. VII, pp. 59–60.

Reviews briefly the fifth report of the shellfish commissioners of the State of Connecticut. See 1885*p*.

1886 q—Anonymous. Oyster grounds. <All the Year Round, London, 1886, vol. LIX, pp. 250 *et seq.*

1886 r—Anonymous. The Oyster Packers of Crisfield. <The Times, Philadelphia, February 1, 1886.

1886 s—Anonymous. Maryland's oyster wealth. <The Sun, Baltimore, August 10, 1886.

1886 t—Anonymous. Our oyster supplies. <The Fish Trades Gazette and Game and Poultry Trades Chronicle, London, September 25, 1886, vol. IV, No. 175.

Discusses the oyster supplies available for the London market.

1886 u—Anonymous. The Connecticut shell-fish commission. <Forest and Stream, New York, December 30, 1886, vol. XXVII, p. 449.

A review of the sixth annual report. See 1886 *k*.

1886 v—Duvar, J. Hunter. Oysters in Prince Edward Island. <Annual Report of the Department of Fisheries, Dominion of Canada, for the year 1885. Printed by order of Parliament, Ottawa. Printed by Maclean, Rogers & Co., 1886. 8°, pp. 257–261.

A report on the condition of the oyster industry of Prince Edward Island during 1885.

1887 a—Atwater, W. O. The chemical changes produced in oysters in floating, and their effects upon the nutritive value. <Transactions of the American Fisheries Society, sixteenth annual meeting. New York, 1887, pp. 37-52.

In floating or fattening oysters in fresher water, as is commonly done in preparing them for market in certain localities, the animal gains from one-eighth to one-fifth in bulk and weight by taking up water, but at the same time parts with some of its salts, with small quantities of nutritive ingredients which escape at the same time, the gain of water and loss of nutriment being evidently due to osmose. The flavor of the oysters is said to be thereby improved and they bear transportation and keep better.

1887 b—Atwater, W. O. The chemistry of "oyster fattening." <Popular Science Monthly, New York, November, 1887, vol. XXXII, pp. 77–87.

An adaptation from 1887 *a*.

1887 c—Atwater, W. O. The chemical changes in oysters by floating. <Forest and Stream, New York, December 1 and 8, 1887, vol. XXIX, pp. 368–369 and 389–390.

A reprint of 1887 *a*.

1887 d—Blackford, Eugene G. Report of an oyster investigation in New York with the steamer *Lookout*. <Report U. S. Fish Commission, 1885. Washington, 1887, vol. XIII, pp. 157–164.

Describes conditions of the oyster-grounds in Peconic Bay, Hudson River, Port Jefferson Harbor, Princess Bay, and in the vicinity of The Kills and Execution Light-House Rock.

1887 e—Blackford, Eugene G. Second Report of the Oyster Investigation and of Survey of Oyster Territory, for the years 1885 and 1886. Transmitted to the Legislature January 20, 1887. Albany, The Argus Company, 1887. 8°, 47 pp., one map, 5 plates.

Describes the oyster beds of The Kills, Execution Light-house Rock, Hudson River, Port Jefferson Harbor, Princess Bay, Hempstead Bay and other localities contiguous to New York City. Reports the area of the natural beds to be 15,586 acres, and of grounds available and suitable for cultivation 393,600 acres. The map indicates the location of a large portion of the natural oyster beds of the State.

1887 f—Bouchon-Brandely, G. Report on the artificial fecundation and generation of oysters. <Bulletin U. S. Fish Commission, 1886. Washington, 1887, vol. VI, pp. 225–240.

Translated by Herman Jacobson from Rapport sur la fécondation artificielle et la génération des huîtres, Paris, 1884.

"The following has been the endeavor of our researches: (1) To find out whether artificial fecundation could yield practical results in entirely closed waters; and (2) To ascertain whether the raising of the Portuguese oyster (*Ostrea angulata*) is possible and profitable in the ponds on the Mediterranean."

1887 g—Brooks, W. K. On the artificial propagation and cultivation of oysters in floats. <Bulletin U. S. Fish Commission, 1886. Washington, 1887, vol. VI, pp. 443–445.

Reprint from Johns Hopkins University circular, vol. V, No. 43.

1887 h—Dean, Bashford. The food of the oyster; its conditions and variations. <Second Report of the Oyster Investigation and of Survey of Oyster Territory, for the years 1885 and 1886. Albany, 1887. Supplement, pp. 49–78, 3 plates.

The observations were made entirely within the waters of the State of New York.

1887 i—Duvar, J. Hunter. Oysters in Prince Edward Island. <Annual Report of the Department of Fisheries, Dominion of Canada, for the year 1886. Printed by order of Parliament. Ottawa, printed by Maclean, Roger & Co., 1887, pp. 181–182.

Reports the condition of the oyster industry in 1886. The product was 33,125 barrels, valued at $99,375.

1887 j—Ganong, W. F. The marine mollusca of New Brunswick. <Bulletin of the Natural History Society of New Brunswick, Saint John, N. B., 1887, No. VI, pp. 17–61.

Refers to the regions in which oysters are found in the Province of New Brunswick.

1887 k—Ingersoll, Ernest. The oyster industry. <The Fisheries and Fishery Industries of the United States. Washington, 1887. Sec. V, vol. II, pp. 505–565.

A modified reprint of "The Oyster Industry," U. S. Fish Commission, Washington, 1881, 4°, 252 pp. See 1881 *e*.

1887 l— Ninni, Alexander. Fish and oyster culture in the Province of Venice. <Bulletin U. S. Fish Commission, 1886. Washington, 1887, vol. VI, pp. 177–186.

Translated by Herman Jacobson from Progetti per estendere la pescicoltura ed introdurre la cocleocoltura nel fondo situato nei comuni censuari di Lugugnana e Caorle in Distretto di Portogruaro, Provincia di Venezia. Rome, 1885.

1887 m—Pike, R. G.; Hudson, W. M., and Bill, J. A. Seventh Report of the Shell Fish Commissioners of the State of Connecticut, for the year ending October 31, 1887. Middletown, Conn., 1887. 8°, 44 pp.

Devoted principally to the procedures of the Commissioners. From 1881 to 1886, inclusive, the State revenue from the oyster industry was $77,331.67, and the disbursements $67,773.51.

1887 n—Ryder, John A. A contribution to the life-history of the oyster (*Ostrea virginica* Gmelin and *O. edulis* Linn.). <The Fisheries and Fishery Industries of the United States. Washington, 1887. Sec. 1, vol. I, pp. 711–758, plate 259.

Discusses the following branches of the title subject: (1) The coarse anatomy of the oyster; (2) The minute anatomy of the oyster; (3) Sex, sexual products, and difference of sexual habits of the American and European oysters; (4) New methods of distinguishing the sexes and of taking the eggs of the oyster; (5) Rate of growth of *Ostrea virginica*; (6) The food of the oyster; (7) On the cause of the green color of the oyster; (8) Local variations in the form and habits of the oyster; (9) The oyster-crab as a messmate and purveyor; (10) Physical and vital agencies destructive to oysters, and (11) Natural and artificial oyster banks. See 1893 *p*.

1887 o—Ryder, John A. An exposition of the principles of a rational system of oyster culture, together with an account of a new and practical method of obtaining oyster spat on a scale of commercial importance. <Report U. S. Fish Commission, 1885. Washington, 1887, vol. XIII, pp. 381–424.

Outlines a method by which "it is possible to certainly secure an abundance of spat under conditions which can be controlled, and within such an area and at such a cost as will render it possible for persons possessing the proper knowledge to undertake spat-culture or the actual propagation of the oyster as a business."

1887 p—Stearns, Silas. Some of the fisheries of western Florida. <Bulletin U. S. Fish Commission, 1886. Washington, 1887, vol. VI, pp. 465–467.

Approximates the area of oyster beds on the west coast of Florida at 12,800 acres, and the product in 1884 at 75,000 bushels, for which the fishermen received $45,000.

1887 q—Worth, S. G. North Carolina encouragement to shell-fish culture. <Transactions of the American Fisheries Society, sixteenth annual meeting. New York, 1887, pp. 53–59.

Reviews the history of the enactment of the North Carolina oyster-planting law of 1887, and quotes that law in its entirety.

1887 r—Worth, S. G. North Carolina encouragement to shell-fish culture. <Forest and Stream, New York, August 11, 1887, vol. XXIX, pp. 50–51.

A reprint of 1887 *q*.

1887 s—Young, Archibald. The Salmon sea-trout, and oyster and mussel fisheries in the Orkney and Shetland Islands. <Fifth Annual Report of the Fishery Board for Scotland, being for the year 1886. Edinburgh, Her Majesty's Stationery Office, 1887. Appendix G, pp. 361–413.

The oyster resources of the Orkney Islands are described on pp. 376–382, and of the Shetland Islands on pp. 393–395. This paper contains an exhaustive review of the oyster fishery in the Orkney Islands since the beginning of the sixteenth century, the same being written by Mr. W. G. T. Watt.

1887 t—Anonymous. The oyster problem: difficulties in the way of North Carolina planters. <The Sun, Baltimore, April 21, 1887.

1887 u—Anonymous. The New York Oyster Commission. <Forest and Stream, New York, July 28, 1877, vol. XXIX, pp. 9–10.

A review of the "Second Report of the Oyster Investigation and Survey of Oyster Territory, for the years 1885 and 1886." Transmitted to the Legislature January 20, 1887. Albany, 1887. 4°, 47 pp., 1 map, 5 plates. See 1887 *e*.

1887 v—Anonymous. Oyster fishing: the industry in Rhode Island and how carried on. <The Providence Journal, Providence, November 6, 1887.

A comprehensive description of the methods of growing oysters in Rhode Island waters.

1887 w—Anonymous. New York oyster franchises. <Forest and Stream, New York, November 17, 1887, vol. XXIX, p. 329.

1887 x—Anonymous. French and Irish oysters. <The Fish Trades Gazette and Game and Poultry Trades Chronicle, London, February 5, 1887, vol. IV, No. 190.

1887 y—Anonymous. Delaware Law. An act in Relation to Oysters. Passed at Dover, March 28, 1887. Dover, Delawarean Print, 1887. 4°, 10 pp.

1887 z—Seed, William. Fish-culture in New Zealand. <Bulletin U. S. Fish Commission, 1886. Washington, 1887, vol. VI, pp. 213–216.

Refers to the regulations governing the oyster fishery of New Zealand and estimates the extent of the product.

1887 aa—Ryder, John A. On a tumor in the Oyster. <Proceedings of the Academy of Natural Sciences of Philadelphia. Philadelphia, 1877, pp. 25–27.

1888 a—Atwater, W. O. Oysters as food. <Report of the Oyster Investigation and Shell Fish Commission, for the year ending November 30, 1887. Appendix A, pp. 53–78. Albany, 1888.

A continuation of 1883 *c* and 1885 *a*.

1888 b—Atwater, W. O. Fattening of oysters. <Report of the Oyster Investigation and Shell Fish Commission for the year ending November 30, 1887. Appendix B, pp. 79–92. Albany, 1888.

Reprinted from Transactions of the American Fisheries Society, sixteenth annual meeting, New York, 1887, pp. 37–52.

1888 c—Bertram, James G. Oyster-growing in England, France, and America. <National Review, London, September, 1888, vol. XII, pp. 102–114.

1888 d—Blackford, Eugene G. Report of the Oyster Investigation and Shell Fish Commission, for the year ending November 30, 1887. Transmitted to the Legislature January 25, 1888. Albany, 1888. 8°, 106 pp.

This, the third and final report on oyster investigation authorized by the General Assembly of New York, discusses on pp. 1–52 the depletion of the public beds of that State and the necessity for private culture; also the pollution of the water contiguous to the oyster beds by refuse from oil refineries and similar establishments. The appendix contains the State shellfish enactments of 1887.

1888 e—De Salis, Harriet A. Oysters à la Mode; or, the Oyster and over 100 Ways of Cooking it, to which are added a few Receipts for Cooking all kinds of Shellfish. London and New York, Longmans, Green & Co., 1888. 12°, 68 pp.

Contains 112 recipes for cooking oysters.

1888 f—Duvar, J. H. (Secretary). Report of the Commissioners Appointed to Report on the Lobster and Oyster Fisheries of Canada. Ottawa, 1888, 65 pp.

1888 g—Fryer, Charles E. Report to the Board of Trade by Mr. C. E. Fryer, Inspector of Fisheries, on the Injury Alleged to be Caused to the Fisheries by the Deposit of Rubbish in the Estuary of the River Thames. London, 1888. 4°, 11 pp.

Cites the damage done to the oyster beds at the mouth of the Thames by the deposit of rubbish and recommends certain regulations for preventing it.

1888 h—Morgan, C. Lloyd. Oysters. <Murray's Magazine, London, January, 1888, vol. III, pp. 87–91.

"All that I propose to do here is to say a few words, suitable for those who do not like to be altogether ignorant of such matters, but have neither the time nor the inclination to be fully instructed, on the life-history of the oyster from its birth to its descent into the eager and expectant tomb." See 1888 *i*.

1888 i—Morgan, C. Lloyd. Oysters. <Littell's Living Age, Boston, January, 1888, vol. 176, pp. 164–168.

A reprint of 1888 *h*.

1888 j—Oemler, A. Needs of the Georgia oyster industry. <The News, Savannah, Ga., November 20, 1888.

1888 k—Pike, R. G.; Hudson, W. M., and Bill, J. A. Eighth Report of the Shellfish Commissioners of the State of Connecticut, for the year ending October 31, 1888. Middletown, 1888. 8°, 27 pp.

Contains an account of the procedures of the Commissioners and the general condition of the oyster industry of the State in 1888. The area of ground held by individuals for planting purposes on October 31, 1888, was 78,167.56 acres.

1888 l—Segrave, E. S. Report on the Oyster Fisheries of Maryland. Foreign Office, Misc. series, No. 8, Reports on subjects of general and commercial importance. United States. London, 1888. 8°, 7 pp.

A compilation of data previously published relative to the extent of the oyster industry of Maryland, with notes on the shipment of the so-called "locked-oysters."

1888 m—Winkley, Henry W. Molluscs found in the oyster beds of Cognac, N. B. Bedeque and Summerside, P. E. I. <Bulletin of the Natural History Society of New Brunswick. No. VII, pp. 69–71. Saint John, N. B., Barnes & Co., 1888.

1888 n—Anonymous. Oyster-culture at Arcachon. <Blackwood's Magazine, London, March, 1888, vol. 143, pp. 366–371.

1888 o—Anonymous. Our oyster navy. <The Sun, Baltimore, November 20, 1888

A description of the Maryland oyster police force and its efficiency.

1888 p—Anonymous. The oyster war. <The Telegraph, Philadelphia, December 12, 1888.

An account of the troubles in the Chesapeake Bay in 1888.

1888 q—Anonymous. Oyster Laws Enacted by the General Assembly of Maryland at the January sessions, 1884, 1886, and 1888. Annapolis, 1888. 8°, 30 pp.

1888 r—Anonymous. Article LXXII. Oysters. Annapolis, 1888. 8°, 36 pp.

A compilation of all the general oyster laws of Maryland operative in 1888.

1889 a—Cowen, John K. The Maryland oyster in State politics. <The Sun, Baltimore, February 4, 1889.

A comprehensive discussion of the political reasons for the lack of encouragement to oyster-culturists in the State of Maryland.

1889 b—Delmonico, Charles. The Blue Point fraud. <The Evening Star, Washington, October 26, 1889.

A gastronomical discussion.

1889 c—Doyle, Edward P. (Secretary). Seventeenth Report of the Commissioners of Fisheries of the State of New York. Transmitted to the Legislature January 10, 1889. Albany, 1889. 8°, 244 pp.

On pp. 107-162 is published the report of the shellfish commissioners of New York State for the year ending November 30, 1888.

1889 d—Folsom, Montgomery M. Gathering oysters: a night on the waves with the fishermen of Brunswick. <The Atlanta Constitution, Atlanta, Ga., March 10, 1889.

1889 e—Ganong, W. F. The economic mollusca of Acadia. <Bulletin of the Natural History Society of New Brunswick. Saint John, N. B., 1889. No. VIII, pp. 3-100.

This paper reviews, on pp. 46-63, the history of the oyster fishery in Canada from earliest times and contains a table showing the value of the oyster product in the three oyster-producing provinces, viz—New Brunswick, Nova Scotia, and Prince Edward Island. See 1889 *f*.

1889 f—Ganong, W. F. The economic mollusca of Acadia. Reprinted from Bulletin No. VIII of the Natural History Society of New Brunswick. St. John, N. B. Barnes & Co., printers. 1889. 8°, 166 pp.

A reprint of 1889 *e*.

1889 g—Nelson, Julius. Oyster interests of New Jersey: New Jersey Agricultural Experiment Station. Special Bulletin. Trenton, 1889. 8°, 40 pp.

A report on the extent, condition, and product of the natural oyster beds of New Jersey, the extent and condition of the oyster planting industry, and the means of extending the cultivation of oysters in the State. Reports the area of natural beds to be 79,000 acres, with an annual product of 2,000,000 bushels of oysters, the greater portion of which are planted in the State; the area of the planted grounds to be 14,990 acres, the annual product of which amounts to 2,052,000 bushels, valued at one dollar per bushel.

1889 h—Oemler, A. The Life History, Propagation, and Protection of the American Oyster. An Essay read before the Georgia Historical Society, March 4 and April 1, 1889, in the Interests of a Bill which is to be Introduced in the Georgia Legislature for the Protection and Development of the Oyster Industry of Georgia. <Savannah, The Morning News Print, 1889. 8°, 28 pp.

1889 i—Ravenel, W. de C. Report of operations at St. Jerome oyster-breeding station for the year 1886. <Report U. S. Fish Commission, 1886. Washington, 1889, vol. XIV, pp. 765-777.

1889 j—Rowe, H. C. Blundering oyster laws. <The Post, New York, February 25, 1889.

A criticism of certain features of the Connecticut oyster-cultivating regulations.

1889 k—Smith, Charles Sydney. Connecticut oyster legislation. <Providence Journal, Providence, February 7, 1889.

This is the report of a joint special committee appointed by the legislature of the State of Rhode Island to inquire into the system of oyster legislation adopted by the State of Connecticut, and the practical workings thereof.

1889 l—Smith, Charles Sydney. Connecticut oyster legislation. <Register, New Haven, February 11, 1889.

A reprint of 1889 *k*.

1889 m—White, Charles T. Enemies of the oyster. <The World, New York, September 1, 1889.

1889 n—Winslow, Francis. Report on the Sounds and Estuaries of North Carolina, with reference to oyster-culture. <Bulletin U. S. Coast and Geodetic Survey, No. 10, 4°, 136 pp., 3 maps.

See 1886 *o*.

1889 o—Young, Archibald. Short report on the oyster and mussel fisheries in parts of Argyleshire, Iverness-shire, Sutherlandshire, and Ross-shire in 1888. <Seventh Annual Report of the Fishery Board for Scotland, being for the year 1888. Edinburgh, 1889.

1889 p—Anonymous. Washington's oyster trade. <The Evening Star, Washington, January 26, 1889.

1889 q—Anonymous. New Orleans oysters. <State, New Orleans, February 14, 1889.

1889 r—Anonymous. The Shellfish Commission. <The Hartford Courant, Hartford, Conn., February 15, 1889.

Reviews the finances of the Connecticut Shellfish Commission.

1889 s—Anonymous. Scarcity of oysters. <Forest and Stream, New York, October 24, 1889, p. 270.

1889 t—Anonymous. The Potomac dispute: Hog Island Flats. <The Sun, Baltimore, November 30, 1889.

1889 u—Anonymous. War on Raritan Bay: A row over oysters and clams. <The News, Newark, New Jersey.

A discussion of the New York-New Jersey boundary line in Raritan Bay so far as it affects the oyster industry.

1889 v—Jackson, R. T. The development of the oyster, with remarks on allied genera. <Proceedings of the Boston Society of Natural History, Boston, 1889, vol. XXIII, pp. 531–556, 4 pls.

1890 a—Bourne, Gilbert C. The generative organs of the oyster. <Journal of the Marine Biological Association of the United Kingdom. Plymouth. Published by the Association, 1889–90. Vol. I, pp. 268–281, pls. XXII and XXIII.

Abstract translation of De Voortplantingsorganen van de Oester. Bijdrage tot de Kennis van hun Bouw en Flunctie. Door Dr. P. P. C. Hoek. Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Deel 1. Leiden, E. J. Brill, 1883–84, pp. 113–254.

This paper gives the result of the observations of Dr. Hoek and reviews the conclusions of other naturalists. See 1883 *m*. It also contains an abstract translation of Vergelijkend Onderzoek van Gekweekte en in het wild Opgegroeide Oesters, * * * Door Dr. P. P. C. Hoek. Tijdschrift der Nederlandsche Dierkundige Vereeniging. Supplement Deel 1. Leiden, E. J. Brill, 1883–84, pp. 481–495. See 1885 *i*.

1890 b—Boyd, Thomas J. (Chairman). Oysters. <Eighth Annual Report of the Fishery Board for Scotland, being for the year 1889. Edinburgh, 1890, pp. 27–33.

A review of the condition of the oyster industry during the preceding seven years, with notes on the progress of oyster-culture in other countries.

1890 c—E———, T. P. An oysterman's views. <The Daily American, Baltimore, December 23, 1890.

Urges a better enforcement of the cull law in Maryland.

1890 d—Fowler, G. Herbert. Notes on oyster-culture. <Journal of the Marine Biological Association of the United Kingdom. Plymouth. Published by the Association, 1889–90. Vol. I, pp. 257–267, pl. XXI.

A detailed description of the practical operations in oyster-culture on the Eastern Schelde, in the Dutch province of Zeeland, with notes on recent legislation relative to English oyster fisheries.

1890 e—Fullarton, J. H. Oyster culture in France and Holland. <Eighth Annual Report of the Fishery Board for Scotland, being for the year 1889. Part III. Scientific Investigations. Edinburgh, 1890, pp. 220–229.

This report is based on observations made by the author during a visit to the chief oyster centers from the East Scheldt in Netherlands to Arcachon in the southwest of France.

1890 f—Hackett, Edward. Oysters in Prince Edward Island. <Annual Report of the Department of Fisheries, Dominion of Canada, for the calendar year 1889. Ottawa, 1890, pp. 152–153.

A report on the oyster industry of Prince Edward Island during the year 1889.

1890 g—Hotchkiss, Samuel M. Fifth Annual Report of the Bureau of Labor Statistics of the State of Connecticut, for the Year ending November 30, 1889. Hartford, Conn., The Case, Lockwood & Brainard Co., 1890. 8°, 215 pp., 5 plates, 2 maps.

On pp. 91–153 is given a statistical résumé of the extent of the oyster industry of Connecticut for the year ending May 1, 1889. The maps, which are worthy of special notice, indicate for the year 1889 the location of all the public and private oyster areas of the State.

1890 h—Lorne, Marquis of. Oyster-culture. <Good Words, London, March, 1890, vol. XXXI, pp. 161–171.

A discussion of present methods practiced in France, with comparisons of the abundance of oysters in France and Great Britain. Illustrated by H. R. H. Princess Louise.

1890 i—Montagu, Lord. Letter on oyster-culture. <Journal of the Marine Biological Association of the United Kingdom. Plymouth. Published by the Association. 1889–90. Vol. I, pp. 282–285.

An account of experiments made in oyster breeding in the Beaulieu River by Lord Montagu of Beaulieu.

1890 j—Nelson, Julius. Report of the Biologist. <Tenth Annual Report of the New Jersey State Agriculture Experiment Station and the Second Annual Report of the New Jersey Agricultural College Experiment Station for the year 1889. Camden, N. J. F. F. Patterson, State Printer. 1890, 8°, pp. 197–220.

Contains an historical résumé of ostreicultural experiments and methods, with notes on certain experiments conducted by the author during the summer of 1889.

1890 k—Thomas, R. S. Oysters and revenue. <The Richmond Dispatch, Richmond, January 12, 1890.

Discusses methods of increasing the oyster revenue in Virginia.

1890 l—Hyatt, Alpheus. The Oyster, Clam, and other Common Mollusks. Boston, D. C. Heath & Co., 1890. 16°, 65 pp., 16 plates.

A guide to the popular anatomical study of these mollusks.

1890 m.—Kent, W. Saville. Oysters and the Oyster Fisheries of Queensland. [Blue Book Rept.] Brisbane, 1890, fol., 17 pp., 9 pls.

1890 n—Anonymous. Blue Point oysters. <The New York Herald, New York, September 28, 1890.

1890 o—Anonymous. The fate of our oyster industry. <The Daily American, Baltimore, November 29, 1890.

Refers to the fishery in Maryland.

1891 a—Agnus, Felix. Is it reform or ruin? <The Daily American, Baltimore, January 9, 1891.

Observations made during a cruise over Maryland's oyster territory, with notes on the necessity for a change in the oyster regulations of the State.

1891 b—Brooks, W. K. Oyster-farming needed. <The Daily American, Baltimore, January 13, 1891.

Discusses the inefficiency of cull laws and the need of regulations for oyster cultivation in Maryland.

1891 c—Brooks, W. K.; Cowen, J. K.; McDonald, Marshall, and Hodson, T. S. Oyster beds. <The Daily American, Baltimore, March 19, 1891.

Abstract of addresses delivered at a meeting held in Baltimore on March 18, 1891, to promote the adoption of an oyster-cultural system in Maryland.

1891 d—Brooks, W. K. The Oyster. Baltimore, Johns Hopkins Press, 1891. 12mo, 230 pp., 14 plates.

A popular summary of all the writings of this erudite biologist on the oyster and the oyster industries.

1891 e—Drake, J. C. Sounds and estuaries of Georgia, with reference to oyster culture. <Bulletin U. S. Coast and Geodetic Survey, No. 19. Washington, 1891, pp. 179-209, 7 maps.

Describes the specific gravity, currents, and characteristics of the bottom of each tide-water area in the State. The area of natural oyster reefs of the State was determined to be 1,756.8 acres. The maps indicate the location of the reefs on a scale of $\frac{1}{30000}$.

1891 f—Du Bois, C. A. The necessity for restricting dredging a few years. <The Daily American, Baltimore, February 2, 1891.

1891 g—Felton, Franklin. What oyster farming would do for Maryland. <The Daily American, Baltimore, April 11, 1891.

1891 h—Gilbert, Charles H. Report upon certain investigations relating to the planting of oysters in Southern California. <Bulletin U. S. Fish Commission, 1889. Washington, 1891, vol. 9, pp. 95-98.

Discusses the advantages and disadvantages in the planting of oysters possessed by Alamitos and Newport bays and the Gulf of California.

1891 i—Hodson, Thomas S. Oyster laws. <The Daily American, Baltimore, February 2, 1891.

Compares the oyster regulations of Maryland with those of Connecticut.

1891 j—Hopkins, Jenny L. An oyster village. <Cosmopolitan, New York, October, 1891, vol. II, pp. 717 *et seq.*

A description of Inwood, N. Y., and the oyster industry thereof.

1891 k—Hudson, W. M.; Waldo, George C., and Treat, B. A. <Annual Report of the Shellfish Commissioners, State of Connecticut, 1891. Hartford, Conn., 1891. 8°, 24 pp.

1891 l—Jones, A. C. A new oyster law. <The Daily American, Baltimore, April 20, 1891.

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1891 m—Knowles, Horace G. Artificial oyster culture in France <U. S. Consular Reports, October, 1891, Washington, 1891, No. 133, pp. 244-246.

General references to the methods practiced at Arcachon.

1891 n—McDonald, Marshall. State oyster policy. <Forest and Stream, New York, April 16, 1891, vol. XXXVI, p. 253.

Abstract of address delivered at Baltimore, March 18, 1891.

1891 o—McKinney, Philip W. The oyster question. <Virginian, Norfolk, December 10, 1891.

Reprint of a special message of the governor of Virginia on the oyster industry of that State.

1891 p—Martin, H. Newell. The oyster question. <Science, New York, March 27, 1891, vol. XVII, pp. 169-170.

Discusses the progress of scientific investigations towards the preservation of the Maryland oyster.

1891 q—Page, Henry, and others. Oyster beds. <The Sun, Baltimore, April 30, 1891.

Abstract of addresses delivered in Baltimore, April 29, 1891, in opposition to the leasing of natural oyster beds in Maryland.

1891 r—Philpots, John R. Oysters, and All About Them. Being a Complete History of the Titular Subject, Exhaustive on all Points of Necessary and Curious Information from the Earliest Writers to those of the Present Time, with Numerous Additions, Facts, and Notes. London, John Richardson & Co., 1891. 8°, 2 vols, 1370 pp.

A voluminous publication filled with repetitions, abstracts, and the undigested results of the inquiries of naturalists and government officials. The first volume, which contained 642 pages, was issued in 1890.

1891 s—Smith, Hugh M. Notes on an improved form of oyster tongs. <Bulletin U. S. Fish Commission, 1889. Washington, 1891, vol. 9, pp. 161–164.

Describes and recommends the employment of the implement commonly known as the "deep-water tong."

1891 t—Thompson, W. H. Some reasons why the State of Maryland should improve the oyster beds. <The Daily American, Baltimore, January 21, 1891.

1891 u—Weeks, Thomas C. Speech delivered at the Concordia Opera House [Baltimore], on Thursday, April 30, 1891, under the auspices of the Canton Oyster Exchange of Baltimore City. 1891. 8°, 16 pp.

Cites reasons why Maryland should not lease or sell to individuals or corporations any portion of the oyster-grounds of the Chesapeake Bay.

1891 v—Wilson, E. L. Biography of the oyster. <Scribner's Monthly, New York, October, 1891, vol. x, pp. 469 *et seq.*

1891 w—Anonymous. Facts about the oyster. <The Daily American, Baltimore, January 26, 1891.

A review of the industry in Maryland and Virginia, with brief references to other States.

1891 x—Anonymous. Oysters. <Saturday Review, London, October 3, 1891, vol. 72, p. 384.

Brief popular reference to the beginning of the oyster season and the reproduction of oysters.

1891 y—Tilton, John. Oysters in the British Provinces. Annual Report of the Department of Fisheries, Dominion of Canada, for the year 1890. Printed by order of Parliament. Ottawa, 1891, pp. LI–LXII.

A history of the regulations of the fishery in Canada.

1891 z—Fullarton, J. H. On the suitability of Scottish waters for oyster culture. <Ninth Annual Report of the Fishery Board for Scotland, being for the year 1890. Part III. Scientific Investigations. Edinburgh, 1891, pp. 184–200.

Paper based on a physical and biological examination made during the summer of 1890. "In Scotland it can hardly be said that the oyster industry exists. If it does exist at all, it is only in the earliest initiatory stage. It seems as if it were merely a groping after oyster culture, and that, too, on a minimum scale." The product of the oyster beds of Scotland in 1888 was valued at £742.

1891 aa—Fullarton, J. H. Oyster fishery of Scotland. <Transactions of the Philosophical Society of Glasgow, session 1890–91. Glasgow, 1891.

A contribution to the economic phases of the industry in Scotland. Compares the present status of the fishery with the condition a century ago.

1891 ab—Nelson, Julius. Report of the biologist. <Eleventh Annual Report of the New Jersey State Agricultural Experiment Station and the Third Annual Report of the New Jersey Agricultural College Experiment Station for the year 1890. Trenton, N. J., 1891, pp. 251–320.

A report of experiments conducted by the author during the summer of 1890, looking toward a practical method of artificially fertilizing and growing oysters.

1891 ac—Collins, J. W. Notes on the oyster fishery of Connecticut. <Bulletin U. S. Fish Commission, 1889. Washington, 1891, vol. IX, pp. 461–497, plates CLIX–CLXVI.

1891 ad—Cox, James C. New South Wales. Fisheries of the Colony. Report of the Commissioners of Fisheries for the year ending 31st December, 1890. [Sydney, 1891.] 4°, 44 pp.

Reports the condition of the oyster industry of New South Wales in 1890, and contains a copy of the act of 1891 that consolidated and amended the oyster laws of the colony.

1892 a—Atwater, W. O. The chemical composition and nutritive values of food fishes and aquatic invertebrates. <Report U. S. Fish Commission, 1888. Washington, 1892, vol. XVI, pp. 679–868.

On pp. 856–866 is given a discussion of the value of oysters as food, the statements and deductions being based on examinations of many specimens from various localities.

1892 b—Battle, John D. An investigation of the coast waters of South Carolina with reference to oyster-culture. <Bulletin U. S. Fish Commission, 1890. Washington, 1892, vol. X, pp. 303–330, 7 maps.

A report of the operations of the U. S. Fish Commission steamer *Fish Hawk* in the winter of 1890–91 in surveying and determining the position and extent of oyster beds and of bottom areas not then producing oysters, but suitable for their cultivation.

1892 c—Bauset, S. P. Oysters. <Annual Report of the Department of Fisheries of the Dominion of Canada, 1891. Printed by order of Parliament. Ottawa Printed by S. E. Dawson, 1892. pp. 34–39.

A report on the condition of the oyster industry of Canada during the preceding seasons, with notes on the regulations for the licensing of oyster-grounds.

1892 d—Bedloe, Edward. Some Chinese fishes. <Forest and Stream, New York, February 4, 1892, vol. XXXVIII, p. 104.

Describes the "bamboo oysters" of Foochow, Amoy and Taiwaufoo in Formosa, and the methods of cultivating them.

1892 e—Collins, J. W. Statistical review of the coast fisheries of the United States. <Report of U. S. Fish Commission, 1888. Washington, 1892, vol. XVI, pp. 271–378.

Reports the extent of the oyster product of the United States in 1888.

1892 f—Collins, J. W. Report on the Fisheries of the Pacific coast of the United States. <Report U. S. Fish Commission, 1888. Washington, 1892, vol. XVI, pp. 3–269.

Contains brief notices of the oyster industry of Shoalwater Bay and Puget Sound, Washington, and of San Francisco Bay, California.

1892 g—Dean, Bashford. The physical and biological characteristics of the natural oyster-grounds of South Carolina. <Bulletin U. S. Fish Commission, 1890. Washington, 1892, vol. X, pp. 335–362, pl. LXI–LXVII.

This report aims to point out the natural advantages offered by the State for successful oyster-culture, and discusses the characteristics of the "raccoon reefs," reasons for absence of oyster spat in deep water, food of the South Carolina oyster, analyses of the waters over the oyster beds, etc.

1892 h—Dean, Bashford. Report on the present methods of oyster-culture in France. <Bulletin U. S. Fish Commission, 1890. Washington, 1892, vol. X, pp. 362–388, plates LXIX–LXXVIII.

From the personal observations of a biologist familiar with the oyster industry in several of the United States.

1892 i—Hicks-Beach, Michael (President). Second Annual Meeting of Representatives of Authorities under the Sea Fisheries Regulation Act, 1888. Tuesday, 21st June, 1892. London. Printed for Her Majesty's Stationery Office, 1892. 4°, 35 pp.

The close season in England for foreign oysters is discussed on pp. 25–27.

1892 j—Kellogg, James L. A contribution to our knowledge of the morphology of lamellibranchiate mollusks. <Bulletin U. S. Fish Commission, 1890. Washington, 1892, vol. X, pp. 389–436, plates LXXIX–XCIV.

1892 k—Nelson, Julius. Report of the biologist. <Twelfth Annual Report of the New Jersey State Agricultural Experiment Station and the Fourth Annual Report of the New Jersey Agricultural College Experiment Station for the year 1891. Trenton, N. J., The John L. Murphy Publishing Co., 1892, pp. 177–232.

A record of experiments conducted in the summer in Virginia, New York, and New Jersey with a view to discovering a practicable and economical method of artificially fertilizing and growing oysters.

1892 l—McMenamin, James. A Review of Governor McKinney's Message on the Oyster Question. Hampton, Va., Monitor Advance Print, 1892, 8°, 11 pp.

1892 m—Rathbun, Richard. Oyster culture on the Atlantic coast. <Report U. S. Fish Commission, 1888. Washington, 1892, vol. XVI, pp. LIX–LXV.

Reviews the scientific work of the U. S. Fish Commission during the fiscal year 1887–88 in the investigation of the oyster beds of the Atlantic coast of the United States.

1892 n—Seth, Joseph B. Annual Report of the Commander of Maryland State Fishery Force to the Board of Public Works, for the Year ended 1891. Annapolis, 1892, 8°, 13 pp., 4 plates.

Reviews briefly the condition of the Maryland oyster fishery in 1891.

1892 o—Thompson, W. H. Free fishery rights in oystering. <The Daily American, Baltimore, March 19, 1892.

1892 p—Weeks, Thomas C. The Oyster Industry of Maryland. <Fourth Biennial Report of the Bureau of Industrial Statistics and Information of Maryland, 1890–91. Annapolis, 1892. 8°, pp. 11–194.

Discusses the general condition of the fishery during the preceding four seasons, and contains a summary or epitome of all the oyster laws of the State operative in 1891.

1892 q—Young, Archibald. Report by Archibald Young, advocate, Inspector of Salmon Fisheries for Scotland, and evidence in application by Mrs. Ogilvie of Barcaldine for an order for a several oyster and mussel fishery in Loch Crevan. <Tenth Annual Report of the Fishery Board for Scotland, being for the year 1891. Edinburgh, 1892, pp. 51–55.

1892 r—Anonymous. Oyster farming. <The Daily American, Baltimore, February 23, 1892.

A description of the present methods of oyster-culture practiced at Arcachon, France.

1892 s—Anonymous. The oyster: How the delicious bivalve is raised and eaten all the world over. <The Evening Star, Washington, September 3, 1892.

1892 t—Anonymous. Compilation of the Oyster Laws of Virginia, 1892. Richmond, J. H. O'Bannon, Superintendent Public Printing, 1892. 8°, 26 pp.

1892 u—Anonymous. Maryland State Fishery Force. Article LXXII. Oysters, 1892. [Annapolis, 1892.] 8°, 37 pp.

A compilation of the general oyster laws operative in Maryland in 1892.

1892 v—Schiedt, R. C., and Ryder, J. A. Diffuse pigmentation of the epidermis [not periostracum] of the oyster, due to prolonged exposure to the light, etc. <Proceedings of the Academy of Natural Sciences of Philadelphia, Philadelphia, November 15, 1892, pp. 350–352.

1893 a—Brooks, W. K., and Knower, H. McE. The Oyster Industry. <Maryland, its Resources, Industries, and Institutions. Prepared for the Board of World's Fair Managers, of Maryland, by members of Johns Hopkins University and others. Baltimore, 1893, pp. 264–312.

A compilation of previously-published data relative to the natural history of oysters and the oyster industry of Maryland.

1893 b—Cox, James C. The Australian oyster, its cultivation and destruction. <History of the Fisheries of New South Wales; with a Sketch of the Laws by which they have been Regulated. Compiled from Official and other Authentic Sources. Sydney, 1893. Appendix, pp. 120–126.

1893 c—Cox, James C. The oyster fisheries laws. Address delivered before the Linnæan Society, by the President, 1883. <History of the Fisheries of New South Wales; with a Sketch of the Laws by which they have been Regulated. Compiled from official and other authentic sources. Sydney, 1893. Appendix, pp. 115–120.

A thorough review of the oyster regulations of New South Wales from the earliest times up to the year 1883, with suggestions as to methods of improving those regulations.

1893 d—Cox, James C. New South Wales. Fisheries of the Colony. Report of the Commissioners of Fisheries for the Year ending 31st December, 1892. [Sydney, 1893.] 4°, 26 pp.

Reports the condition of the oyster industry of New South Wales in 1892.

1893 e—Dean, Bashford. Report on the European methods of oyster-culture. <Bulletin U. S. Fish Commission, 1891. Washington, 1893, vol. x, pp. 357–406, plates 75–88.

Describes the present methods of oyster-culture in Italy, Spain, Portugal, Germany, Holland, Belgium, and England.

1893 f—Dean, Bashford. The present methods of oyster-culture in France. <The Fishing Gazette, New York, February 23–June 29, 1893, vol. x, Nos. 8–15.

A reprint of 1892 *e*.

1893 g—Haman, B. Howard. Oysters and Roads. Address Delivered before the Maryland Convention for Good Roads, held at Baltimore on January 12, 1893. Baltimore, 1893, 8°, 24 pp., with chart.

Urges the leasing of the barren bottoms of the Chesapeake Bay, the revenue therefrom to be applied to the improvement of the public roads in Maryland.

1893 h—Howard, A. B., Jr. First Annual Report of the Bureau of Industrial Statistics of Maryland, 1893. Baltimore, 1893, 8°, 225 pp.

The oyster industry of Maryland is discussed on pp. 113–142, detailed statistics of the industry during the seasons 1889–90 and 1890–91 being presented.

1893 i—Hudson, W. M.; Waldo, G. C., and Beardsley, C. W. Annual Report of the Shell-fish Commissioners, State of Connecticut, 1893. Hartford, Conn., 1893, 8°, 36 pp.

Reviews the work of the commissioners and discusses the condition of the oyster industry of Connecticut during the preceding year, and contains a list of the owners of oyster-ground in the State waters, with a statement of the acreage owned by each.

1893 j—Jennings, C. E. The oyster, that succulent bivalve. <The Fishing Gazette, New York, January 5, 1893, vol. x, No. 1, p. 3.

A review of the oyster industry tributary to New York City.

1893 k—Kemp, Ernest. Report on the Oyster Fisheries of Canada. Ottawa, 1893, 8°, 13 pp.

Observations made by a practical oyster-grower of England after examining the oyster beds in New Brunswick, Nova Scotia, and Prince Edward Island.

1893 l—McMillan, William (President). World's Columbian Exposition, Chicago, 1893. Catalogue of the Exhibits in the New South Wales Courts. Sydney: Charles Potter, 1893. 8°, 782 pp.

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1893 m—Mather, Fred. The propagation and natural history of the American oyster (*Ostrea virginiana*). <The Fishing Gazette, New York, January 19–February 16, 1893, vol. x, Nos. 3–7.

An account of investigations carried on at Cold Spring Harbor, N. Y., during the summer of 1892.

1893 n—Mundella, A. J. (President). Third Annual Meeting of the Representatives of Authorities under the Sea Fisheries Regulation Act, 1888. Tuesday, 6th June, 1893. London. Printed for Her Majesty's Stationery Office, 1893. 4°, 38 pp.

On pp. 11–17 is discussed the regulations for acquiring land for oyster-culture in certain parts of Great Britain.

1893 o—N———, W. History of the oyster industry in New York. <The Fishing Gazette, New York, January 5, 1893, vol. x, No. 1.

A history of the location of the various oyster markets in New York City.

1893 p—Ryder, John A. A Contribution to the Life-History of the Oyster (*Ostrea virginica* Gmelin and *O. edulis* Linn.). <Natural History of Economic Mollusks of the United States, by Ernest Ingersoll and John A. Ryder. Washington, 1893, pp. 687–758.

On pp. 711–758 is given a reprint of 1887 *n*, the edition being struck from the same plates as the latter.

1893 q—Smith, Marion deK. Record of Licenses Issued to Take Oysters in the State of Maryland and the Several Counties thereof during the Season of 1892–93, and Licenses to Take Oysters with Scrape and Dredge, Issued by the Comptroller of the Treasury. Baltimore, 1893, 8°, 135 pp.

This pamphlet, being issued before the close of the season 1892–93, does not contain a complete list of the licenses issued during that season.

1893 r—Smith, William. Oyster culture. <Twenty-fifth Report of the Department of Marine and Fisheries for the fiscal year ended June 30, 1892. Ottawa. Parliamentary paper, 1893. Royal 8°, pp. XV–XIX.

An account of the condition of the oyster industry in Canada in 1892.

1893 s—Stevenson, Charles H. Report on the Coast Fisheries of Texas. <Report U. S. Fish Commission, 1891. Washington, 1893, vol. XVIII, pp. 373–420, plates 12–27.

Contains a history of the oyster industry of Texas, and a description of the oyster-grounds, with an account of the regulations affecting them.

1893 t—Thompson, Lindsay G. History of the Fisheries of New South Wales; with a Sketch of the Laws by which they have been regulated: Compiled from Official and other Authentic Sources. Published by Authority of the New South Wales Commissioners for the World's Columbian Exposition, Chicago, 1893. Sydney: Charles Potter, Government Printer, 1893. Royal 8°, 101 pp.

On pp. 52–72 the oyster fisheries of New South Wales and the laws regulating them are discussed with great thoroughness. The various oyster-producing localities, the area and condition of the reefs, and the extent of the product are noted with much detail.

1893 u—Tonning, H. Ostréiculture. A Report Concerning the Actual Condition of this Industry. Copenhagen. Andr.-Fred. Höst and Fils, 1893, 8°, without numbered pages.

This paper is intended as a practical guide to carrying on the culture of oysters on the coasts of Norway.

1893 v—Townsend, Charles H. Report of Observations Respecting the Oyster Resources and Oyster Fishery of the Pacific Coast of the United States. <Report U. S. Fish Commission, 1891. Washington, 1893, vol. XVIII, pp. 343–372, plates 2–11.

Is accompanied by charts showing the locations of the public and private areas of oyster-grounds.

1893 w—Whiteledge, Thomas. Extracts from report on the worm disease affecting the oysters on the coast of New South Wales. <History of the Fisheries of New South Wales; with a Sketch of the Laws by which they have been Regulated: Compiled from Official and other Authentic Sources. Sydney, 1893. pp. 109–115.

These worms appear to be *Polydora ciliata*. The following branches of the subject are discussed: (1) The infected area; (2) Symptoms of the disease; (3) How the worms effect an entrance into the oysters; (4) Evidence as to boring, from an examination of the shell; and (5) the remedy. The original report was printed in Records of the Australian Museum, Sydney, 1890, vol. I, pp. 41–55, pls. III–VI.

1893 x—Anonymous. Schedule of applications for licenses of areas for oyster culture between the years 1882 and 1892, with action taken thereon. <Twenty-fifth Annual Report of the Department of Marine and Fisheries for the fiscal year ended June 30, 1892. Ottawa, Parliamentary paper, 1893, appendix No 6, pp. 197–200.

1894 a—Brown, Frank. Oysters. <Message of the Governor of Maryland to the General Assembly at its regular session, January, 1894. Baltimore, 1894, pp. 16–20.

Discusses the condition of the State oyster fund.

1894 b—Fox, Howard. Falmouth oyster fishery. <U. S. Consular Reports, February, 1894. Washington, 1894, vol. XLIV, pp. 341–342.

A brief note on the condition of the industry since 1859.

1894 c—Howard, T. C. B. Report of the Commander of Maryland State Fishery Force, to the Board of Public Works. Annapolis, Md., 1894, 8°, 12 pp.

A report on certain features of the oyster industry of Maryland, the principal subjects discussed being the oyster fund, condition of the navy, the cull law, the oyster season, and magistrates and fines.

1894 d—Oemler, A. The World's Fisheries Congress, Chicago, 1893. The past, present, and future of the oyster industry in Georgia. <Bulletin U. S. Fish Commission, 1893. Washington, 1894, vol. XIII, pp. 263–272.

1894 e—Stevenson, Charles H. The Oyster Industry of Maryland. <Bulletin U. S. Fish Commission, 1892. Washington, 1894, vol. XII, pp. 203–298, plates LVI–LXXI.

A comprehensive economic discussion which reviews the regulations of the fishery from the earliest period, and discusses the past and present condition of the industry under the following captions: (1) The oyster-grounds; (2) Tonging; (3) Dredging; (4) Scraping; (5) Oyster culture in Maryland; (6) Transporting; (7) The oyster markets; (8) Statistical summary; (9) State revenue and fishery force; (10) Conclusion. The paper is accompanied by a map indicating the general location of the oyster reefs of the State of Maryland and showing the areas on which the various forms of oyster fishery are authorized. See 1894 *f*.

1894 f—Stevenson, Charles H. The Oyster Industry of Maryland. <Second Annual Report of the Bureau of Industrial Statistics of Maryland, 1894. Annapolis, King Bros., 1894, pp. 215–388.

A reprint of 1894 *e*.

1894 g—Anonymous. Proceedings of the Convention Called to Consider and Discuss the Oyster Question, held at the Richmond Chamber of Commerce, Richmond, Va., Jan. 12, 1894, with Papers Issued in Calling the Convention. Richmond. J. W. Ferguson & Son, 1894, 8°, 47 pp.

Relates to the methods of improving the condition of the oyster industry of Virginia. Contains addresses delivered by J. B. Baylor, H. C. Rowe, Francis Winslow, Marshall McDonald, W. K. Brooks, O. A. Brown, and others.

GENERAL CLASSIFICATION BY SUBJECTS.

For the purpose of facilitating reference to special branches of oyster literature the accompanying classification by subjects is here appended. Those numbers in heavy-faced type indicate the principal papers on the subjects under which they are listed.

I. NATURAL HISTORY.

1. Distribution of oysters, 1841*b*, 1843*b*, **1849**, **1853**, 1857*a*, 1857*d*, 1861*b*, 1864*d*, 1865*d*, 1869*b*, 1869*f*, 1873*c*, 1877*k*, 1878*g*, 1883*h*, 1883*u*.
2. Anatomy, general, 1814, 1836, 1841*a*, 1846, **1854a**, 1858*b*, 1864*d*, 1865*a*, 1865*g*, 1877*b*, 1878*d*, **1880b**, 1880*s*, 1881*h*, 1881*e*, 1882*h*, 1882*m*, **1883n**, 1883*ac*, **1884u**, **1887n**, 1888*b*, **1890a**, 1890*l*, **1891d**, 1891*r*, 1892*j*.
   - *a*. Bronchiæ 1852*a*. See also Anatomy, general.
   - *b*. Organ of Bojanus, 1883*ae*. See also Anatomy, general.
   - *c*. Sexual characteristics, 1883*ad*, 1887*n*.
   - *d*. Visual senses, 1837*a*.
   - *e*. Shell formation, 1855*a*, 1855*b*, 1855*c*, 1878*f*, **1883v**.
   - *f*. Blood corpuscles, 1879*g*.
3. Habits and mode of life, general, 1669, 1722, 1744, 1837*b*, 1852*b*, 1852*c*, 1856*a*, 1858*b*, 1860*a*, 1863*f*, 1864*d*, **1865a**, 1865*b*, 1865*g*, 1867*g*, 1867*o*, 1868*a*, 1868*h*, 1872*a*, 1874*b*, 1877*e*, 1877*h*, 1878*d*, 1879*i*, 1880*g*, **1881e**, 1881*h*, 1883*j*, 1883*l*, 1883*q*, 1883*r*, 1883*s*, 1883*u*, 1883*x*, 1883*aj*, 1884*m*, **1884u**, 1885*q*, 1885*w*, 1885*ag*, **1887n**, 1888*h*, 1889*h*, **1891d**, 1891*r*, 1891*v*.
   - *a*. Enemies and associates, 1665, 1693, 1865*c*, 1867*c*, 1873*c*, 1874*d*, 1880*g*, 1883*al*, 1884*m*, 1885*h*, **1887n**, **1888m**, 1889*m*, 1891*z*.
   - *b*. Resting position of oysters, 1669, 1885*g*, 1885*k*, 1885*n*, 1885*s*, **1885u**, 1885*v*.
   - *c*. Food and green color, 1669, 1863*e*, 1866*a*, **1866e**, 1870*g*, 1874*c*, 1877*d*, 1880*g*, 1880*n*, 1881*e*, **1882e**, 1882*f*, 1882*g*, 1883*af*, **1884o**, 1884*u*, 1887*h*, **1887n**. See "Habits and mode of life, general," for other papers relative to the food of oysters.
   - *d*. Corallines on oyster shells, 1755.
4. Embryology and natural reproduction, 1669, 1697, 1722, **1827**, 1828, 1857*b*, 1858*b*, 1864*a*, 1865*b*, 1865*e*, 1866*a*, 1867*a*, 1869*a*, 1873*a*, 1874*c*, 1876*b*, 1876*c*, 1876*e*, 1876*h*, 1879*a*, 1880*a*, **1880b**, 1880*c*, 1882*b*, 1882*e*, 1882*f*, 1882*g*, 1882*h*, 1883*e*, 1883*f*, 1883*m*, 1883*n*, **1883r**, 1883*ad*, **1884t**, 1884*u*, 1884*w*, 1885*i*, 1885*q*, **1886g**, **1887n**, 1889*h*.
5. Artificial propagations, experiments, etc., 1866*a*, 1868*d*, 1869*d*, 1878*d*, 1879*b*, 1879*c*, **1880b**, 1880*e*, 1881*f*, 1881*i*, 1882*h*, 1882*k*, 1883*b*, 1883*e*, 1883*f*, 1883*j*, 1883*l*, 1883*aa*, 1883*ag*, 1883*am*, 1883*an*, 1883*ax*, 1884*a*, 1884*j*, 1884*o*, 1884*q*, 1884*r*, 1884*s*, 1884*y*, 1885*e*, 1885*r*, 1885*t*, 1886*h*, 1887*f*, 1887*g*, 1887*k*, **1887n**, **1890a**, **1891ab**, 1892*k*, 1893*m*.

II. ECONOMIC HISTORY.

1. Oyster industry of the world, 1884*g*, 1891*r*, **1894c**.
2. France, 1859*b*, 1862*b*, 1863*c*, 1864*b*, 1864*c*, 1864*d*, 1864*e*, 1865*a*, 1865*j*, 1866*a*, 1866*g*, 1866*h*, **1867b**, 1867*d*, 1867*e*, 1867*n*, **1868f**, 1868*i*, **1868j**, 1870*a*, 1870*e*, 1877*a*, 1878*a*, 1878*b*, **1878c**, 1878*j*, 1882*a*, 1883*d*, **1883g**, 1883*i*, 1883*j*, 1883*k*, 1883*u*, 1883*y*, 1883*aw*, 1884*b*, 1884*c*, 1884*e*, 1888*c*, 1888*n*, **1890e**, **1890h**, 1891*m*, **1892h**, 1882*r*, 1893*f*.
3. England, **1669**, 1722, 1837*b*, 1852*d*, 1854*b*, 1857*c*, **1858b**, 1863*b*, 1864*b*, 1864*d*, **1865a**, 1865*f*, 1865*j*, 1866*a*, **1866b**, 1866*d*, 1866*f*, 1866*g*, 1866*i*, 1867*c*, 1867*h*, 1867*i*, 1867*j*, 1867*k*, 1867*l*, 1867*n*, 1867*o*, **1868c**, **1868j**, 1868*k*, 1869*a*, 1869*f*, 1870*a*, 1870*f*, 1872*d*, 1875, **1876d**, 1876*i*, 1877*i*, 1877*j*, 1877*l*, 1878*i*, 1879*d*, 1880*m*, 1882*i*, 1883*q*, 1883*r*, 1883*aa*, 1885*ac*, 1886*t*, 1888*c*, 1888*g*, 1890*d*, 1893*e*, **1894b**.
4. English Channel, **1839**, 1857*d*.
5. Ireland, 1837*b*, **1838a**, 1864*f*, 1865*f*, 1866*b*, **1870a**, 1870*b*, 1871*b*, **1881a**.

6. Scotland, 1837*b*, 1862*a*, 1864*g*, 1865*a*, 1865*f*, 1866*b*, 1868*g*, 1883*a*, 1887*s*, 1889*o*, **1890b, 1891z, 1891aa,** 1892*q*.
7. Wales, 1720, 1837*b*, 1879*d*.
8. Germany, 1877*f*, 1878*h*, **1879k, 1883u,** 1883*bb*, 1885*m*, 1893*e*.
9. Italy, **1883g,** 1883*ay*, 1887*l*, 1893*e*.
10. Netherlands, 1883*p*, 1883*ak*, 1883*ba*, 1890*c*, 1893*e*.
11. Spain, 1893*e*.
12. Portugal, 1893*e*.
13. Austria, 1883*x*.
14. Belgium, 1893*e*.
15. China, 1880*h*, 1883*at*, 1892*d*.
16. Canada, 1850, 1863*a*, 1866*c*, 1867*p*, 1874*d*, 1874*f*, 1876*f*, 1877*k*, 1881*e*, 1884*ac*, 1886*v*, 1887*i*, 1887*j*, 1888*f*, 1888*m*, **1889e,** 1890*f*, **1891y,** 1892*c*, 1893*k*, 1893*r*.
17. United States, general, 1865*a*, 1869*c*, **1876a,** 1877*h*, 1879*m*, 1880*i*, **1881e,** 1881*g*, 1882*c*, 1884*e*, 1884*x*, 1885*j*, **1887k,** 1888*c*, 1892*e*, 1892*m*, **1894e.**
18. California, 1891*h*, 1892*f*, **1893v,** 1894*e*.
19. Connecticut, 1858*a*, 1877*h*, 1879*e*, 1879*f*, 1880*j*, 1880*k*, **1882d,** 1883*o*, **1883w,** 1884*k*, 1884*l*, **1884n, 1885o,** 1885*p*, 1885*ad*, 1885*ae*, 1886*d*, 1886*e*, 1886*k*, 1886*l*, 1887*m*, 1888*k*, 1889*j*, 1889*k*, 1889*l*, **1890g,** 1891*k*, **1891ac,** 1893*i*, 1894*e*.
20. Florida, 1887*p*, 1894*e*.
21. Georgia, 1888*j*, 1889*d*, **1891e,** 1894*e*.
22. Louisiana, 1869*c*, 1880*w*, 1889*q*, 1894*e*.
23. Massachusetts, 1841*b*, 1870*d*, 1894*e*.
24. Maryland, 1858*a*, 1859*a*, 1865*i*, **1870c, 1872c, 1873b,** 1877*e*, 1878*a*, 1878*d*, 1878*e*, 1880*t*, 1881*c*, 1881*g*, 1882*j*, **1884e,** 1884*f*, 1884*v*, 1884*z*, 1885*j*, 1886*f*, 1886*r*, 1886*s*, 1888*l*, 1888*o*, 1888*q*, 1889*a*, 1889*t*, 1890*c*, 1890*t*, 1891*a*, 1891*b*, 1891*c*, 1891*f*, 1891*g*, 1891*p*, 1891*q*, 1891*u*, 1891*w*, 1892*n*, 1892*p*, 1893*a*, 1893*g*, 1893*h*, 1894*a*, 1894*c*, **1894e,** 1894*f*.
25. New Jersey, **1889g,** 1889*u*, 1890*j*, 1891*ab*, 1892*l*.
26. New York, 1843*a*, 1843*b*, 1880*l*, **1885b,** 1885*c*, 1885*d*, 1885*e*, 1885*z*, 1887*d*, **1887e,** 1887*u*, 1887*w*, **1888d, 1889c,** 1889*u*, 1890*m*, 1891*j*, 1893*j*, 1893*o*, 1894*e*.
27. North Carolina, 1885*f*, 1885*x*, **1886o,** 1887*q*, 1887*r*, 1889*n*, 1894*e*.
28. Rhode Island, 1884*i*, **1887v,** 1894*e*.
29. South Carolina, **1892b, 1892g.**
30. Texas, **1893s.**
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32. Washington, 1892*f*, 1893*v*.
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35. Australia, etc., 1880*p*, 1880*q*, 1883*h*, 1883*az*, 1887*z*, 1891*ad*, 1893*b*, 1893*c*, 1893*d*, 1893*t*, 1893*w*.
36. European trade in American oysters, 1886*j*, **1886n.**

III. MISCELLANEOUS.

1. Archæological notes, **1851,** 1858*b*, 1861*a*, 1867*o*, 1868*e*.
2. Chemical composition of oysters, 1866*a*, 1867*a*, **1883c,** 1883*u*, 1885*a*, 1887*a*, 1887*b*, 1887*c*, **1892a.**
3. Examinations of oyster-grounds, 1870*g*, 1886*o*, 1887*d*, 1891*e*, 1892*b*, 1892*g*, 1893*s*, 1894*e*.
4. Poisonings caused by oysters, 1808, 1865*h*. See also "Food and green color."
5. Apparatus for catching oysters, **1883ap,** 1891*s*.
6. Exposition catalogues, etc., **1866h,** 1878*j*, 1883*t*, **1883ap,** 1883*at*, 1883*bc*, 1886*c*, 1893*l*.
7. Uses for oyster shells, 1668, 1675, 1681, 1698, 1881*c*, **1894e.**
8. Gastronomical notes and cook books, 1858*b*, 1861*a*, 1863*f*, 1867*g*, 1867*o*, **1868e,** 1871*a*, 1880*u*, 1881*b*, 1883*av*, 1884*p*, **1888a,** 1888*e*, 1889*b*.
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4.—THE FISHERIES OF THE GREAT LAKES.

INTRODUCTORY NOTE.

The fisheries of the Great Lakes, by reason of their great extent and the energetic measures taken by the General Government and the various States to maintain and increase their productiveness, have received an unusual amount of public attention, which has been increasing during late years, owing to the more extensive fish-cultural operations carried on, the threatened depletion of some of the lakes, due to wasteful methods or overfishing, and the growing necessity for concurrent action on the part of the several States and Canadian Provinces for the preservation of this important industry.

This Commission has aimed to keep well informed as to the status of the lake fisheries and has within a comparatively short time conducted two thorough investigations of the industry, viewed from the standpoint of the economic fisherman. The first canvass of this region, since the census of 1880, was made in 1885; the results of this comprehensive investigation of the history, apparatus, methods, and statistics of the fisheries were published in a report entitled "Review of the Fisheries of the Great Lakes in 1885" (330 pages, 7 charts, and 37 illustrations of fishes, apparatus, etc.).

The present paper represents the results of an investigation of the commercial fisheries of the Great Lakes conducted by this Commission during the fiscal year 1892, and illustrates the condition and extent of the industry during the year ending December 31, 1890. Notice of the field work and a summarized account of the results of the inquiry have appeared in my annual report for 1892. The following agents of the Division of Fisheries participated in the investigation and canvassed the regions specified: W. A. Wilcox and T. M. Cogswell, Lake Superior; E. E. Race and H. P. Parker, northern, western, and eastern shores of Lake Michigan, south of and including South Haven; Ansley Hall, eastern shore of Lake Michigan north of South Haven; W. A. Wilcox, Lake St. Clair, St. Clair and Detroit rivers, and the fisheries of the southern shore of Lake Huron tributary to Port Huron and the St. Clair River; Charles H. Stevenson, the shore of Lake Erie east of Port Clinton, including the Bass Islands, and part of the shore of Lake Ontario west of the Genesee River; and H. M. Smith, Lake Ontario, with the exception of part covered by Charles H. Stevenson. Messrs. Seymour

Bower and E. A. Tulian were detailed from the Division of Fish-culture to assist in the field inquiries. Mr. Bower canvassed that part of Lake Erie west of Sandusky, and Mr. Tulian the American shores of Lake Huron. The duty of preparing the notes of the agents for publication and of discussing the prominent features disclosed by the statistics has devolved upon Dr. Hugh M. Smith, the assistant in charge of the Division of Statistics and Methods of the Fisheries.

This report is essentially a detailed statistical presentation of the various phases of the lake fisheries. The previous full discussions of the methods employed, descriptions of the apparatus and boats used, and notes on the fishes taken render further information of this kind uncalled for and make necessary at this time only a notice of the principal changes which have occurred in these matters since the last inquiry. The statistical matter and the accompanying text are arranged with a view to show (1) the general extent of the lake fisheries and their importance as compared with 1880 and 1885; (2) the fisheries considered by lakes; (3) the fisheries considered by States; and (4) the extent and results of artificial propagation.

Attention may properly be directed to one feature of the paper which has not appeared in any previous report on the Great Lakes fisheries, viz, the presentation of statistics showing the quantity of each principal fish taken with each kind of apparatus. The tables are interesting for the information given and are important in affording an opportunity to make comparisions of the relative catch of the different species with the different appliances in future years. An invaluable basis is furnished for determining the existence of augmentation or diminution in the supply of the various fishes, the extent of the increase or decrease, and the form of fishery in which it has occurred.

The extent of the fisheries of the Great Lakes region, as determined by the inquiries of this Commission, was as follows: Persons employed, 9,738; capital invested, $5,362,744 pounds of fish taken, 113,898,531; value of the catch to the fishermen, $2,471,768.

The canvass of the fisheries of the lake region was materially assisted by the fishermen and wholesale dealers, without whose hearty coöperation a satisfactory inquiry could not have been made. Dealers in every section gave to the agents of the Commission free access to their records, thus permitting the collection of the most reliable statistics and, in some instances, furnishing necessary data that could not otherwise have been obtained, in the absence of records kept by the fishermen. Dealers in many places also accorded to the Commission's agents free passage on their fishing and collecting steamers, and so contributed to a better understanding of the fisheries as well as a saving of time and expense. The thanks of the Commission are heartily extended to the fishing interests of the lakes.

MARSHALL MCDONALD,
U. S. Commissioner of Fish and Fisheries.

THE FISHERIES OF THE GREAT LAKES.

By Hugh M. Smith, M. D.,

Assistant in charge of Division of Statistics and Methods of the Fisheries.

I.—GENERAL REMARKS ON THE LAKE FISHERIES.

In the basin of the Great Lakes there are about 100,000 square miles of water, distributed as follows:

	Square miles.
Lake Superior	32,000
Lake Michigan	22,000
Lake Huron	21,000
Lake Erie	9,500
Lake Ontario	6,500
St. Mary, St. Clair, Detroit, Niagara, and St. Lawrence rivers, Lake St. Clair	9,000
Total	100,000

This enormous area supports a fish fauna that is peculiarly rich and varied. At least 40 species of recognized food value are found in greater or less abundance, including some of the most highly esteemed and valuable food and game fishes occurring in North America. The fisheries here prosecuted by the people of the United States and Canada are the most extensive lake fisheries in the world. The quantity of fish annually taken is now over 150,000,000 pounds, having a value of more than $4,400,000. The wonderful fertility of these waters may be better appreciated when it is recalled that since 1880 not less than 1,400,000,000 pounds of food-fish have been put on the market from this region, the value of which was not less than $42,000,000, and that up to within a comparatively short time no serious or apparently permanent diminution in the general supply had been observed. Even at the present time the output is wonderfully well maintained, all things considered, and it may be safely stated that in much the larger part of this region the resources are not fully utilized.

While the fisheries of the American side of the Great Lakes are not important by comparison with the fishing industry of some of the coast sections of the country, their actual extent is great, and in some respects they are more prominent and interesting than those of any other region;

but the importance which the fisheries of this great basin are destined to attain in the not far distant future overbalances the mere question of their present extent. The development of other industries, the increase in population, especially in the more western and northern parts of the chain, and the growing demand for food-fish in the country at large, will undoubtedly lead to the advance of the lake fisheries.

In anticipating the continued growth of the lake fisheries, the serious effects of overfishing must not be disregarded, and the possibility of practical extinction of some of the more important fishes must not be lost sight of. While the natural resources of the lakes, their large size, and their physical features conduce to the preservation of the supply even when exceedingly large quantities of fish are caught, the history of the fisheries, in the two smallest lakes at least, clearly indicates the influence which man may exert on the abundance of the lake fishes and suggests what may be the case in even the largest lakes if the fishing operations are sufficiently extensive and if no regard is given to the question of needed protection. In looking, therefore, for the continued increase and prosperity of the lake fisheries, the necessity for rational regulations in certain lines must be recognized.

Of fully as great importance and, in some instances, of even greater consequence, is the resort to adequate artificial methods for the counteraction of the effects of fishing and for the regeneration of depleted grounds.

The investigation of the Commission in 1891–92 disclosed the fact that the lake fisheries gave employment to about 9,740 persons, that the amount of capital invested was over $5,362,000, that nearly 114,000,000 pounds of fish were taken, and that the value of the catch was about $2,471,700.

The different capacities in which the persons were employed were as follows:

Persons employed in the fisheries of the Great Lakes.

How engaged.	Number.
On fishing vessels	598
On transporting vessels	133
In shore or boat fishing	7,393
On shore	1,614
Total	9,738

The details of the investment are shown in the following table. The prominent features of the lake fisheries disclosed by the statistics are the relatively expensive class of vessels employed, the great importance of the pound-net and gill-net fisheries as shown by the number of pound nets and gill nets operated, and the expensive shore property devoted to the industry.

Vessels, boats, apparatus, shore property, and cash capital employed in the fisheries of the Great Lakes.

Items.	Number.	Value.
Vessels fishing	97	*$373,771
Vessels transporting	31	*233,055
Boats	3,710	361,648
Apparatus:		
Pound nets	3,750	949,957
Gill nets	†103,800	498,096
Seines	154	17,236
Fyke nets	2,968	96,868
Lines and other apparatus	....	13,052
Shore and accessory property	....	1,634,871
Cash capital	....	1,184,190
Total	....	5,362,744

* Including outfit. † 28,901,071 feet in length.

Of the 113,898,531 pounds of fish resulting from the operations of the Great Lakes fishermen, the minor varieties of whitefish known under the general name of lake herring represent much the largest part; next in point of quantity are the pike and pike perch, the lake trout, the whitefish, the perch, and the sturgeon. The quantities and values of the principal fish are as follows:

Products of the fisheries of the Great Lakes.

Species.	Pounds.	Value.
Herring	48,753,349	$561,703
Perch	7,754,028	113,260
Pike and pike perch	16,835,119	417,038
Sturgeon	4,289,759	148,366
Trout	12,890,441	507,950
Whitefish	12,401,335	518,891
All others	10,974,500	204,560
Total	113,898,531	2,471,768

Reference should be made to the bulletin relating to the fisheries of the Great Lakes issued by the Eleventh Census.* This is a more condensed exhibit of the subject than is given in the present paper. The statistical data in the two reports are presented from somewhat different standpoints, and each has some features that the other lacks, owing to different methods of treatment, different objects in view, and the adoption of different plans for the prosecution of the field investigations on which the reports are based. The census bulletin relates to the year 1889, and gives the following figures as representing the extent of the Great Lake fisheries during that year, the tables being condensed to meet the requirements of the present notice.

* Fisheries of the Great Lakes. By Charles F. Pidgin and Bert Fesler. Census Bulletin 173. Issued March, 1892.

STATISTICS OF THE FISHERIES OF THE GREAT LAKES IN 1889, AS REPORTED BY THE ELEVENTH CENSUS.

Persons employed.

Lakes.	Fishermen.	Shore help.	Total.
Superior	762	27	789
Michigan	2,049	35	2,084
Huron and St. Clair	1,432	12	1,444
Erie	1,965	216	2,181
Ontario	390	8	398
Total	6,598	298	6,896

Apparatus, boats, etc.

Designation.	Lake Superior.		Lake Michigan.		Lakes Huron and St. Clair.		Lake Erie.		Lake Ontario.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels	9	$27,350	48	$165,400	12	$30,000	42	$143,700	....	....	111	$366,450
Boats	475	30,568	1,225	62,115	736	37,117	1,183	173,606	253	$13,232	3,872	316,638
Pound nets	210	36,810	856	171,146	755	123,818	1,838	483,920	172	8,225	3,831	823,919
Gill nets	....	72,624	......	184,742	....	43,116	......	94,978	....	13,337	......	408,797
Seines	36	3,094	48	4,489	49	4,691	34	2,150	9	665	176	15,089
Fyke nets	2	190	1,171	17,291	251	2,987	930	30,680	558	5,807	2,912	56,955
Other apparatus	....	9,712	......	7,997	....	12,636	......	8,302	....	1,650	......	40,297
Shore and other property	....	30,477	......	103,369	....	121,771	......	544,397	....	4,800	......	804,814
Total	....	210,825	......	716,549	....	376,136	......	1,481,733	....	47,716	......	2,832,959

Products.

Species.	Lake Superior.		Lake Michigan.		Lakes Huron and St. Clair.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	80	$5	47,082	$2,464	70,895	$3,122
Catfish	500	11	224,680	4,415	285,874	7,205
Herring	382,123	5,002	9,568,587	190,359	4,659,221	78,327
Perch	27,590	447	2,181,426	37,603	2,634,488	28,218
Pike and pickerel	122,055	4,271	488,784	18,101	2,724,583	71,914
Sturgeon	84,469	1,931	612,353	26,634	656,369	19,400
Suckers	800	20	1,728,674	9,589	1,145,885	12,292
Trout	3,366,724	112,516	5,580,358	249,255	2,181,346	86,508
Whitefish	3,898,558	156,572	5,523,971	246,493	2,556,804	119,850
Others	1,050	32	51,029	3,623	23,932	386
Total	7,883,949	280,807	26,006,944	788,536	16,939,397	427,252

Species.	Lake Erie.		Lake Ontario.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	854,957	$34,953	44,994	$1,683	1,018,008	$43,227
Catfish	1,251,990	41,973	167,006	7,413	1,930,050	61,017
Herring	37,200,850	395,171	1,850,140	48,202	53,660,921	717,061
Perch	3,830,039	45,383	85,496	1,621	8,759,039	113,272
Pike and pickerel	14,583,471	284,201	184,254	10,959	18,103,147	389,476
Sturgeon	1,244,607	47,045	200,927	10,925	2,798,725	105,935
Suckers	1,072,495	10,609	74,344	890	4,022,198	33,400
Trout	66,703	3,714	6,500	511	11,201,631	452,504
Whitefish	3,323,772	167,172	23,383	1,476	15,326,488	691,563
Others	134,448	3,537	54,902	1,751	265,361	9,329
Total	63,563,332	1,033,758	2,691,946	85,431	117,085,568	2,615,784

Attention may be directed to the permanent value of the detailed statistics presented in the following pages, showing the extent of the fishing industry in each county bordering on the lakes. Such data afford an invaluable guide for determining the changes in the condition of the fisheries, and furnish the most satisfactory basis for noting comparisons from time to time. In the increased attention now being bestowed on the lake fisheries, and in the consideration of questions of legislation and propagation which are continually arising, detailed comparative statistics will necessarily have great utility.

II.—THE FISHERIES CONSIDERED BY LAKES.

GENERAL STATISTICS.

As an introduction to a detailed presentation of the statistics of the fisheries in each lake, the following series of general tables is given, showing, by lakes, the number of persons engaged in the industry, the apparatus, boats, etc., employed, and the quantity and value of the catch.

The fisheries of Lake Erie, as is well known, are much more extensive than those of any other lake. In all the essential items which enter into a statistical consideration—persons, capital, and products—this lake takes precedence. In the canvass conducted by this office, 4,482 persons were found to be directly connected with the fisheries, $2,816,302 was ascertained to be invested, and 64,850,873 pounds of fishery products were taken, having a value to the fishermen of $1,000,905.

Lake Michigan ranks next to Lake Erie. Here 2,877 persons found employment in the fishing industry, $1,437,224 was invested, 26,434,266 pounds of fish were caught, and the income of the fishermen was $830,465.

Third in general importance is Lake Huron, although in the items of fishing population and investment it is surpassed to a comparatively slight extent by Lake Superior, and the value of the catch is so little in excess of that of Lake Superior that the relative positions of the two lakes might be changed from time to time without the supervention of any specially marked changes in the condition of the fisheries in either. The fisheries of Lake Huron gave employment to 726 persons and $408,858 invested capital, and yielded 10,056,381 pounds of fish, which were sold for $221,067.

Lake Superior had 653 persons engaged in the industry, had $366,682 invested therein, and was credited with a catch of 6,115,992 pounds, valued at $220,968.

Next to Lake Superior in the quantity and value of the catch is Lake Ontario, which is, however, surpassed by Lake St. Clair in the number of fishermen and the amount of invested capital. It had 389 fishery employés, fishing property to the value of $123,533, and a catch of 3,446,448 pounds, worth $124,786.

Last in point of importance is Lake St. Clair and the two rivers connected therewith. The fisheries gave employment to 611 persons, $210,145 was invested, and 2,994,571 pounds of fish were secured, for which $73,577 was received.

Table showing by lakes the number of persons employed in the fisheries of the Great Lakes in 1890.

How employed.	Superior.	Michigan.	Huron.	St. Clair.	Erie.	Ontario.	Total.
On vessels fishing	45	284	18	28	218	5	598
On vessels transporting	13	9	8	....	97	6	133
In shore fisheries	517	2,215	590	517	3,198	356	7,393
On shore, in fish houses, etc	78	369	110	66	969	22	1,614
Total	653	2,877	726	611	4,482	389	9,738

Table showing by lakes the apparatus and capital employed in the fisheries of the Great Lakes in 1890.

Items.	Superior.		Michigan.		Huron.	
	No.	Value.	No.	Value.	No.	Value.
Vessels fishing	7	$22,700	48	$151,850	3	$9,700
Tonnage	91.08	....	671.57	....	37.94	....
Outfit	....	6,600	....	19,703	....	1,960
Vessels transporting	1	25,000	2	21,500	4	2,800
Tonnage	165.62	....	122.08	....	41.11	....
Outfit	....	7,000	....	1.615	....	130
Boats	320	23,975	1,052	71,663	410	22,308
Apparatus of capture, vessel fisheries:						
Gill nets	1,318	18,438	18,810	106,854	324	3,933
Apparatus of capture, shore fisheries:						
Pound nets and trap nets	140	34,435	844	244,880	551	88,515
Gill nets	4,656	45,038	22,086	109,060	1,882	17,732
Fyke nets	9	415	731	11,316	221	6,385
Seines	19	955	29	3,480	6	600
Lines, spears, dip nets, etc	....	2,348	....	2,144	....	770
Shore property	....	109,878	....	434,759	....	208,625
Cash capital	....	69,900	....	258,400	....	45,400
Total	....	366,682	....	1,437,224	....	408,858

Items.	St. Clair.		Erie.		Ontario.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing	4	$21,000	34	$115,400	1	$2,800	97	$323,450
Tonnage	38.56	....	344.42	....	13.69	....	1,197.26	....
Outfit	....	3,400	....	18,158	....	500	....	50,321
Vessels transporting	....	....	22	154,700	2	5,280	31	209,280
Tonnage	....	....	1,040.92	....	32.48	....	1,402.21	....
Outfit	....	....	....	14,025	....	1,005	....	23,775
Boats	162	4,375	1,393	217,750	373	21,577	3,710	361,648
Apparatus of capture, vessel fisheries:								
Gill nets	814	9,418	19,046	67,944	50	200	42,607	206,787
Apparatus of capture, shore fisheries:								
Pound nets and trap nets	34	9,450	1,893	548,100	288	24,577	3,750	949,957
Gill nets	....	....	30,274	101,569	2,295	17,910	61,193	291,309
Fyke nets	148	4,480	1,175	64,450	684	9,822	2,968	96,868
Seines	28	6,240	44	5,305	27	656	153	17,236
Lines, spears, dip nets, etc	....	1,100	....	6,151	....	539	....	13,052
Shore property	....	106,082	....	749,750	....	25,777	....	1,634,871
Cash capital	....	44,600	....	753,000	....	12,890	....	1,184,190
Total	....	210,145	....	2,816,302	....	123,533	....	5,362,744

Table showing by lakes and species the yield of the fisheries of the Great Lakes in 1890.

Species.	Superior.		Michigan.		Huron.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	....	....	143, 139	$6, 477	29, 351	$2, 167
Herring	199, 121	$4, 616	6, 082, 082	102, 721	2, 514, 551	28, 181
Perch	....	....	1, 943, 953	46, 641	1, 817, 628	20, 792
Pike and pike perch	26, 362	1, 134	566, 021	21, 987	1, 483, 072	50, 834
Sturgeon	47, 482	1, 401	946, 897	34, 253	365, 718	8, 924
Trout	2, 613, 378	88, 201	8, 364, 167	349, 193	1, 505, 619	51, 042
Whitefish	3, 213, 176	124, 987	5, 455, 079	219, 059	1, 004, 094	37, 247
Other fish	16, 473	629	2, 932, 928	50, 134	1, 336, 348	21, 880
Total	6, 115, 992	220, 968	26, 434, 266	830, 465	10, 056, 381	221, 067

Species.	St. Clair.		Erie.		Ontario.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	9, 086	$544	248, 418	$13, 521	33, 092	$2, 364	463, 086	$25, 073
Herring	490, 334	5, 797	38, 868, 283	399, 452	598, 978	20, 936	48, 753, 349	561, 703
Perch	763, 093	10, 160	2, 870, 407	30, 299	358, 947	5, 368	7, 754, 028	113, 260
Pike and pike perch	524, 669	17, 533	13, 774, 503	290, 537	460, 492	35, 013	16, 835, 119	417, 038
Sturgeon	309, 003	7, 794	2, 078, 907	73, 703	541, 752	22. 291	4, 289, 759	148, 366
Trout	244, 847	12, 242	121, 420	5, 183	41, 010	2, 089	12, 890, 441	507, 950
Whitefish	238, 764	14, 753	2, 341, 451	115, 970	148, 771	6, 875	12, 401, 325	518, 891
Other fish	414, 775	4, 751	4, 547, 484	72, 240	1, 263, 406	29, 850	10, 511, 414	179, 487
Total	2, 994, 571	73, 577	64, 850, 873	1, 000, 905	3, 446, 448	124, 786	113, 898, 531	2, 471, 768

LAKE SUPERIOR.

General features of the fisheries.—The condition of the fishing industry of this lake in the year covered by the investigation of the Fish Commission was generally regarded as satisfactory and as representing the average in recent years; the figures presented therefore afford a basis for rational comparisons.

The fishery resources of this lake are less developed than those of any other member of the chain. Long stretches of shore line are not only without fishing communities, but also without settlements of any kind. The sparsity of the population and the relative remoteness of most parts of the lake from markets will doubtless retard the rapid growth of the fisheries and prevent them attaining for some years the importance which the natural resources warrant.

While some fishes which in parts of the Great Lakes chain have great commercial importance are not relatively abundant in Lake Superior, still the most prominent of the lake fishes are here present in large quantities, and it is probable that in no other lake can a continued supply of desirable food-fishes be more certainly depended on. The great area of the lake (32,000 square miles) and its depth (1,200 feet in places) are conditions favorable to the maintenance of fisheries of much larger extent than are now prosecuted anywhere in the Great Lakes basin.

The fishing centers in this lake are, beginning at the western end of the lake, Duluth, Minn.; Bayfield and Ashland, Wis.; Ontonagon, L'Anse, Baraga, Marquette, Whitefish Point, and Sault Ste. Marie, Mich. Important places for the collection, sale, and shipment of fish are Duluth, Bayfield, Houghton, Marquette, Whitefish Point, and Sault Ste. Marie.

A prominent feature of the fisheries during recent years has been the movement of considerable quantities of apparatus from the American to the Canadian side of the lake, and the establishment of important fisheries at a number of places on the Canadian shore. In certain sections having important fisheries in 1885, the diversion of apparatus to the other side of the lake has resulted in a practical obliteration of once extensive interests. The most conspicuous instance of this kind was in the vicinity of Duluth.

Notes on the principal fishes.—The movements of fish in this lake appear to be less definite and less understood than in any of the other Great Lakes. An enormous run of fish and apparently favorable prospects will often be changed to an entire absence of fish for weeks, and, on the contrary, dull periods will sometimes be terminated by the advent of large bodies of fish without any apparent cause and independently of the migrations for spawning purposes which here, as in other lakes, are observed. During the spring fishing season of 1891 the fish came on to the shores in great abundance, and the prospects of a large catch appeared unusually good. Suddenly, however, the fish disappeared, and for weeks the catch was very light, and in many places scarcely any fish were taken. The fishermen became discouraged and moved their nets from point to point. Mr. A. Booth, of Chicago, the well-known fish-dealer, remarked on this point, "No one can say what the year's business will be until it is over. The best prospects come far short, and the poorest opening may turn out remarkably well."

The fishermen and dealers attribute to the weather a very marked influence on the abundance and catch of fish, which seems to be borne out by the results. The cold north wind which prevails in this lake during a large part of the year keeps the fish out in the lake in the deeper and warmer water. In 1890 and 1891, in the vicinity of Bayfield and the Apostle Islands, a very cold wind from the north continued during the greater part of the fishing season, a light catch being the result. Within twenty-four hours after a change from a northerly to a southerly wind there are usually a large run of fish and a good catch. In the vicinity of Lighthouse Point, Ashland County, Wis., 35 pound nets were put down in 1891, which, up to July 22, had not taken as many fish as were caught by 8 nets in the same region in the previous year, owing, as the fishermen believe, to the prevalence of northerly winds and the consequent cold water.

Foremost among the fishes of Lake Superior is the whitefish. This species represents more than half the quantity and value of the catch, and in nearly every fishing center is more important than all other fish combined. In the vessel gill-net fishery, however, it is less valuable than the lake trout. About two-thirds of the catch is taken in Michigan, and practically all the remainder in Wisconsin, this fish now being an insignificant element in the fisheries of Minnesota. In Michigan the largest quantities of whitefish are taken in Chippewa County, situated at the extreme eastern end of the lake and including, as its most important fishing-ground, Whitefish Bay. The fish is also prominent in the fisheries of Marquette, Houghton, and Alger counties. Ashland County, in Wisconsin, has a large whitefish catch, the yield being greater than in any other county on the lake except Chippewa.

Next to the whitefish in general importance is the lake trout. The cold, deep waters of this lake are well adapted to this fish, which is here found in greater abundance and of larger size than in any other lake, with the possible exception of Lake Michigan. In the gill-net fishery carried on with vessels, and also in the shore gill-net fishery, it is the most prominent fish, but in the pound-net fishery it is of slight value compared with whitefish. Considerable quantities are taken in ice fishing, and small catches are made in the minor fishing carried on with spears, fyke nets, and seines. The average weight of the fish marketed is about 6 pounds, but very large examples are not uncommon.

The variety of the trout known as the siscowet is found only in deep water. It is taken with trawl lines and gill nets at a depth of 600 to 800 feet. While extremely abundant and of large size, there is scarcely any demand for it in a fresh state, owing to its excessive fatness. A limited demand exists for it in a salted condition. In the more northern parts of the lake, where it is most numerous and where the largest quantities are taken, the fishermen report that it is always abundant, but they will only catch it when other fish that are in greater demand and more easily taken are scarce. The weight of the siscowet is from 3 to 15 pounds. Compared with 1885, the catch of siscowet shows a large decrease; this, however, is due entirely to the demand.

The lake herring is abundant throughout the lake, but, being regarded as a cheap fish, it has little market value at the present time. The small catch reported was taken chiefly in the gill nets of Houghton, Ashland, and Bayfield counties and the seines of Marquette County. A few fish, caught in gill nets, are used as bait in the trawl-line fishery for trout. In the year covered by the investigation on which this paper is based a very large supply of herring was observed; but the low price and small demand deterred the fishermen from taking it, and the catch was much less than in 1885.

The pike perches, which are of great importance in lakes Erie and Ontario, are taken in smaller quantities and appear to be less abundant in Lake Superior than in any other lake. Only a few thousand pounds are annually taken, principally in the pound-net fishery of Chippewa and Ashland counties and in the fyke-net fishery of the latter county. The wall-eyed pike caught in this lake are shipped to market in a round condition, thus constituting a notable exception in the fish trade; they are sold in an undressed state to supply a special demand for hard fish coming from the Jewish population.

The catch of sturgeon in this lake has always been small. The fish appears to be less abundant than in the shallower, warmer waters of the lower lakes. In many places where sturgeon are incidentally caught no value is attached to them, and in but few localities are any special efforts made to secure them. The bulk of the catch is taken in pound nets in Chippewa County, Mich. The average weight of the fish is about 60 pounds.

Both the fishermen and dealers take much interest in the artificial propagation of fish and realize its value in keeping up the supply; they concede the importance of fish-cultural work in enabling the fishermen to supply the increasing demand for food-fish. The following statement regarding the results of fish-culture in this lake emanates from the Census Office:

The information of local fishermen on the work of the U. S. Fish Commission in Saint Louis County, Minn., is that much good has been done and the catch, especially of whitefish, considerably increased. The fishermen claim that they are able to judge accurately of the benefit done them by the hatching and distribution of whitefish, for the reason that, as the ova used at the Duluth, Minn., hatcheries are obtained from Lakes Erie and Michigan, the fish are different and can readily be distinguished from those native to those waters. They say that the fish from Lakes Erie and Michigan are lighter in color and rarely weigh over 4.5 pounds, while Lake Superior whitefish often weigh as much as 16 pounds.—(Census Bulletin 173. Fisheries of the Great Lakes.)

Apparatus and methods.—While practically every form of fishing apparatus found in the Great Lakes region is represented in the fisheries of Lake Superior, the pound net and gill net are especially prominent. Fyke nets, seines, dip nets, spears, and lines are in some regions locally important as means of capture, but are insignificant taking the entire lake into consideration.

The pound net is employed in every county on this lake, with the exception of two counties in Minnesota. The most important fisheries are in Alger, Baraga, Chippewa, and Ontonagon counties, Mich., and Ashland County, Wis. The 140 nets used in the American waters of the lake were valued at $34,435. A prominent feature of the pound-net fishery of the lake is the great depth of water in which some nets are set. At Whitefish Point, in Chippewa County, at the eastern end of the lake, some of the pounds are 86 feet deep, and are put in water 80 feet deep, the surplus of 6 feet being allowed for slacking; the poles to which the nets are attached are 97 or 98 feet long, and consist of spliced tamarack and pine poles. The leaders are 40 to 75 rods long, the pot 36 feet square, and the heart or pound 4 rods long. In lifting the pot a windlass is used. These are among the largest and deepest pound nets found in the Great Lakes. Others from 40 to 70 feet in depth are operated in various sections of the lake, but much the largest number of the pound nets are set in 20 to 30 feet of water.

The prevailing sizes of mesh in the different parts of the net are as follows: Leader, 7 to 8 inches (stretch); bowl or heart, 5 to 6 inches; pot, 3½ inches. The tendency to set the net in long continuous lines, which is so noticeable in Lake Erie, is not observed in Lake Superior, owing chiefly to the great depth of water, which not only makes the setting of pounds difficult and expensive, but also unnecessary in view of the fact that the fish naturally resort to the inshore waters. The largest and most expensive pound nets cost between $500 and $600 and the smallest about $190, the average being $246. The only fish, considering the entire lake, that occupies a prominent place in the pound-net fishery is the whitefish, although in Baraga, Chippewa, and Isle Royale counties, Michigan, the lake trout is of considerable importance.

Gill nets are employed in every county bordering on the lake, but are specially important, on account of their number and catch, in Alger, Chippewa, Houghton, Isle Royale, Keweenaw, and Marquette counties in Michigan, and Ashland and Bayfield counties in Wisconsin. Vessels are employed in the gill-net fishery of Chippewa and Marquette counties in Michigan, St. Louis County in Minnesota, and Bayfield County in Wisconsin. The number of vessels so engaged was 7, 3 of which were in Marquette County, 2 in Chippewa County, and 1 in each of the other counties. The 1,318 gill nets operated from the vessels had a value of $18,438 and a length of 1,017,976 feet, or 193 miles, an average of 27½ miles to each vessel. The gill nets fished from small boats numbered 4,656; these, valued at $45,038, had a combined length of 2,352,560 feet, or 446 miles. The gill nets are mostly machine-made; a few, however, are made by hand by the fishermen's families during the winter.

Considerable ice fishing is done with hand lines along certain parts of the shore. The method followed in this lake is somewhat different from that pursued in other places. As soon as the ice is firm enough to bear the weight of the men, regular fishermen and semi-professionals begin their winter work or sport. Through a hole cut in the ice a line 6 feet long is dropped, supported by a small stick which runs across the hole and is soon firmly frozen on either side. To the line a single hook is attached, although sometimes 2 hooks are used on each line. The lines, baited with fresh herring, are left to fish themselves. One man will sometimes operate as many as 100 lines. These are visited every morning. The catch, consisting almost entirely of lake trout, is removed, and the hooks newly baited. In the western part of the lake a similar method is followed, but the lines are fished deeper, being 18 feet long. Trout is the only fish thus taken in noticeable quantities, although a few pike perch are caught in places.

Set lines, or trot lines, are used, to a limited extent, in a number of counties on this lake. The usual method of rigging the lines is to attach 50 hooks to each line, the hooks being 30 feet apart. These are baited with herring. They are set mostly for lake trout, and are fished in water from 100 to 130 fathoms deep. When fished for lake trout, the lines are buoyed about 3 fathoms from the bottom; but in fishing for siscowet, they are used directly on the bottom. Besides lake trout a few sturgeon and pike perch are caught.

The use of dip nets is restricted to the Chippewa Indians living in the vicinity of the rapids of St. Mary River. No such fishery is carried on in other lakes. While the method is primitive, the fishing-ground limited in extent, and the season short, relatively large quantities of fish are taken. The fish obtained are chiefly whitefish, although small quantities of lake trout, pike, pike perch, suckers, and other minor fish are also caught; a few brook trout are also taken. The State law forbids the selling of any brook trout, which have to be consumed by the fisherman or given away when caught. About 20 Indians, using 10 canoes, engage regularly in the fishery; who are assisted on shore by 10 others, employed in preparing the catch for market. On the Canadian side of the river, about the same number of Indians follow the fishery. The catch on the Michigan side is sold to wholesale dealers in Sault Ste. Marie, while that on the Canadian side is shipped principally to Montreal and other Canadian cities. The fishery opens in May and continues as long as the fish run freely, usually until the middle of June; after that time but few fish are seen, and the fishery is practically suspended until the late fall run. During the summer, when a few fish are found, the fishery is limited to the small number of Indians who take tourists through the rapids and fish for sport or for home use. There is an abundance of fish in the river during the late fall and early winter, when fishing is resumed. Formerly this run was in October and November, but of late years, owing to climatic conditions, the run of fish has commenced and ended in December.

In dipping in the rapids two Indians occupy a canoe together; one sits or stands in the stern to guide or pole the boat, while his companion occupies the bow with a pole or paddle or dip net in hand. The Indian in the bow keeps a sharp lookout for fish that are ascending the rapids, while his companion gives his attention to the management of the canoe. The fish are always seen before any attempt is made to dip them, this practice being in marked contrast with the important salmon dip-net fishery carried on by Indians in the Upper Columbia River. When the fish is spied, the dip net is rapidly seized and thrust downward into the turbulent water with great velocity and dexterity, the fish usually being secured. During the best of the run boats will average 300 pounds of fish daily; individual catches are often much larger. On May 8, 1891, a noted Indian guide, scout, and fisherman, known as John Bouche, dipped 825 whitefish, averaging 2 pounds each; in April, 1878, the same Indian dipped 2,952 pounds of whitefish in a single day.

The nets are all made by the Indians. They are about 6 feet deep, 4 feet in diameter, and are attached to a pole about 12½ feet long. The size of the mesh is 3½ or 4 inches; about 100 meshes enter into the depth. The Indians lay considerable stress on the size, shape, and general composition of the dip nets. Any departure from the approved style is thought by them to prevent a good catch being made. The time occupied by an Indian in knitting and rigging such a net is a week to ten days. When fish are abundant, the net lasts only about two weeks. The average value of the net is $12. A small amount of dip-net fishing is also done from rude platforms erected over the rapids near the shore. This kind of fishing is followed chiefly by those who are not expert enough to dip from a canoe.

Spear fishing for commercial purposes is limited to the vicinity of Bayfield, Wis., where it is chiefly carried on by Indians, 500 or 600 of whom live in Bayfield. Spears are employed only in fishing through the ice. The usual type of spear consists of 6 double-barbed prongs, 6 inches long, which are fastened to a crossbar, to which is attached a 10-foot wooden handle. The Indians go out to the fishing-grounds in the vicinity of their homes with hand sleds or dog teams. On four uprights at the corners of the sleds a canvas house is constructed to protect the fishermen from the wind. A hole is cut in the ice, over which the sled is drawn, and through this the fisherman suspends a decoy fish attached to a line, which is pulled up and down to attract the attention of passing fish. When a fish is seen the spear is thrown with great force, often to a depth of 30 or 40 feet, the same being withdrawn by means of a line attached to it. This fishing is often carried on with the mercury 40° to 45° below zero, and sometimes lower, the Indians remaining on the ice all day watching and fishing. Often large catches are taken, but at times few fish are secured. The catch is made up of whitefish and trout, about three-fourths consisting of the former.

Winter fishing through the ice with spears is followed by nearly all the male Indians living at or near the rapids of the St. Mary River. While considerable quantities of fish are caught, the fishery is not a commercial one, the catch being used to supply the Indian families. The fish caught are mostly whitefish and herring, which are chiefly consumed in a salted condition, a small amount being smoked. Spear fishing of this character is not carried on elsewhere in the Great Lakes, and, while not commercially important, deserves mention. The method pursued is as follows: A hole having been cut through the ice and a small sheltering tent placed over it, the Indian takes his stand and gently raises and lowers a wooden decoy attached to the end of a short line, all the while keeping a sharp lookout for any fish that may be attracted. When a fish is seen the line is dropped and the spear is instantly brought into use. Of late the Indians have found that they can fish as well by night as by day, by simply scooping out a hole in the ice and placing a lantern therein in such a manner as to throw its rays through the ice beneath the open hole.

Three kinds of spears are used. One, introduced by white men, is called by the Indians the "Yankee spear"; it has a handle 18 to 20 feet long, and is provided with three prongs attached to a cross-piece, each 10 inches long, and with a barb on either side of each prong, one placed a few inches above the other.

The favorite spear of the Indian is his own device and make. It is provided with three prongs, each fastened independently to the end of the handle. The outer prongs are fitted into little grooves on the side of the handle and are kept in place by rivets, while the middle prong is driven into the center of the pole. Another form of spear used for taking herring consists of a one-pronged piece of barbed iron, driven into or fastened to the end of a pole. This is supplemented with a long piece of iron attached to the end of the spear by its middle and bent into the shape of an incomplete circle, the free ends spreading. The Indians say that in using this spear, if a herring is touched it darts inside the iron band and virtually spears itself.

A feature of the fisheries of this lake that contrasts strongly with the conditions in most other fishing regions is the extreme neatness and cleanliness observed at the packing, curing, and cleansing houses and on the fishing steamers. The houses where the fish are handled are usually built partly over the water, yet no offal is permitted to go into the lake. On the arrival of a fishing steamer or boat a gang of men or women at once dress the fish and then thoroughly wash them. Then all offal is at once carried ashore, in many places some distance from the houses. The refuse is quickly visited by flocks of gulls hovering near by for that purpose and is quickly taken up. The fishing firms protect the gulls, which serve the useful functions of scavengers. The crews of steamers engaged in collecting fish from distant pound-net or gill-net fisheries employ their time on the return trip in dressing the fish, but no offal or blood is allowed to be thrown into the lake, and even the bloody water from the hold is carried ashore.

In parts of the lake considerable changes in the prevailing kinds of apparatus have occurred since 1885. A poor catch with one form of apparatus, or an unusually large catch with another, may have led, in a very short time, to a complete reversal of methods, the establishment of new fishing centers, or the discontinuance of old fisheries. Among other changes of this kind which have occurred the following may be mentioned:

The use of seines is much less extensive than in 1885; in that year 43 were employed, while at present only 19 or 20 are operated. What was said of the seine fishery in 1885 applies now with equal force:

> Prior to the introduction of pound nets seines were extensively used for catching the fish that chanced to be swimming in the vicinity of the shore; but these are now only occasionally employed for a few weeks, when the fishing is at its height, by those who are not so fortunate as to own pound nets. The continued use of pounds is said to have interfered with the migrations of fish in the inshore waters, and seines are not now sufficiently remunerative to warrant their extended use.

Seines are used in 5 counties, but the catch is usually insignificant. About two-thirds the quantity and value of the catch is whitefish.

Fresh and salt fish.—The demand for fresh fish is so constant that a ready market exists for all fish that can be caught. In placing fresh fish on the market the two methods chiefly adopted are to ship the fish in special fish cars or in ordinary boxes. The cost of transportation, however, from Lake Superior to the chief distributing centers is so great that cheap or inferior fish, like herring, are not profitable to catch or ship, even if very abundant.

The fishermen of this lake are averse to salting any of their catch, for the reason that it requires extra labor and brings them less money than fresh fish. In places remote from the wholesale purchasing-houses and in regions which are not regularly visited by the collecting steamers of the firms, a certain amount of salt fish is necessarily prepared each year. This consists of trout and whitefish. The usual practice is for the wholesale dealers to furnish salt and barrels to the fishermen free of charge, on condition that fish be returned to the firms furnishing the packages and that the supplies needed in the fisheries be purchased from them. A slight charge is made for the empty packages, but the fishermen are credited for the amount when the barrels are returned filled.

In salting fish the method is as follows: The heads and viscera are removed and the fish are split down the belly like a codfish, though the backbone is not removed. This practice, together with the shrinkage from salting, makes a loss of one-fourth or one-third in the original weight of the fish. The price received for the salt fish is about the same as that commanded by fish when sold fresh in a round condition.

Whitefish have for a number of years been graded as Nos. 1, 2, and 3; No. 1 to weigh 2 pounds or over; No. 2, from 1 to 1½ pounds, and No. 3, 1 pound or less. Previous to 1891 trout were all branded No. 1, regardless of size. In that year, however, the trade began packing and numbering the salt trout as follows: No. 1 to weigh 1½ pounds or more, and No. 2 under 1½ pounds. The rules as to packing and grading are unwritten laws of the trade, not being subject to legal regulations.

Statistics of Lake Superior fisheries.—In the following tables, the extent of the fisheries of Lake Superior is shown by States and counties. The tables relate to the persons employed in different capacities, the vessels, boats, apparatus, and capital devoted to the industry, and the quantity and value of the products taken. For the products, three tables are shown, one giving the catch of the entire lake, classified by species, another showing the results of the vessel fishery, and the third giving in great detail the catch of each form of apparatus.

Table showing by States and counties the number of persons employed in the fisheries of Lake Superior in 1890.

States and counties.	How engaged.				
	On vessels fishing.	On vessels transporting.	In shore fisheries.	On shore, in fish-houses, etc.	Total.
Michigan:					
Alger			14	2	16
Baraga			62		62
Chippewa	14		49	20	83
Houghton			37	12	49
Isle Royale			66		66
Keweenaw			30		30
Marquette	17		21	10	48
Ontonagon and Gogebic			42		42
Total	31		321	44	396
Minnesota:					
Cook			7		7
Lake			8		8
St. Louis	6	13	2	15	36
Total	6	13	17	15	51
Wisconsin:					
Ashland			42	6	48
Bayfield	8		131	13	152
Douglas			6		6
Total	8		179	19	206
Grand total	45	13	517	78	653

Table showing by States and counties the apparatus and capital employed in the fisheries of Lake Superior in 1890.

States and counties.	Vessels fishing.				Vessels transporting.				Boats.	
	No.	Tonnage.	Value.	Value of outfit.	No.	Tonnage.	Value.	Value of outfit.	No.	Value.
Michigan:										
Alger									8	$4,025
Baraga									11	440
Chippewa	2	35.68	$9,000	$2,000					24	2,550
Houghton									20	1,230
Isle Royale									59	3,690
Keweenaw									24	1,275
Marquette	3	25.98	8,200	1,700					11	790
Ontonagon and Gogebic									31	1,760
Total	5	61.66	17,200	3,700					188	15,760
Minnesota:										
Cook									8	385
Lake									4	290
St. Louis	1	11.23	2,000	900	1	165.62	$25,000	$7,000	4	160
Total	1	11.23	2,000	900	1	165.62	25,000	7,000	16	835
Wisconsin:										
Ashland									44	2,215
Bayfield	1	18.19	3,500	2,000					65	4,785
Douglas									7	380
Total	1	18.19	3,500	2,000					116	7,380
Grand total	7	91.08	22,700	6,600	1	165.62	25,000	7,000	320	23,975

States and counties.	Apparatus of capture—vessel fisheries.		Apparatus of capture—shore fisheries.								Value of lines, dip-nets, and spears.
	Gill nets.		Pound nets.		Gill nets.		Fyke nets.		Seines.		
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	
Michigan:											
Alger			16	$3,510	142	$1,594					
Baraga			12	3,500	94	770					$100
Chippewa	550	$9,350	17	7,300	80	1,400			1	$50	405
Houghton			7	1,800	794	6,520	3	$60			100
Isle Royale			8	1,600	941	9,410					924
Keweenaw			4	1,100	105	1,260					
Marquette	496	6,224	2	400	191	2,040			2	80	30
Ontonagon and Gogebic			24	5,125	390	3,415	1	20	5	375	
Total	1,046	15,574	90	24,335	2,737	26,409	4	80	8	505	1,559
Minnesota:											
Cook			1	200	94	940					39
Lake					100	1,000					140
St. Louis	200	2,000			29	290					70
Total	200	2,000	1	200	223	2,230					249
Wisconsin:											
Ashland			31	6,370	288	2,008	5	335			40
Bayfield	72	864	16	3,130	1,363	13,941			11	450	500
Douglas			2	400	45	450					
Total	72	864	49	9,900	1,696	16,399	5	335	11	450	510
Grand total	*1,318	18,438	140	34,435	*4,656	45,038	9	415	19	955	2,348

*Length of gill nets, 3,370,536 feet.

Table showing by States and counties the apparatus and capital employed in the fisheries of Lake Superior—Continued.

States and counties.	Shore property and accessories	Cash capital.	Total investment.
Michigan:			
Alger	$2,675		$11,801
Baraga	1,650		6,460
Chippewa	22,000	$20,000	74,055
Houghton	2,000		11,710
Isle Royale	2,755		18,379
Keweenaw	1,700		5,335
Marquette	4,670	15,000	39,134
Ontonagon and Gogebic	2,315		13,010
Total	39,765	35,000	179,887
Minnesota:			
Cook	165		1,729
Lake	225		1,655
St. Louis	52,278	20,300	109,998
Total	52,668	20,300	113,382
Wisconsin:			
Ashland	1,180		12,148
Bayfield	15,955	14,600	59,725
Douglas	310		1,540
Total	17,445	14,600	73,413
Grand total	109,878	69,900	366,682

Table showing by States, counties, and species the yield of the vessel fisheries of Lake Superior in 1890.

States and counties.	Trout, fresh.		Trout, salted.	
	Pounds.	Value.	Pounds.	Value.
Michigan				
Chippewa	202,750	$7,603		
Marquette	331,650	12,151	2,300	$92
Total	534,400	19,754	2,300	92
Minnesota				
St. Louis	33,542	1,408		
Wisconsin				
Bayfield	38,505	770	1,924	39
Grand total	606,447	21,932	4,224	131

States and counties.	Whitefish, fresh.		Whitefish, salted.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan						
Chippewa	101,375	$3,802			304,125	$11,405
Marquette	244,308	10,995	3,300	$149	581,558	23,387
Total	345,683	14,797	3,300	149	885,683	34,792
Minnesota						
St. Louis	30,734	1,359			64,276	2,767
Wisconsin						
Bayfield	77,011	2,695	920	23	118,360	3,527
Grand total	453,428	18,851	4,220	172	1,068,319	41,086

Table showing by counties and species the yield of the fisheries of Lake Superior in 1890.

States and counties.	Herring, fresh and salted.		Pike, fresh and salted.		Sturgeon, fresh and salted.		Trout, fresh.		Trout, salted.	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Michigan:										
Alger	....	......	....	......	....	......	66,000	$2,348	1,000	$40
Baraga	4,000	$120	1,000	$50	3,000	$90	76,800	3,840	14,290	715
Chippewa	....	......	6,000	180	29,000	907	303,927	10,791	....	......
Houghton	60,000	1,800	280	10	1,000	30	317,030	9,680	77,000	2,310
Isle Royale	10,590	204	470	19	....	......	460,058	15,021	239,547	4,816
Keweenaw	....	......	....	......	....	......	....	......	103,800	4,152
Marquette	24,000	480	....	......	....	......	388,422	14,216	12,300	517
Ontonagon and Gogebic.	1,100	15	230	9	6,824	136	37,857	1,512	20,729	749
Total	99,690	2,619	7,980	268	39,824	1,163	1,650,094	57,408	468,666	13,299
Minnesota:										
Cook	4,700	90	....	......	....	......	25,800	719	4,195	113
Lake	....	......	....	......	....	......	51,013	1,687	21,392	484
St. Louis	629	12	....	......	....	......	36,088	1,516	....	......
Total	5,329	102	....	......	....	......	112,901	3,922	25,587	579
Wisconsin:										
Ashland	35,000	710	18,200	860	7,658	238	78,368	2,755	1,204	49
Bayfield	59,102	1,185	118	4	....	......	221,065	8,251	51,372	1,803
Douglas	....	......	64	2	....	......	2,602	94	1,519	23
Total	94,102	1,895	18,382	866	7,658	238	302,035	11,100	54,095	1,875
Grand total	199,121	4,616	26,362	1,134	47,482	1,401	2,065,030	72,430	548,348	15,771

States and counties.	Whitefish, fresh.		Whitefish, salted.		Other fish, fresh and salted.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:								
Alger	142,640	$5,260	12,500	$575	....	....	222,140	$8,223
Baraga	47,000	2,350	53,164	2,658	....	....	199,254	9,823
Chippewa	768,375	28,412	....	....	12,000	$480	1,119,302	40,770
Houghton	290,250	9,286	88,750	2,763	2,000	60	836,310	25,935
Isle Royale	71,229	2,781	12,415	351	....	....	794,309	23,192
Keweenaw	....	....	142,320	7,116	....	....	246,120	11,268
Marquette	275,886	12,393	3,300	149	....	....	703,908	27,755
Ontonagon and Gogebic	81,739	3,255	74,753	2,947	1,875	75	225,112	8,698
Total	1,677,119	63,737	387,207	16,559	15,875	615	4,346,455	155,668
Minnesota:								
Cook	2,780	80	5,841	168	....	....	43,316	1,170
Lake	....	....	....	....	....	....	72,405	2,171
St. Louis	30,984	1,369	....	....	....	....	67,701	2,897
Total	33,764	1,449	5,841	168	....	....	183,422	6,238
Wisconsin:								
Ashland	266,913	10,568	204,677	7,784	....	....	612,020	22,964
Bayfield	421,016	17,722	189,788	5,913	598	14	943,059	34,892
Douglas	24,299	1,036	2,552	51	....	....	31,036	1,206
Total	712,228	29,326	397,017	13,748	598	14	1,586,115	59,062
Grand total	2,423,111	94,512	790,065	30,475	16,473	629	6,115,992	220,968

Table showing by States, counties, and apparatus of capture the yield of the shore fisheries of Lake Superior in 1890.

States, apparatus, and counties.	Herring, fresh and salted.		Pike, fresh and salted.		Sturgeon, fresh and salted.		Trout, fresh.		Trout, salted.	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Michigan.										
Pound nets:										
Alger	....	......	....	......	....	......	14,500	$435	1,000	$40
Baraga	....	......	1,000	$50	3,000	$90	31,800	1,590	10,000	500
Chippewa	....	......	6,000	180	29,000	907	41,177	1,388	....	......
Houghton	....	......	280	10	1,000	30	7,800	310	....	......
Isle Royale	....	......	....	......	....	......	42,927	1,368	16,759	382
Keweenaw	....	......	....	......	....	......	....	......	5,133	205
Marquette	....	......	....	......	....	......	2,400	84	....	......
Ontonagon and Gogebic	1,100	$15	230	9	6,824	136	17,527	699	9,210	317
Total	1,100	15	7,510	249	39,824	1,163	158,131	5,874	42,102	1,444
Gill nets:										
Alger	....	......	....	......	....	......	51,500	1,913	....	......
Baraga	2,000	60	....	......	....	......	20,000	1,000	4,290	215
Chippewa	....	......	....	......	....	......	60,000	1,800	....	......
Houghton	60,000	1,800	....	......	....	......	237,230	7,210	77,000	2,310
Isle Royale	10,590	204	....	......	....	......	321,012	10,535	171,511	3,398
Keweenaw	....	......	....	......	....	......	....	......	98,667	3,947
Marquette	....	......	....	......	....	......	49,372	1,781	10,000	425
Ontonagon and Gogebic	....	......	....	......	....	......	20,330	813	11,519	432
Total	72,590	2,064	....	......	....	......	759,444	25,052	372,987	10,727
Seines:										
Baraga	2,000	60	....	......	....	......	....	......	....	......
Marquette	24,000	480	....	......	....	......	....	......	....	......
Total	26,000	540	....	......	....	......	....	......	....	......
Lines:										
Baraga	....	......	....	......	....	......	25,000	1,250	....	......
Houghton	....	......	....	......	....	......	72,000	2,160	....	......
Isle Royale	....	......	470	19	....	......	96,119	3,118	51,277	1,036
Marquette	....	......	....	......	....	......	5,000	200	....	......
Total	....	......	470	19	....	......	198,119	6,728	51,277	1,036
Total for State	99,690	2,619	7,980	268	39,824	1,163	1,115,694	37,654	466,366	13,207
Minnesota.										
Pound nets:										
Cook	1,700	30	....	......	....	......	400	13	2,580	77
Gill nets:										
Cook	3,000	60	....	......	....	......	22,200	610	1,115	26
Lake	....	......	....	......	....	......	38,260	1,266	16,044	363
St. Louis	629	12	....	......	....	......	1,910	77	....	......
Total	3,629	72	....	......	....	......	62,370	1,953	17,159	389
Lines:										
Cook	....	......	....	......	....	......	3,200	96	500	10
Lake	....	......	....	......	....	......	12,753	421	5,348	121
St. Louis	....	......	....	......	....	......	636	31	....	......
Total	....	......	....	......	....	......	16,589	548	5,848	131
Total for State	5,329	102	....	......	....	......	79,359	2,514	25,587	597
Wisconsin.										
Pound nets:										
Ashland	....	......	5,000	200	3,158	103	13,368	480	1,204	49
Bayfield	510	10	118	4	....	......	11,864	415	1,000	40
Douglas	....	......	....	......	....	......	425	14	1,232	18
Total	510	10	5,118	204	3,158	103	25,657	909	3,436	107
Gill nets:										
Ashland	35,000	710	....	......	....	......	57,500	1,900	....	......
Bayfield	58,592	1,175	....	......	....	......	133,759	5,259	46,623	1,660
Douglas	....	......	64	2	....	......	2,177	80	287	5
Total	93,592	1,885	64	2	....	......	193,436	7,239	46,910	1,665

Table showing by States, counties, and apparatus of capture the yield of the shore fisheries of Lake Superior—Continued.

State, apparatus, and counties.	Herring, fresh and salted.		Pike, fresh and salted.		Sturgeon, fresh and salted.		Trout, fresh.		Trout, salted.	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Wisconsin—Continued.										
Fyke nets:										
Ashland			13,200	$660			3,500	$175		
Seines:										
Bayfield							2,657	93	1,825	$64
Spears:										
Bayfield							10,920	546		
Lines:										
Ashland					4,500	$135	4,000	200		
Bayfield							23,360	1,168		
Total					4,500	135	27,360	1,368		
Total for State	94,102	$1,895	18,382	866	7,658	238	263,530	10,330	52,171	1,836
Total pound-net catch	3,310	55	12,628	453	42,982	1,266	184,188	6,796	48,118	1,628
Total gill-net catch	169,811	4,021	64	2			1,015,250	34,244	437,056	12,781
Total fyke-net catch			13,200	660			3,500	175		
Total seine catch	26,000	540					2,657	93	1,825	64
Total dip-net catch										
Total spear catch							10,920	546		
Total line catch			470	19	4,500	135	242,068	8,644	57,125	1,167
Grand total	199,121	4,616	26,362	1,134	47,482	1,401	1,458,583	50,498	544,124	15,640

States, apparatus, and counties.	Whitefish, fresh.		Whitefish, salted.		Other fish, fresh and salted.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan.								
Pound nets:								
Alger	98,000	$3,505	12,500	$575			126,000	$4,555
Baraga	37,000	1,850	51,000	2,550			133,800	6,630
Chippewa	408,000	14,875					481,177	17,350
Houghton	46,500	1,860	10,000	400			65,580	2,610
Isle Royale	42,751	1,724	1,631	39			104,068	3,513
Keweenaw			48,600	2,430			53,783	2,635
Marquette	1,600	72					4,000	156
Ontonagon and Gogebic	34,683	1,386	52,215	2,052			121,789	4,614
Total	668,534	25,272	175,946	8,046			1,093,147	42,063
Gill nets:								
Alger	44,640	1,755					96,140	3,668
Baraga	10,000	500	2,164	108			38,454	1,883
Chippewa	60,000	1,800					120,000	3,600
Houghton	243,750	7,426	78,750	2,363			696,730	21,109
Isle Royale	28,478	1,057	10,784	312			542,375	15,506
Keweenaw			93,720	4,686			192,387	8,633
Marquette	29,978	1,326					89,350	3,532
Ontonagon and Gogebic	38,550	1,529	18,543	735			88,942	3,509
Total	455,396	15,393	203,961	8,204			1,864,378	61,440
Fyke nets:								
Houghton					2,000	$60	2,000	60
Ontonagon and Gogebic					1,875	75	1,875	75
Total					3,875	135	3,875	135
Seines:								
Baraga							2,000	60
Chippewa	10,000	375					10,000	375
Marquette							24,000	480
Ontonagon and Gogebic	8,506	340	4,000	160			12,506	500
Total	18,506	715	4,000	160			48,506	1,415

Table showing by States, counties, and apparatus of capture the yield of the shore fisheries of Lake Superior—Continued.

States, apparatus, and counties.	Whitefish, fresh.		Whitefish, salted.		Other fish, fresh and salted.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan—Continued.								
Dip nets:								
Chippewa	189,000	$7,560			12,000	$480	201,000	$8,040
Lines:								
Baraga							25,000	1,250
Houghton							72,000	2,160
Isle Royale							147,866	4,173
Marquette							5,000	200
Total							249,866	7,783
Total for State	1,331,436	48,940	383,907	$16,410	15,875	615	3,460,772	120,876
Minnesota.								
Pound nets:								
Cook	900	30	4,940	148			10,520	298
Gill nets:								
Cook	1,880	50	901	20			29,096	766
Lake							54,304	1,629
St. Louis	250	10					2,789	99
Total	2,130	60	901	20			86,189	2,494
Lines:								
Cook							3,700	106
Lake							18,101	542
St. Louis							636	31
Total							22,437	679
Total for State	3,030	90	5,841	168			119,146	3,471
Wisconsin.								
Pound nets:								
Ashland	200,413	7,818	204,677	7,784			427,820	16,434
Bayfield	24,656	893	79,677	2,060	598	14	118,423	3,436
Douglas	16,160	629	1,290	19			19,107	680
Total	241,229	9,340	285,644	9,863	598	14	565,350	20,550
Gill nets:								
Ashland	62,500	2,550					155,000	5,160
Bayfield	276,503	12,142	76,720	2,694			592,197	22,930
Douglas	8,139	407	1,262	32			11,929	526
Total	347,142	15,099	77,982	2,726			759,126	28,616
Fyke nets:								
Ashland	4,000	200					20,700	1,035
Seines:								
Bayfield	10,018	351	32,471	1,136			46,971	1,644
Spears:								
Bayfield	32,828	1,641					43,748	2,187
Lines:								
Ashland							8,500	335
Bayfield							23,360	1,168
Total							31,860	1,503
Total for State	635,217	26,631	396,097	13,725	598	14	1,467,755	55,535
Total pound-net catch	910,663	34,642	466,530	18,057	598	14	1,669,017	62,911
Total gill-net catch	804,668	30,552	282,844	10,950			2,709,693	92,550
Total fyke-net catch	4,000	200			3,875	135	24,575	1,170
Total seine catch	28,524	1,066	36,471	1,296			95,477	3,059
Total dip-net catch	189,000	7,560			12,000	480	201,000	8,040
Total spear catch	32,828	1,641					43,748	2,187
Total line catch							304,163	9,965
Grand total	1,969,683	75,661	785,845	30,303	16,473	629	5,047,673	179,882

LAKE MICHIGAN.

Importance of the fisheries.—The fishing industry of this lake is but little inferior to that of Lake Erie in general extent and importance, and exceeds that of all the other members of the Great Lakes combined, excluding Lake Erie. Several features of the fisheries serve to distinguish this lake from the others. The use of vessels for fishing is more extensive than elsewhere in the lakes; in fact, fully half the fishing vessels of the lakes are found in Lake Michigan, although the practice of employing vessels for the special purpose of collecting fish is not so common as in Lake Erie or Lake Huron. While there are several prominent fishes which are found in much greater abundance in other lakes than in Lake Michigan, the general fishery resources of the latter are very large, and the two most popular food-fishes of the entire lake region here exist in larger numbers and are taken in greater quantities than in any other lake. A kind of whitefish not found in the other lakes is an important economic product.

While fishing is prosecuted in all the 35 counties of the four States bordering on the lake, the industry is most extensive in the northern third, particularly in Green Bay, Big Bay de Noquet, Little Bay de Noquet, Grand Traverse Bay, along the north shore, and round the several groups of islands which break the surface of the upper section of the lake. Owing chiefly to the extensive use of vessels, the fisheries of several lower counties of Michigan and Wisconsin also have considerable importance.

In Michigan the specially prominent counties as regards fisheries are Schoolcraft, Mackinac, Delta, and Berrien; in Wisconsin the principal counties are Brown, Door, Milwaukee, and Sheboygan.

In the opinion of many fisherman, considerable damage has been done to the fisheries of this lake by sawdust, which escapes from mills situated on or near the lake and covers the feeding and spawning grounds of the principal fish. While most of the sawdust is consumed by the mills in large kilns in consequence of a State law prohibiting its deposit in the waters of the lake, nevertheless, much sawdust escapes in various other ways than by directly throwing it in the water.

Notes on the principal fishes.—The fish which is the most important factor in the fisheries of this lake is the lake trout. It is the most generally distributed of all the leading fishes, being taken in greater or less quantities in every county and at practically every fishing center. It is most abundant in the northern part of the lake, and is secured in especially large numbers in the fisheries of Berrien, Charlevoix, Emmet, and Schoolcraft counties in Michigan, and Door, Manitowoc, Milwaukee, and Sheboygan counties, Wisconsin. Much the largest part of the catch is taken with gill nets, although the pound-net yield is also important.

The existence in this lake of the siscowet, or deep-water variety of lake trout, which is so abundant in Lake Superior, was made known in the previous report on the fisheries of the Great Lakes issued by the Fish Commission. It is very common in the vicinity of the islands in the northern part of the lake, and in some places constitutes fully half the trout catch.

About two-thirds of the trout taken in the Great Lakes are obtained in Lake Michigan, the value of whose trout fishery is one-sixth that of all of the other fisheries of the Great Lakes. Considering the large annual production, the supply of this fish is remarkably well sustained, and the catch is now larger than ever before, being fully three times greater than in 1880 and about one-third more than in 1885.

At least five species of whitefish are of economic importance in the fisheries of this lake, and there are doubtless several others of rarer occurrence which in some places constitute an element of the catch, but are perhaps not usually distinguished by the fishermen from closely related species. Those which are generally recognized by the fishermen are the common whitefish, the lake herring, the blackfin or bluefin whitefish, the long-jaw whitefish, and the Menominee whitefish.

The common whitefish is more abundant in this lake than in any other member of the chain, the catch being over a million pounds larger than in Lake Superior, the lake having the next largest output. The fish occurs throughout the lake, but is comparatively uncommon in the southern part, and is secured in largest quantities in that part of the lake north of Manistee County, Mich. The principal part of the catch is taken with pound nets.

The lake herring ranks next to the trout and common whitefish in importance, and is here taken in much larger quantities than in all the other lakes, except Erie, combined. The regions of maximum abundance in Lake Michigan correspond closely with those of the regular whitefish. In some counties it is the principal fish taken, among them being Menominee and Ottawa counties in Michigan, and Oconto and Racine counties in Wisconsin.

A species whose capture constitutes a fishery peculiar to this lake is the blackfin or bluefin whitefish (*Coregonus nigripinnis*), which occurs in great abundance in the deepest water. The fish often reaches the weight of 4 or 5 pounds, but the average is under 3 pounds. About November 1, the fish are reported to make their appearance in the accessible localities, gradually increasing in abundance till December, during which month the maximum point is attained. The fishermen have found that in December and January the blackfins resort to stony bottoms for the purpose of spawning, but at other seasons they seem to prefer clay bottoms. This fish has up to this time been detected in none of the other Great Lakes.

Associated with the blackfin is a species similar in shape and size, but without the black marking on the fins, generally known among the fishermen as the longjaw. It resembles the blackfin in habits and edible qualities, but is by some regarded as inferior to the latter in food value.

In the accompanying statistics, the blackfin and the longjaw whitefishes have been included with the common whitefish. This is in harmony with the practice followed in previous investigations, including those of the Fish Commission in 1885 and of the census in 1880 and 1889. A statement of the catch of these fish in 1885 and 1890 will be found in footnotes to the products tables.

The habit of these fish of frequenting the deepest parts of the lake makes their capture in the appliances set in the inshore waters uncommon. They are sought mostly in steam vessels, and are taken in gill nets set 60 to 110 fathoms deep. A few are occasionally caught in pound nets. The principal fishery for them is carried on from Benzie, Leelanaw, Ottawa, Schoolcraft, and Charlevoix counties in Michigan, and in Sheboygan, Milwaukee, Kenosha, and Manitowoc counties in Wisconsin.

The Menominee whitefish is not abundant. It is taken in the northern part of the lake, the principal catch being in Green Bay (where it is known as the blackback), around the Manitou Islands, and along the north shore. The fish weighs from 4 to 6 pounds, and has about the same market value as the blackfin, viz, 3 cents per pound. The aggregate yield is not more than 30,000 pounds. In the tables this fish has been included with the common whitefish.

The sturgeon, while more important than in any other lake except Erie, is not abundant anywhere in this lake, and is annually decreasing in numbers. Like several other species, it is found in greatest numbers in the northern part of the lake. The catch is nowhere noticeably large except in Delta County, Mich., where it is, next to the whitefish, the principal fish taken in pound nets.

The yellow perch is another fish caught in larger quantities in this lake than elsewhere in the lake system. It is of relatively greater value in the southern part of the lake than any other species, being taken in especially large numbers in Cook County, Ill.

As an incidental element of the output, suckers are not unimportant, nearly 2,000,000 pounds being disposed of by the fishermen. They figure most prominently in the fisheries of Delta County in Michigan, and Brown, Kewaunee, and Oconto counties in Wisconsin.

Wall-eyed pike, pike, and the various basses, which complete the list of prominent species of this lake, are not of great general value, although in a few fishing communities they have a relatively important place. The fresh-water drum, which in most localities is not utilized, on account of the low price received, is in a few centers marketed; in Allegan County, Mich., for instance, 20,000 pounds caught in pound nets were sold for $100.

Notes on apparatus and methods.—The fishery which gives to Lake Michigan the special prominence which it holds in the Great Lake system is that prosecuted with gill nets. While the number of pound nets employed is larger than in any other lake except Erie, and while the pound-net catch is very important, the gill-net fishery represents the larger investment and yields the larger quantities of fish having the greater money value. This fishery is here more extensive than in any other lake as regards the value of apparatus used, the number of vessels employed, and the value of fish taken.

The gill-net fishery prosecuted from small boats is rather more important in Michigan than in Wisconsin. The counties maintaining the most extensive fishing are Charlevoix, Delta, Manitou, and Schoolcraft in Michigan, and Brown, Door, Kewaunee, and Manitowoc in Wisconsin. The specially important counties are Schoolcraft and Door.

Of the 22,086 gill nets used from small boats, 11,928 were operated by Michigan fishermen and 9,673 by Wisconsin fishermen. The value of the nets was $109,060, an average of a little less than $5 each.

The species taken are trout, the various whitefishes, sturgeon, suckers, bass, perch, pike, and wall-eyed pike, the principal part of the catch consisting of trout, common whitefish, lake herring, longjaws, and perch. The nets used for all of these have about the same dimensions, differing only in the size of the mesh. The average length is about 250 feet. The whitefish, trout, and pike nets have about a $4\frac{1}{4}$-inch mesh, those for sturgeon a 12-inch mesh, and those for perch and the minor species about a $2\frac{1}{2}$ or 3-inch mesh.

The number of vessels engaged in the gill-net fishery of Lake Michigan is 48, having a net tonnage of 671.57, a value of $151,850, and carrying outfits worth $19,703, exclusive of nets. The crews numbered 284, giving an average of about 6 men to a vessel. The nets employed numbered 18,810, and were valued at $106,854, an average of about $6 each. The vessels are operated from all parts of the lake, but are most numerous in Milwaukee and Sheboygan counties in Wisconsin, and Ottawa, Berrien, and Emmet counties in Michigan, where 29 of the 48 vessels made their headquarters. The distribution of the vessels among the fishing centers of the lake is as follows:

The gill-net fleet of Lake Michigan.

Fishing headquarters.	County.	No. of vessels.
Michigan:		
Petoskey	Emmet	4
Charlevoix	Charlevoix	2
Northport	Leelanaw	1
Frankfort	Benzie	2
Grand Haven	Ottawa	6
Saugatuck	Allegan	1
Ludington	Mason	2
Manistique	Schoolcraft	2
St. Joseph	Berrien	6
Total		26
Wisconsin:		
Fish Creek	Door	1
Sturgeon Bay	do	1
Two Rivers	Manitowoc	2
Kenosha	Kenosha	1
Milwaukee	Milwaukee	8
Sheboygan	Sheboygan	5
Racine	Racine	1
Total		19
Illinois:		
Chicago	Cook	2
Indiana:		
Michigan City	Laporte	1
Grand total		48

The gill nets carried by the vessels are of various lengths, varying from 200 to 720 feet, the average being about 300 feet. The depth is 6 feet, the usual mesh $4\frac{1}{4}$ inches. The number of nets used by each vessel varies from 300 to 600, and the quantity of netting operated by each is 10 to 50 miles in length. Fishing continues during the season of open water, and may be carried on, with slight intermissions, from January 1 to December 31. Usually, however, the season does not begin till March or April.

The vessel catch consists of trout, common whitefish, blackfins, longjaws, herring, and a few minor fishes, blackfins, longjaws, and trout predominating. In 1890 the amount of stock of vessels which fished regularly was from $6,000 to $13,000 each.

Pound nets to the number of 844 were operated in Lake Michigan in 1890; they had a value of $244,880. They were distributed among the four States bordering on the lake as follows: Michigan, 552; Wisconsin, 250; Indiana, 32, and Illinois, 10. The counties having the largest numbers of such nets were Delta, Mackinac, Manitou, and Schoolcraft in Michigan, and Door and Oconto in Wisconsin. Mackinac and Oconto counties, which lead in the item of pound nets in their respective States, each had 111 nets, although the catch of these counties was less valuable than in Delta County in Michigan or in Door County in Wisconsin.

The preëminent fish in the pound-net fishery of this lake are whitefish, which constitute nearly one-third the quantity and more than one-third the value of the pound-net catch. Lake herring rank next in point of quantity, but trout as regards value. Sturgeon are of considerable importance, as are also perch, suckers, and pike perch. The total pound-net catch was about 8,785,000 pounds, having a value to the fishermen of $270,000.

Fyke nets are employed in considerable numbers in three counties in Wisconsin, but are unimportant in other parts of this lake. Of the 731 used in 1890, 524 were owned in Brown County, 96 in Door County, and 95 in Oconto County, Wis. The species taken in fyke nets are chiefly lake herring, perch, suckers, and pike. The whole catch consisted of about 1,311,000 pounds, having a value to the fishermen of $25,560.

Seines are sparingly used, principally in the capture of perch, suckers, and pike. They are found in seven counties bordering on the lake, but are most numerous in Delta County, Mich., and Brown County, Wis., where more than half of the total number employed are owned.

Set lines or hand lines are fished in most of the counties on this lake. Much of the fishing is done in the winter, but there are also considerable quantities of set lines and troll lines used during the season of open weather. The principal part of the catch consists of sturgeon, perch, trout, and bass. The most important fisheries thus carried on are in the more northern parts of the lake. The counties having noticeably important line fishing are Brown, Keewaunee, and Oconto counties, in Wisconsin, where trout is the principal fish taken. Cook County, in Illinois, also has an important line fishery for perch, more of which are here caught than elsewhere in the lake.

Statistics by counties.—The following series of tables shows for each county bordering on Lake Michigan (1) the persons engaged in various capacities in the fisheries, (2) the vessels, boats, apparatus, and capital engaged in the industry, (3) the quantity and value of the principal fishes taken, and (4) the catch by each of the prominent kinds of apparatus used.

Table showing by States and counties the number of persons employed in the fisheries of Lake Michigan in 1890.

States and counties.	On vessels fishing.	On vessels transporting.	In shore fisheries.	Shoresmen.	Total.
Michigan:					
Allegan	6	....	17	....	23
Antrim	....	....	16	....	16
Benzie	11	....	13	....	24
Berrien	37	....	80	21	138
Charlevoix	11	....	25	....	36
Delta	....	....	140	26	166
Emmet	28	....	96	53	177
Grand Traverse	....	....	32	4	36
Leelanaw	3	....	90	....	93
Mackinac	....	....	153	9	162
Manistee	....	....	17	....	17
Manitou	....	....	100	13	113
Mason	8	....	8	....	16
Menominee	....	....	60	6	66
Muskegon	....	....	104	....	104
Oceana	....	....	10	....	10
Ottawa	30	....	17	30	77
Schoolcraft	15	6	48	18	87
Van Buren	....	3	14	....	17
Total	149	9	1,040	180	1,378
Indiana:					
Lake	....	....	24	....	24
Laporte	5	....	46	....	51
Porter	....	....	19	....	19
Total	5	....	89	....	94
Illinois:					
Cook	12	....	302	63	377
Lake	....	....	7	2	9
Total	12	....	309	65	386
Wisconsin:					
Brown	....	....	133	31	164
Door	12	....	232	17	261
Kenosha	6	....	6	2	14
Kewaunee	....	....	118	3	121
Manitowoc	12	....	38	8	58
Marinette	....	....	45	7	52
Milwaukee	51	....	2	31	84
Oconto	....	....	178	12	190
Ozaukee	....	....	4	....	4
Racine	7	....	5	2	14
Sheboygan	30	....	16	11	57
Total	118	....	777	124	1,019
Grand total	284	9	2,215	369	2,877

Table showing by States and counties the apparatus and capital employed in the fisheries of Lake Michigan in 1890.

States and counties.	Vessels fishing.				Vessels transporting.				Boats.	
	No.	Tonnage.	Value.	Value of outfit.	No.	Tonnage.	Value.	Value of outfit.	No.	Value.
Michigan:										
Allegan	1	11.31	$1,000	$240					17	$1,154
Antrim									13	455
Benzie	2	19.01	3,500	975					7	840
Berrien	6	80.06	19,000	3,093					16	1,800
Charlevoix	2	15.71	2,000	850					12	1,040
Delta									73	6,295
Emmet	4	76.95	16,500	1,120					30	1,715
Grand Traverse									34	1,310
Leelanaw	1	5.50	800	150					72	1,740
Mackinac									79	7,800
Manistee									16	835
Manitou									74	5,075
Mason	2	24.03	3,500	425					8	540
Menominee									35	3,130
Muskegon									33	1,134
Oceana									13	1,150
Ottawa	6	116.46	25,650	2,755					13	1,030
Schoolcraft	2	33.82	7,000	1,035	1	112.49	$19,500	$1,200	58	6,650
Van Buren					1	9.59	2,000	415	2	280
Total	26	382.85	78,950	10,643	2	122.08	21,500	1,615	605	43,883
Indiana:										
Lake									15	950
Laporte	1	5.51	1,200	420					24	1,620
Porter									13	800
Total	1	5.51	1,200	420					52	3,370
Illinois:										
Cook	2	40.11	7,000	485					26	955
Lake									7	325
Total	2	40.11	7,000	485					33	1,280
Wisconsin:										
Brown									85	3,275
Door	2	26.62	7,600	875					116	8,100
Kenosha	1	14.02	3,500	665					5	75
Kewaunee									17	1,405
Manitowoc	2	18.81	6,300	725					30	2,335
Marinette									33	2,150
Milwaukee	8	117.54	27,500	3,405					2	170
Oconto									60	4,255
Ozaukee									2	230
Racine	1	11.42	3,000	655					3	350
Sheboygan	5	54.69	16,800	1,830					9	785
Total	19	243.10	64,700	8,155					362	23,130
Grand total	48	671.57	151,850	19,703	2	122.08	21,500	1,615	1,052	71,663

Table showing by States and counties the apparatus and capital employed in the fisheries of Lake Michigan in 1890—Continued.

States and counties.	Apparatus of capture, vessel fisheries.		Apparatus of capture, shore fisheries.								
	Gill nets.		Pound nets.		Gill nets.		Fyke nets.		Seines.		Lines, spears, and dip nets.
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	Value.
Michigan:											
Allegan	359	$2,300	12	$2,400	276	$1,038					$129
Antrim			13	2,600	52	154					
Benzie	900	5,000	5	1,100	760	3,570					
Berrien	3,780	16,125	16	5,600	84	390					186
Charlevoix	1,040	8,650	1	[illegible]	1,102	5,424					
Delta			90	28,675	1,135	5,775			7	$1,050	66
Emmet	[illegible]	12,960	27	7,150	477	[illegible]					[illegible]
Grand Traverse			25	5,000	159	[illegible]					[illegible]
Leelanaw	100	1,2[illegible]0	43	[illegible]	827	2,468			1	30	22
Mackinac			111	35,805	820	4,170					126
Manistee			7	[illegible]	765	3,870	2	$225	1	35	
Manitou			61	25,800	1,175	[illegible]					
Mason	80	1,2[illegible]0	5	1,000	225	[illegible]					
Menominee			31	10,385	150	760					69
Muskegon			20	2,200	410	1,670	6	[illegible]			173
Oceana			10	[illegible]	14	70					
Ottawa	2,232	14,684	5	[illegible]	697	2,874					
Schoolcraft	825	4,185	60	19,900	2,800	13,950					18
Van Buren			7	2,450							36
Total	10,612	66,304	552	161,850	11,928	58,302	8	285	9	1,115	853
Indiana:											
Lake			16	5,600	45	225					66
Laporte	363	1,640	12	4,900	305	1,740					168
Porter			4	1,300	40	200					75
Total	363	1,640	32	11,800	390	2,165					309
Illinois:											
Cook	550	2,650			69	345			3	380	315
Lake			10	3,750	26	130					
Total	550	2,650	10	3,750	95	475			3	380	315
Wisconsin:											
Brown			9	2,375	1,600	7,975	524	8,060	10	1,150	39
Door	1,025	4,875	65	20,325	4,285	21,425	96	1,340			164
Kenosha	250	1,150			68	408					
Kewaunee					1,135	5,675					173
Manitowoc	700	3,825	25	9,700	1,415	7,075			2	250	
Marinette			11	3,180	460	2,025	8	116			42
Milwaukee	3,160	15,500	2	700							
Oconto			111	21,075	445	2,210	95	1,515	5	585	249
Ozaukee					150	750					
Racine	760	3,960			115	575					
Sheboygan	1,390	6,950	27	10,125							
Total	7,285	36,260	250	67,480	9,673	48,118	723	11,031	17	1,985	667
Grand total	*18,810	106,854	844	244,880	*22,086	109,060	731	11,316	29	3,480	2,144

* Length of gill nets, 10,428,880 feet.

Table showing by States and counties the apparatus and capital employed in the fisheries of Lake Michigan in 1890—Continued.

States and counties.	Shore property.	Cash capital.	Total investment.
Michigan:			
Allegan	$1,503		$9,764
Antrim	875		4,084
Benzie	7,723		23,308
Berrien	3,125	$3,800	53,119
Charlevoix	5,880		23,444
Delta	18,125	2,800	62,696
Emmet	7,410	10,000	59,794
Grand Traverse	2,225	3,000	11,952
Leelanaw	1,945	1,000	17,330
Mackinac	5,705	2,000	55,586
Manistee	650		6,565
Manitou	11,505	16,000	66,215
Mason	300		7,965
Menominee	2,725		17,060
Muskegon	988		6,230
Oceana	626		3,646
Ottawa	3,469		51,262
Schoolcraft	13,330	6,000	92,808
Van Buren	160		5,341
Total	88,269	44,600	578,169
Indiana:			
Lake	110		6,951
Laporte	465		12,153
Porter	70		2,445
Total	645		21,549
Illinois:			
Cook	248,000	165,000	425,130
Lake	210		4,415
Total	248,210	165,000	429,545
Wisconsin:			
Brown	31,400	19,800	74,074
Door	14,380	3,000	82,084
Kenosha	1,150		6,948
Kewaunee	2,465	1,200	10,918
Manitowoc	3,475	3,000	36,685
Marinette	7,525	4,000	19,038
Milwaukee	20,700	14,300	82,275
Oconto	9,925		39,814
Ozaukee	265		1,245
Racine	2,500		11,040
Sheboygan	3,850	3,500	43,840
Total	97,635	48,800	407,961
Grand total	434,759	258,400	1,437,224

Table showing by States and counties the yield of the fisheries of Lake Michigan in 1890.

States and counties.	Bass.		Herring.		Perch.		Pike and pike perch.		Sturgeon.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:										
Allegan	......	......	20,000	$500	88,300	$3,039	......	......	44,185	$1,595
Benzie	......	......	......	......	......	......	......	......	3.500	125
Berrien	6,300	$315	412,425	8,243	83,806	2,519	......	......	82,970	3,046
Charlevoix	......	......	30,000	750	......	......	......	......	......	......
Delta	5,300	265	219,052	3,230	74,400	976	76,870	$2,603	275,000	9,625
Emmet	100	5	8,700	187	......	......	2,000	80	3,200	128
Grand Traverse	......	......	6,000	150	......	......	......	......	......	......
Leelanaw	......	......	15,200	306	......	......	......	......	25,715	900
Mackinac	......	......	169,882	2,367	......	......	......	......	47,085	1,648
Manistee	......	......	7,100	162	......	......	100	4	14,200	500
Mason	......	......	......	......	2,500	75	1,800	90	......	......
Menominee	4,800	240	366.452	5,052	40,400	780	20,400	810	24.250	848
Muskegon	32,500	950	27,200	799	15,400	462	2,000	120	83,205	2,998
Oceana	......	......	3,900	117	800	24	100	5	34,508	1,250
Ottawa	......	......	769,433	19,054	5,000	100	......	......	13,400	489
Schoolcraft	......	......	70,337	1,153	......	......	......	......	23,143	810
Van Buren	1,050	53	3,500	70	8,137	278	......	......	58,350	2,330
Total	50,050	1,828	2,129,181	42,140	318,743	8,253	103,270	3,712	732,711	26,292
Indiana:										
Lake	......	......	16,443	329	34,200	1.000	......	......	9,913	390
Laporte	3,287	164	134,909	2,697	58,489	1,761	......	......	37,103	1,464
Porter	2,106	106	9,056	180	13,275	423	......	......	23,700	926
Total	5,393	270	160,408	3,206	106,064	3,184	......	......	70,716	2,780
Illinois:										
Cook	......	......	81,575	1,638	495.209	13,539	......	......	16,480	640
Lake	......	......	6,800	130	15,800	470	......	......	......	......
Total	......	......	88,375	1,768	511,009	14,009	......	......	16,480	640
Wisconsin:										
Brown	13,321	664	518,773	7,050	578,275	12,307	192,945	7,578	30,670	996
Door	20,350	1,017	963,175	13,964	100,200	1,983	57,700	2,254	42,900	1,545
Kenosha	......	......	22,100	442	15,400	462	......	......	......	......
Kewaunee	26,630	1,331	295,553	3,994	29.410	598	4.080	160	......	......
Manitowoc	......	......	185,554	2,698	62,660	1,312	18,370	750	10,570	370
Marinette	11,140	556	194,135	2,711	36,480	808	14,360	574	6,200	310
Milwaukee	......	......	407,300	8,104	......	......	......	......	......	......
Oconto	16,255	811	816,660	11,053	134,412	2,685	175,356	6,959	36,650	1,320
Ozaukee	......	......	15,110	270	......	......	......	......	......	......
Racine	......	......	118,330	2,463	......	......	......	......	......	......
Sheboygan	......	......	167,428	2.858	51,300	1,040	......	......	......	......
Total	87,696	4,379	3,704,118	55,607	1,008.137	21,195	462,751	18,275	126,990	4,541
Grand total	143,139	6,477	6,082,082	102,721	1,943,953	46,641	566,021	21,987	946,897	34,253

States and counties.	Suckers.		Trout.		Whitefish.		Others.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:										
Allegan	5,000	$50	82,200	$2,910	28,900	$920	20,000	$100	288,585	$9,114
Antrim	......	......	23.300	890	55,700	2,695	......	......	79,000	3,585
Benzie	......	......	298,480	13,022	206,000	8,738	......	......	507,980	21,885
Berrien	29,650	578	540,832	24,115	224,185	10,744	46,825	866	1,426,993	50,426
Charlevoix	......	......	591,842	17,877	243,900	10,441	......	......	865,742	29,068
Delta	204,520	3,163	331,197	13,642	654,150	26,031	30,820	564	1,871,309	60,099
Emmet	500	10	797,620	23,957	285,637	12,069	......	......	1,097,757	36,436
Grand Traverse	......	......	57,700	2,528	68,720	3,299	......	......	132,420	5,977
Leelanaw	20,800	260	326,700	9,761	250,160	8.687	......	......	638.575	19,914
Mackinac	82,200	1,446	305,160	12,272	754,489	29,933	101,960	2,008	1,460.776	49,674
Manistee	......	......	153,400	6,539	46.500	1,650	2,000	72	223,300	8,927
Manitou	......	......	293,100	10,125	504,800	21,856	10,000	150	807,900	32,131
Mason	......	......	48,000	2,270	36,100	1,576	......	......	88,400	4,011
Menominee	85,393	1,304	52,245	2,390	95,000	3,720	14,462	274	703,402	15,418
Muskegon	2,000	40	29,200	1,688	23,800	1,382	2,150	78	217,455	8,517
Oceana	......	......	13,300	665	5,900	295	......	......	58,508	2,356
Ottawa	2,300	23	121,420	5,087	216,410	5,947	......	......	1,127,963	30,700
Schoolcraft	48,500	852	590,030	24,987	576,370	22,968	59,000	1,175	1,367,380	51,945
	......	......	18,000	900	5,200	364	4,500	135	98,737	4,130
Total	480,863	7,726	4,673,726	175,625	4,281,921	173,315	291,717	5,422	13,062,182	444,813

Table showing by States and counties the yield of the fisheries of Lake Michigan in 1890—
Continued.

States and counties.	Suckers.		Trout.		Whitefish.		Others.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Indiana:										
Lake	21,56[illegible]	$4[illegible]0	10,565	$525	8,480	$[illegible]	6,460	$129	107,7[illegible]0	$[illegible],228
La Porte	1[illegible]	88	127,[illegible]58	6,[illegible]73	54,651	2,[illegible]	6,140	403	451,7[illegible]6	15,58[illegible]
Porter	[illegible]	180	16,7[illegible]0	8[illegible]2	3,770	1[illegible]	2,2[illegible]0	42	80,[illegible]57	2,[illegible]2
Total	50,[illegible]58	9[illegible]8	154,73[illegible]	7,7[illegible]0	66,90[illegible]	2,[illegible]	24,82[illegible]	57[illegible]	639,4[illegible]	21,093
Illinois:										
Cook	19,8[illegible]0	361	67,080	3,250	17,52[illegible]	8[illegible]	73,920	1,918	771,674	22,226
Lake	10,060	[illegible]96	4,58[illegible]	229	10,[illegible]15	5[illegible]	3,165	65	50,720	1,610
Total	29,95[illegible]	557	71,660	3,479	27,8[illegible]5	1,4[illegible]	77,085	1,983	822,394	23,836
Wisconsin:										
Brown	489,068	6,500	40,995	1,9[illegible]9	11,2[illegible]7	49	[illegible]02,6[illegible]	6,2[illegible]2	2,177,[illegible]97	4[illegible],739
Door	112,113	1,[illegible]	9[illegible]5,[illegible]	[illegible]3,[illegible]67	364,[illegible]2	15,[illegible]74	8[illegible]5	1,772	2,740,77[illegible]	82,907
Kenosha			80,[illegible]0	4,025	50,[illegible]35	1,7[illegible]	19,5[illegible]	210	179,[illegible]35	6,9[illegible]7
Kewaunee	280,50[illegible]	4,110	2[illegible]70	1[illegible],742	28,[illegible]0	1,2[illegible]	9[illegible]	646	9[illegible]0,[illegible]	22,817
Manitowoc			470,[illegible]82	22,276	59,[illegible]79	2,2[illegible]	[illegible]	750	828,[illegible]55	[illegible]0,359
Marinette	82,360	1,28[illegible]	[illegible]73	3,[illegible]25	25,000	1,[illegible]	[illegible]	[illegible]	452,0[illegible]8	10,668
Milwaukee			[illegible]	12,[illegible]55	69,510	2,[illegible]	[illegible]8,5[illegible]0	1,[illegible]70	1,[illegible]	53,751
Oconto	275,471	4,[illegible]	1,2[illegible]8[illegible]	[illegible]	39,584	1,7[illegible]	84,[illegible]	1,[illegible]71	1,711,722	37,063
Ozaukee			5,7[illegible]0	[illegible]5	48[illegible]	[illegible]2	1,2[illegible]5	[illegible]7	22,5[illegible]5	605
Racine			97,10[illegible]	[illegible]5	11,[illegible]76	4[illegible]	18,98[illegible]	82	2[illegible]5,889	8,168
Sheboygan			51[illegible],315	23,65[illegible]	418,289	14,5[illegible]7	79,6[illegible]2	1,576	1,2[illegible]2,974	43,639
Total	1,2[illegible]9,512	17,[illegible]8,5[illegible]	[illegible]1,0[illegible]8	162,359	1,[illegible]78,422	41,[illegible]39	738,523	15,049	11,910,197	340,623
Grand total	1,[illegible]	27,[illegible]	[illegible]64,167	349,[illegible]	*5,[illegible]55,079	219,[illegible]5[illegible]	1,132,145	23,028	26,434,266	830,465

*Includes 1,3[illegible]8,238 pounds of blackfin or bluefin whitefish, longjaw whitefish, and Menominee or round whitefish, valued at $42,3[illegible]9.

Table showing by apparatus and species the yield of the fisheries of Lake Michigan.

Apparatus and species.	Michigan.									
	Allegan.		Antrim.		Benzie.		Berrien.		Charlevoix.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:										
Herring							95,300	$1,906		
Perch	400	$12					17,580	520		
Sturgeon	32,885	1,151			3,500	$125	67,320	2,460		
Suckers	4,000	40					17,800	340		
Trout	1,200	60	23,300	$890	13,000	520	41,022	1,855	3,000	$120
Whitefish	2,700	135	46,700	2,335	32,000	1,280	22,550	1,015	4,500	225
Others	20,000	100					11,875	231		
Total	61,185	1,498	70,000	3,225	48,500	1,925	273,447	8,327	7,500	345
Gill nets:										
Herring	20,000	500					317,125	6,337	30,000	750
Perch	86,900	2,992					59,320	1,759		
Sturgeon	5,375	207								
Suckers	1,000	10					11,850	238		
Trout	81,000	2,850			285,480	12,502	480,610	21,300	588,842	17,757
Whitefish	26,200	785	9,000	360	174,000	7,458	201,635	9,729	239,400	10,216
Others							34,950	635		
Total	220,475	7,344	9,000	360	459,480	19,960	1,105,490	39,998	858,242	28,723
Lines, spears, and dip nets:										
Bass							6,300	315		
Perch	1,000	35					6,906	240		
Sturgeon	5,925	237					15,650	586		
Trout							19,200	960		
Total	6,925	272					48,056	2,101		
Grand total	288,585	9,114	79,000	3,585	507,980	21,885	1,426,993	50,426	865,742	29,068

Table showing by apparatus and species the yield of the fisheries of Lake Michigan—Cont'd.

Apparatus and species.	Michigan.									
	Delta.		Emmet.		Grand Traverse.		Leelanaw.		Mackinac.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:										
Bass	5,300	$265	100	$5	....	....	....	....	....	....
Herring	149,500	2,240	7,200	154	....	....	200	$6	147,140	$2,060
Perch	14,100	270	....	....	....	....	....	....	....	....
Pike and pike perch	35,730	1,383	2,000	80	....	....	....	....	....	....
Sturgeon	275,000	9,625	3,200	128	....	....	25,715	900	47,085	1,648
Suckers	119,400	2,390	500	10	....	....	200	4	82,200	1,446
Trout	164,597	6,586	23,100	869	34,300	$1,374	84,500	2,741	215,900	8,477
Whitefish	532,125	20,045	74,999	3,400	55,220	2,751	108,360	4,546	644,175	25,607
Others	20,200	384	....	....	....	....	....	....	98,100	1,942
Total	1,315,952	43,188	111,099	4,646	89,520	4,125	218,975	8,197	1,234,600	41,180
Gill nets:										
Herring	65,882	950	1,500	33	6,000	150	15,000	300	22,742	307
Suckers	35,440	563	....	....	....	....	5,000	100	....	....
Trout	127,375	5,095	744,520	21,588	15,400	594	242,200	7,020	60,472	2,356
Whitefish	146,150	5,746	210,638	8,669	13,500	548	137,400	4,009	110,314	4,326
Others	7,820	146	....	....	....	....	....	....	3,860	66
Total	382,667	12,500	956,658	30,290	34,900	1,292	399,600	11,429	197,388	7,055
Seines:										
Herring	3,670	40	....	....	....	....	....	....	....	....
Perch	60,300	706	....	....	....	....	....	....	....	....
Pike and pike perch	41,140	1,220	....	....	....	....	....	....	....	....
Suckers	19,680	210	....	....	....	....	15,600	156	....	....
Whitefish	5,875	240	....	....	....	....	....	....	....	....
Others	2,800	34	....	....	....	....	....	....	....	....
Total	133,465	2,450	....	....	....	....	15,600	156	....	....
Lines, spears, and dip nets:										
Trout	39,225	1,961	30,000	1,500	8,000	560	....	....	28,788	1,439
Whitefish	....	....	....	....	....	....	4,400	132	....	....
Total	39,225	1,961	30,000	1,500	8,000	560	4,400	132	28,788	1,439
Grand total	1,871,309	60,099	1,097,757	36,436	132,420	5,977	638,575	19,914	1,460,776	49,674

Apparatus and species.	Michigan.									
	Manistee.		Manitou.		Mason.		Menominee.		Muskegon.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:										
Bass	....	....	....	....	....	....	....	....	1,000	$65
Herring	5,000	$100	....	....	....	....	311,040	$4,280	8,200	166
Perch	....	....	....	....	2,500	$75	40,400	780	12,600	278
Pike and pike perch	....	....	....	....	1,800	90	20,400	810	2,000	120
Sturgeon	14,200	500	....	....	....	....	24,250	848	74,085	2,593
Suckers	....	....	....	....	....	....	41,143	576	2,000	40
Trout	2,000	80	19,200	$702	3,000	150	9,220	365	12,700	743
Whitefish	22,000	880	387,100	16,471	10,000	500	73,500	2,900	23,800	1,382
Others	....	....	10,000	150	....	....	7,962	146	....	....
Total	43,200	1,560	416,300	17,323	17,300	815	527,915	10,705	136,385	5,387
Gill nets:										
Bass	....	....	....	....	....	....	2,400	120	....	....
Herring	2,000	60	....	....	....	....	55,412	772	19,000	633
Perch	....	....	....	....	....	....	....	....	2,000	160
Sturgeon	....	....	....	....	....	....	....	....	4,920	195
Suckers	....	....	....	....	....	....	44,250	728	....	....
Trout	150,400	6,419	273,900	9,423	45,000	2,120	12,650	506	16,500	945
Whitefish	20,500	610	117,700	5,385	26,100	1,076	21,500	820	....	....
Others	....	....	....	....	....	....	6,500	128	....	....
Total	172,900	7,089	391,600	14,808	71,100	3,196	142,712	3,074	42,420	1,933
Fyke nets:										
Bass	....	....	....	....	....	....	....	....	1,500	60
Herring	100	2	....	....	....	....	....	....	....	....
Perch	....	....	....	....	....	....	....	....	800	24
Pike and pike perch	100	4	....	....	....	....	....	....	....	....
Trout	1,000	40	....	....	....	....	....	....	....	....
Whitefish	3,000	120	....	....	....	....	....	....	....	....
Others	2,000	72	....	....	....	....	....	....	2,000	70
Total	6,200	238	....	....	....	....	....	....	4,300	154

Table showing by apparatus and species the yield of the fisheries of Lake Michigan—Cont'd.

Apparatus and species.	Michigan.									
	Manistee.		Manitou.		Mason.		Menominee.		Muskegon.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Seines:										
Whitefish	1,000	$40								
Lines, spears, and dip nets:										
Bass							2,400	$120	30,000	$825
Sturgeon									4,200	210
Trout							30,375	1,519		
Others									150	8
Total							32,775	1,639	34,350	1,043
Grand total	223,300	8,927	807,900	$32,131	88,400	$4,011	703,402	15,418	217,455	8,517

Apparatus and species.	Michigan.									
	Oceana.		Ottawa.		Schoolcraft.		Van Buren.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:										
Bass									6,400	$335
Herring	3,900	$117			50,500	$757	3,500	$70	781,480	11,856
Perch	800	24					4,700	141	93,080	2,100
Pike and pike perch	100	5							62,030	2,488
Sturgeon	34,508	1,250	9,850	$355	23,143	810	58,350	2,330	693.091	24,723
Suckers			800	8	48,500	852			346,543	5,706
Trout	10,800	540			150,850	5,849	14,800	740	826,489	32,661
Whitefish	4,400	220	3,100	155	306,250	12,084	5,200	364	2,328,679	96,295
Others					30,600	625	4,500	135	203,237	3,713
Total	54,508	2,156	13,750	518	609,843	20,977	91,050	3,780	5,341,029	179,877
Gill nets:										
Bass									2,400	120
Herring			769,433	19,054	19,837	396			1,343,931	30,242
Perch			5,000	100					153,220	5,011
Sturgeon			3,550	134					13,845	536
Suckers			1,500	15					99,040	1,654
Trout	2,500	125	121,420	5,087	435,067	18,932			3,683,336	134,619
Whitefish	1,500	75	213,310	5,792	270,120	10,884			1,938,967	76,488
Others					28,400	550			81,530	1,525
Total	4,000	200	1,114,213	30,182	753,424	30,762			7,316,269	250,195
Fyke nets:										
Bass									1,500	60
Herring									100	2
Perch									800	24
Pike and pike perch									100	4
Trout									1,000	40
Whitefish									3,000	120
Others									4,000	142
Total									10,500	392
Seines:										
Herring									3,670	40
Perch									60,300	706
Pike and pike perch									41,140	1,220
Suckers									35,280	366
Whitefish									6,875	280
Others									2,800	34
Total									150,065	2,646
Lines, spears, and dip nets:										
Bass							1,050	53	39,750	1,313
Perch							3,437	137	11,343	412
Sturgeon									25,775	1,039
Trout					4,113	206	3,200	160	162,901	8,305
Whitefish									4,400	132
Others									150	8
Total					4,113	206	7,687	350	244,319	11,203
Grand total	58,508	2,356	1,127,963	30,700	1,367,380	51,945	98,737	4,130	13,062,182	444,313

Table showing by apparatus and species the yield of the fisheries of Lake Michigan—Cont'd.

Apparatus and species.	Indiana.							
	Lake.		Laporte.		Porter.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:								
Herring	14, 300	$286	26, 565	$531	7, 240	$145	48, 105	$962
Perch	32, 300	940	22, 110	680	8, 370	254	62, 780	1, 874
Sturgeon	9, 913	390	16, 463	624	7, 430	266	33, 806	1, 280
Suckers	16, 850	335	10, 940	218	4, 120	80	31, 910	633
Trout	9, 300	465	18, 200	910	5, 050	250	32, 550	1, 625
Whitefish	8, 000	400	14, 300	715	3, 250	165	25, 550	1, 280
Others	5, 850	117	8, 750	185	1, 410	27	16, 010	329
Total	96, 513	2, 933	117, 328	3, 863	36, 870	1, 187	250, 711	7, 983
Gill nets:								
Herring	2, 143	43	108, 344	2, 166	1, 816	35	112, 303	2, 244
Perch	2, 000	60	30, 600	850	2, 430	70	35, 030	980
Suckers	4, 719	95	8, 729	170	5, 100	100	18. 548	365
Trout	1, 265	60	95, 420	4, 771	1, 720	85	98, 405	4, 916
Whitefish	480	25	40, 351	1, 618	520	28	41, 351	1, 671
Others	610	12	7, 390	218	810	15	8, 810	245
Total	11, 217	295	290, 834	9, 793	12, 396	333	314, 447	10, 421
Lines, spears, and dip nets:								
Bass			3, 287	164	2, 106	106	5, 393	270
Perch			5, 779	231	2, 475	99	8, 254	330
Sturgeon			20, 640	840	16, 270	660	36, 910	1, 500
Trout			13, 838	692	9, 940	497	23, 778	1, 189
Total			43, 544	1, 927	30, 791	1, 362	74, 335	3, 289
Grand total	107, 730	3, 228	451, 706	15, 583	80, 057	2, 882	639, 493	11, 693

Apparatus and species.	Illinois.					
	Cook.		Lake.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:						
Herring			3, 500	$70	3, 500	$70
Perch			10, 300	305	10, 300	305
Suckers			9, 260	180	9, 260	180
Trout			4, 580	229	4, 580	229
Whitefish			10, 315	520	10, 315	520
Others			3, 165	65	3, 165	65
Total			41, 120	1, 369	41, 120	1, 369
Gill nets:						
Herring	75, 075	$1, 508	3, 300	60	78, 375	1, 568
Perch	39, 860	1, 196	5, 500	165	45, 360	1, 361
Suckers	10, 760	175	800	16	11, 560	191
Trout	67, 080	3, 250			67, 080	3, 250
Whitefish	17, 520	880			17, 520	880
Others	750	18			750	18
Total	211, 045	7, 027	9, 600	241	220, 645	7, 268
Seines:						
Herring	6, 500	130			6, 500	130
Perch	17, 065	510			17, 065	510
Suckers	9, 130	186			9, 130	186
Others	1, 670	30			1, 670	30
Total	34, 365	856			34, 365	856
Lines, spears, and dip nets:						
Perch	438, 284	11, 833			438, 284	11, 833
Sturgeon	16, 480	640			16, 480	640
Others	71, 500	1, 870			71, 500	1, 870
Total	526, 264	14, 343			526, 264	14, 343
Grand total	771, 674	22, 226	50, 720	1, 610	822, 394	23, 836

Table showing by apparatus and species the yield of the fisheries of Lake Michigan—Cont'd.

Apparatus and species.	Wisconsin.									
	Brown.		Door.		Kenosha.		Kowaunee.		Manitowoc.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:										
Herring	50,900	$762	478,675	$6,462	......	......	......	......	36,445	$510
Perch	97,600	1,952	35,900	718	......	......	......	......	53,600	1,112
Pike and pike perch	26,000	1,040	30,000	1,200	......	......	......	......	17,475	715
Sturgeon	27,920	896	42,900	1,545	......	......	......	......	10,570	370
Suckers	72,000	1,240	52,220	745	......	......	......	......	......	......
Trout	1,160	50	372,590	16,394	......	......	......	......	139,380	6,697
Whitefish	8,100	360	128,900	5,672	......	......	......	......	11,410	555
Others	42,900	858	39,380	787	......	......	......	......	26,700	480
Total	326,580	7,158	1,180,565	33,523	......	......	......	......	295,580	10,439
Gill nets:										
Bass	1,156	58	1,337	67	......	......	8,075	$403	......	......
Herring	272,592	3,688	456,000	7,122	22,100	$442	295,553	3,994	146,929	2,158
Perch	56,840	1,475	34,500	690	15,400	462	29,410	598	......	......
Pike and pike perch	37,400	1,496	9,150	362	......	......	4,080	160	......	......
Sturgeon	2,750	100	......	......	......	......			......	......
Suckers	57,500	920	32,143	450	......	......	280,500	4,110	......	......
Trout	10,570	465	581,841	24,627	80,500	4,025	165,545	7,284	311,602	15,579
Whitefish	2,387	95	234,232	10,008	50,935	1,768	28,090	1,236	47,684	1,633
Others	28,943	539	38,610	821	10,500	210	31,490	646	12,200	244
Total	470,138	8,836	1,387,813	44,147	179,435	6,907	842,743	18,431	518,415	19,614
Fyke nets:										
Bass	8,100	405	6,500	325	......	......	......	......	......	......
Herring	183,750	2,450	28,500	380	......	......	......	......	......	......
Perch	357,500	7,725	29,800	575	......	......	......	......	......	......
Pike and pike perch	93,560	3,750	18,550	692	......	......	......	......	......	......
Suckers	270,425	3,092	27,750	370	......	......	......	......	......	......
Trout	5,925	237	650	26	......	......	......	......	......	......
Whitefish	760	38	1,200	60	......	......	......	......	......	......
Others	29,320	733	6,550	164	......	......	......	......	......	......
Total	949,340	18,430	119,500	2,592	......	......	......	......	......	......
Seines:										
Herring	11,531	150	......	......	......	......	......	......	2,180	30
Perch	66,335	1,155	......	......	......	......	......	......	9,060	200
Pike and pike perch	35,985	1,292	......	......	......	......	......	......	895	35
Suckers	89,143	1,248	......	......	......	......	......	......	......	......
Whitefish	......	......	......	......	......	......	......	......	385	15
Others	20,800	625	......	......	......	......	......	......	1,540	26
Total	223,794	4,470	......	......	......	......	......	......	14,060	306
Lines, spears, and dip nets:										
Bass	4,065	201	12,513	625	......	......	18,555	928	......	......
Trout	23,340	1.157	40,388	2,020	......	......	69,155	3,458	......	......
Others	180,640	3,487	......	......	......	......	......	......	......	......
Total	208,045	4,845	52,901	2,645	......	......	87,710	4,386	......	......
Grand total	2,177,897	43,739	2,740,779	82,907	179,435	6,907	930,453	22,817	828,055	30,359

Table showing by apparatus and species the yield of the fisheries of Lake Michigan—Cont'd.

Apparatus and species.	Wisconsin.							
	Marinette.		Milwaukee.		Oconto.		Ozaukee.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:								
Bass	8,400	$420	...	...	...	...	...	...
Herring	160,500	2,258	8,000	$124	454,700	$6,179	...	...
Perch	18,000	375	...	...	31,120	622	...	...
Pike and pike perch	12,600	504	...	...	99,800	3,992	...	...
Sturgeon	6,200	310	...	...	30,400	1,100	...	...
Suckers	43,500	670	...	...	64,600	1,092	...	...
Trout	20,565	908	3,400	170	20,400	882	...	...
Whitefish	14,700	644	1,180	66	14,200	616	...	...
Others	5,700	114	1,500	30	51,180	1,024	...	...
Total	290,165	6,203	14,080	390	766,400	15,507	...	...
Gill nets:								
Bass	874	43	...	...	6,337	315	...	...
Herring	26,885	363	399,300	7,980	235,560	3,180	15,110	$270
Perch	15,480	385	...	...	42,335	1,058	...	...
Pike and pike perch	...	...	...	...	34,480	1,444	...	...
Suckers	36,000	576	...	...	137,925	2,347	...	...
Trout	28,091	1,236	839,700	41,985	15,520	683	5,700	285
Whitefish	10,100	446	68,330	2,056	21,365	940	480	23
Others	9,850	177	67,000	1,340	19,840	364	1,275	27
Total	127,280	3,226	1,374,330	53,361	513,362	10,331	22,565	605
Fyke nets:								
Bass	410	20	...	...	2,800	140	...	...
Herring	6,750	90	...	...	113,550	1,514	...	...
Perch	3,000	48	...	...	28,600	490	...	...
Pike and pike perch	1,700	70	...	...	28,050	1,041	...	...
Suckers	2,860	35	...	...	34,375	390	...	...
Trout	605	25	...	...	3,800	142	...	...
Whitefish	200	10	...	...	125	7	...	...
Others	480	12	...	...	4,400	110	...	...
Total	16,005	310	...	...	215,700	3,834	...	...
Seines:								
Herring	...	...	...	...	12,850	180	...	...
Perch	...	...	...	...	32,357	515	...	...
Pike and pike perch	...	...	...	...	13,026	482	...	...
Sturgeon	...	...	...	...	6,250	220	...	...
Suckers	...	...	...	...	38,571	540	...	...
Whitefish	...	...	...	...	3,894	170	...	...
Others	...	...	...	...	9,100	273	...	...
Total	...	...	...	...	116,048	2,380	...	...
Lines, spears, and dip nets:								
Bass	1,456	73	...	...	7,118	356	...	...
Trout	17,112	856	...	...	93,044	4,655	...	...
Total	18,568	929	...	...	100,212	5,011	...	...
Grand total	452,018	10,668	1,388,410	53,751	1,711,722	37,063	22.565	605

Table showing by apparatus and species the yield of the fisheries of Lake Michigan—Cont'd.

Apparatus and species.	Wisconsin.						Total for lake.	
	Racine.		Sheboygan.		Total.			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:								
Bass	...	...	...	...	8,400	$420	14,800	$755
Herring	...	...	81,428	$1,138	1,270,648	17,433	2,103,733	30,321
Perch	...	...	51,300	1,040	287,520	5,819	453,680	10,098
Pike and pike perch	...	...	...	...	185,875	7,451	247,905	9,939
Sturgeon	...	...	...	...	117,990	4,221	844,887	30,224
Suckers	...	...	...	...	232,320	3,747	620,033	10,266
Trout	...	...	92,115	4,145	649,610	29,246	1,513,229	63,761
Whitefish	...	...	17,422	784	195,912	8,697	2,560,456	106,792
Others	...	...	36,842	720	204,202	4,013	426,614	8,120
Total	...	...	279,107	7,827	3,152,477	81,047	8,785,337	270,276
Gill nets:								
Bass	...	...	...	...	17,779	886	20,179	1,006
Herring	118,330	$2,463	86,000	1,720	2,074,359	33,380	3,608,968	67,434
Perch	...	...	...	...	193,965	4,668	427,575	12,020
Pike and pike perch	...	...	...	...	85,110	3,462	85,110	3,462
Sturgeon	...	...	...	...	2,750	100	16,595	636
Suckers	...	...	...	...	544,068	8,403	673,216	10,613
Trout	97,100	4,855	424,200	19,513	2,560,369	120,537	6,409,190	263,322
Whitefish	11,476	468	400,867	13,723	875,946	32,396	2,873,784	111,435
Others	18,983	382	42,800	856	281,491	5,606	372,581	7,394
Total	245,889	8,168	953,867	35,812	6,635,837	209,438	14,487,198	477,322
Fyke nets:								
Bass	...	...	...	...	17,810	890	19,310	950
Herring	...	...	...	...	332,550	4,434	332,650	4,436
Perch	...	...	...	...	418,900	8,838	419,700	8,862
Pike and pike perch	...	...	...	...	141,860	5,553	141,960	5,557
Suckers	...	...	...	...	335,410	3,887	335,410	3,887
Trout	...	...	...	...	10,980	430	11,980	470
Whitefish	...	...	...	...	2,285	115	5,285	235
Others	...	...	...	...	40,750	1,019	44,750	1,161
Total	...	...	...	...	1,300,545	25,166	1,311,045	25,558
Seines:								
Herring	...	...	...	...	26,561	360	36,731	530
Perch	...	...	...	...	107,752	1,870	185,117	3,086
Pike and pike perch	...	...	...	...	49,906	1,809	91,046	3,029
Sturgeon	...	...	...	...	6,250	220	6,250	220
Suckers	...	...	...	...	127,714	1,788	172,124	2,340
Whitefish	...	...	...	...	4,279	185	11,154	465
Others	...	...	...	...	31,440	924	35,910	988
Total	...	...	...	...	353,902	7,156	538,332	10,658
Lines, spears, and dip nets:								
Bass	...	...	...	...	43,707	2,183	88,850	3,766
Perch	...	...	...	...	...	...	457,881	12,575
Sturgeon	...	...	...	...	...	...	79,165	3,173
Trout	...	...	...	...	243,089	12,146	429,768	21,640
Whitefish	...	...	...	...	...	...	4,400	132
Others	...	...	...	...	180,640	3,487	252,290	5,365
Total	...	...	...	...	467,436	17,816	1,312,354	46,651
Grand total	245,889	8,168	1,232,974	43,639	11,910,197	340,623	26,434,266	830,465

LAKE HURON.

Importance of the fisheries.—In proportion to the size of this lake and the natural advantages which it affords, the fisheries are but imperfectly developed, and in the year covered by the investigation presented a decrease as compared with 1885. Both whitefish and trout have undergone a diminution in abundance, as shown by the smaller catch, while the output of herring, sturgeon, pike, and pike perch is larger than in 1885. These changes have been coincident with a slight decrease in the fishing population, and an augmented amount of investment made up chiefly of shore property. In some counties or sections a noticeable improvement has taken place in the fisheries, mostly due to the development of the resources, but in the important fisheries prosecuted from Alpena and in Saginaw Bay the decline has been enough to overbalance the increase in other regions.

Notes on the abundance and distribution of the principal fishes.—The fishes of this lake which deserve special mention are trout, whitefish, pike perch, herring, sturgeon, black bass, yellow perch, catfish, pike, and suckers.

The most important fish in Lake Huron is the lake trout. It is generally distributed in the deeper parts of the lake, and is taken chiefly with gill nets and pound nets, and in small quantities with seines and lines. About a fourth of the total catch is obtained by steamers from Alpena and Huron counties using gill nets between 5 and 50 miles off shore. In the boat gill-net fishing, the largest quantity is secured in Alpena, Chippewa, and Presque Isle counties. This fish is most prominent in the pound-net fisheries of Alpena County, Saginaw Bay, and Iosco County. The average weight of the trout is about 4 pounds.

Whitefish is the second important fish in Lake Huron. It is especially prominent in the pound-net fishery of that part of the lake north of Saginaw Bay and in the gill-net fishery from Alpena. The average weight of the whitefish is about 2 pounds.

Everywhere in this lake the effects of whitefish propagation are manifested and appreciated by the fishermen and fish-dealers. While the output in the year covered by this inquiry was somewhat less than in 1885, the increase in the past few years has been marked. A prominent feature of the fishery for this fish was the unprecedentedly large run in many places of small fish of a size that had not been observed in abundance for many years.

The lake herring is an important fish in the pound-net fishery of this lake. It is most abundant and taken in largest numbers in Saginaw Bay, although it is also caught in relatively large quantities in Alpena, Huron, and St. Clair counties.

While pike and pike perch are taken in greater or less numbers in all the shore waters of the lake, they are economically valuable only in the pound-net and fyke-net fisheries of the Saginaw Bay region.

Sturgeon are generally distributed in this lake, but are nowhere abundant. They are taken only in pound nets in the inshore waters, and much more than half the yield is obtained in Saginaw Bay. The aggregate catch in the year covered by the inquiry was greater than in 1885; the north shore, however, showed a markedly decreased catch, while in Saginaw Bay there was an increased production.

Black bass, perch, catfish, and suckers are noteworthy elements in the fisheries of this lake only in Saginaw Bay and River, where they are caught with pound nets and fyke nets. The most important of these are perch and suckers.

On the north shore of this lake, including the counties of Chippewa and Mackinac, whitefish and trout are the most abundant commercial fishes; sturgeon, lake herring, pike, and pike perch are also taken, but in relatively small quantities. In the fisheries centering at Detour, prosecuted between the north shore of Drummond Island and Albany Island, and 7 miles west of Detour Light, at the entrance of Detour Passage, whitefish were found to be much more abundant than in the preceding few years, while trout and pike perch were yearly growing scarcer. Mr. Benjamin Butterfield, who has fished in this locality for the past thirty-six years, stated to an agent of the Commission that at times in 1890 and 1891 he took as many as 6,000 pounds of whitefish from one small pound at one night's fishing, this being a great many more fish than he and other fishermen were ever able previously to catch in the same time and with the same apparatus during his long experience. Mr. Butterfield attributes the growing increase in whitefish almost entirely to artificial propagation, and remarks that previous to the planting in this locality of whitefish fry from the Alpena station whitefish were becoming very scarce and small fish were seldom caught. In 1890, however, a large part of the yield consisted of fish averaging a little more than 1 pound in weight, and the following year their average weight was 1½ pounds. Mr. Thomas Sims, another experienced fisherman of Detour, agreed with Mr. Butterfield in the foregoing statements, and said that, if the mesh in the pound nets were as small as in former years, on a number of occasions his boat, which has a capacity of 4 or 5 tons, would not have carried the whitefish caught in one small pound net in the course of one night.

Along the shore between St. Ignace and Detour, an increase in the abundance of whitefish as compared with a number of preceding years was reported, the increase being especially marked in Les Cheneaux and Prentice Bay. Trout and some other fish appear to be diminishing in number. One reason assigned by Mr. Isaac Goudreau, Mr. Charles Gronden, and other prominent fishermen for the increase of whitefish in the inshore waters and among the islands is that the fish have been driven from their regular resorts in the lake by the large accumulation on the favorite grounds of sawdust and other refuse from a mill at St. Ignace. The bottom, for a mile from the shore at St. Ignace, was said to be completely covered with sawdust and slabs, which also extended along the shore for 5 or 6 miles below that place. An agent of the Commission, Mr. E. A. Tulian, found the sawdust in large heaps along the shore for 5 miles below St. Ignace, where it had rolled up in such quantities that the farmers in the vicinity were carting it away to be used in leveling roads; the mill at the time of the agent's visit had not been running for six months.

Other causes assigned by the fishermen for the recent increased abundance of this species are artificial propagation and enlargement of the mesh in the bowl of the pound nets.

The principal fishermen of this section think there will be no difficulty in keeping up the supply of whitefish if liberal consignments of fry are planted annually and the size of the mesh in the cribs of the pound nets is regulated so as to permit the escape of immature fish. In the vicinity of St. Ignace the fishermen want also a law to prohibit the pollution of the lake either by sawdust or other refuse, and some favor a close season on all kinds of fishing after November 1 for a period of years in order to give trout and other fish whose abundance has decreased a better opportunity to multiply.

In the fisheries of the southern side of the Strait of Mackinac and the adjacent western shore of Lake Huron, whitefish constitute fully nine-tenths of the catch, the remaining species consisting of trout, pike perch, herring, and sturgeon. During the last two years the number of whitefish in the fisheries tributary to Mackinac City have been steadily increasing.

The only dealer at Mackinac City who has bought and handled fish caught in that vicinity during the past six years says that it has been no uncommon thing in the last two years to take 2,500 pounds of whitefish from one small pound net in one night's fishing, while in previous years if half that quantity was taken under similar circumstances it was considered a big catch; he is satisfied that the fish now being caught were planted in that vicinity by the United States and Michigan fish commissions.

In the vicinity of Cheboygan, while a great many trout are caught, whitefish is the principal species. Every fisherman in this region has commented on the very large increase in the number of whitefish caught during the past two years. Mr. Maynard Corbett, of the fishing firm of Corbett & Duffy, stated that he had fished in that vicinity for twenty-five years, and up to two or three years ago the whitefish were becoming scarcer each season, but during the past three years they have undergone a marked increase in abundance. He is positive it is the result of artificial propagation. He bases this opinion partly on the circumstance that up to the last few years he never saw many small whitefish around the grounds. In the spring of 1891, on the day when his pound net on the east side of Bois Blanc Island was first hauled, the whitefish completely filled the bowl and the net contained at least

10 tons of fish, but when they drew it to get out the fish all but 9 fish were so small that they made their escape through the meshes.

Mr. Charles Corbett stated that he had seen just such a condition in his nets at Hammond Bay. He and others think there is no doubt that the fish they are now catching in Hammond Bay are fish that were artificially hatched. The results of propagation are here so marked and so thoroughly appreciated by the fishermen that they earnestly desire a continuance of fish-cultural work, and the principal fishermen are anxious to see the beneficial effects of fish-culture supplemented by an enlargement of the mesh in the pots of the pound nets, so as to permit the escape of small fish.

In the gill-net fisheries of Presque Isle County, centering at Rogers City, most of the catch consists of trout, although a few whitefish are also taken. Trout at this place are gradually decreasing, but whitefish appear to be holding their own.

Trout is the most abundant and important fish in the extensive fisheries carried on from Alpena and other places in Alpena County. Whitefish rank next in importance. Four-fifths of the catch in the gill nets operated from small boats consists of trout and the rest of whitefish. A few thousand pounds of Menominee whitefish are also thus taken. In the gill-net fisheries carried on with steamers the relative proportions of trout and whitefish are the same. The lake herring is the prominent fish taken in pound nets; after which come trout, sturgeon, whitefish, pike, and pike perch. During the year covered by the inquiries of the Fish Commission no special increase in the abundance of whitefish in this county was noted. In the fall of the previous year, however, the fish came to the shoals north of Thunder Bay Island in very large numbers, and a better catch was made than at any time for many years previous. In the fall of 1890 the advent of another large body of fish appeared to be imminent, when a protracted spell of stormy weather caused the fish to leave the shoals. Indications at the time pointed to a larger run of fish than had been observed in that region for ten years. The fishermen are quite enthusiastic over the prospects of good fishing, which they attribute almost entirely to artificial propagation. They think, however, that the results would be more marked if it were not for the damage done by the large amount of refuse from sawmills thrown into the water along this shore, causing the fish to seek other parts of the lake. The increase of whitefish in Georgian Bay in recent years has been pronounced.

In the report on the fisheries of the Great Lakes in 1885 the following statements were made regarding the causes of the decrease of fish in the Alpena fisheries:

At first whitefish and trout were both abundant, and fishermen found no difficulty in catching with a few small gill nets as many fish as they could sell. But since 1881 or 1882 they have been comparatively scarce. Various causes are given for this decrease. The gill-net fishermen lay the blame on the small-meshed pound nets. The pound-net fishermen, on the other hand, throw the responsibility upon the sawmills and the gill-net men. The sawmills, they say, pollute the waters with sawdust and vegetable refuse, and the gill-net men lose a great many nets, which, with the fish in them, soon decay and become a putrid mass, which contaminates the fishing-grounds and causes the fish to leave for other places. Mr. S. P. Wires reports: "On two questions they all agree. First, twenty years and less ago the waters on the shores of Alpena County swarmed with whitefish and trout. Second, to-day these fish are not abundant. In 1883 the trap-net grounds of Thunder Bay failed for the first time, and the fishing in 1884 was equally as bad."

The same authority says that in his own opinion (as one interested in the fisheries, but not actively concerned either with gill nets or trap nets) the decrease is owing mainly to excessive and unwise fishing, especially during the spawning season. When whitefish were abundant their favorite spawning-ground was a shoal about 5 miles from the shore, which they visited in countless numbers during the month of November. On this ground it was not an uncommon thing to catch in one net 200 pounds of whitefish during a single night, and boats often returned to their fish-houses with from 20 to 30 barrels, taken at a single lift from a gang of twenty or more gill nets. During a season hundreds and thousands of barrels of whitefish were thus caught, the females being full of spawn, which was left to rot in the offal pile. The water on the spawning-ground is 5 or 6 fathoms in depth, and being fully exposed to the seas that roll on Lake Huron in November is stirred to the bottom whenever a gale is raging from the northeast or southwest. At such times hundreds of gill nets loaded with fish were swept away and never recovered by the fishermen, but remained on the bottom polluting the waters. Mr. Wires further states: "Weeks before the spawning season commenced the gill nets and trap nets had been at work catching fish full of unripe spawn. Is it, therefore, any wonder that whitefish have decreased in numbers, and that once valuable fisheries have become almost barren and worthless?" He says the fishermen look to artificial propagation to restore the abundance of fish in this locality.

In the fisheries of Alcona County whitefish, herring, and Menominee whitefish are the only species taken. The decrease in the abundance of fish at this place is doubtless attributable to the fact that the best grounds formerly frequented by whitefish are literally covered with refuse from the sawmill, consisting of bark and sawdust. Mr. Edward Miller, of Alcona, and Capt. J. E. Henderson, of Sturgeon Point, in this county, stated that they had recently seen a great many small whitefish and thought they were fish that had been put into the lake by the fish commissions, as no fish of similar size had been observed for a great many years before.

Along the shores of Iosco County there is so much refuse from sawmills thrown into the water that most of the fish are kept at some distance from the shore, and pound nets can not be fished to advantage. Even when the gill nets are set 6 or 8 miles from the shore, they are often found full of bark, logs, etc., after a storm. Mr. James McCoy, one of the oldest fishermen of Au Sable, states that he has had nets completely ruined in two or three days by getting rolled up on the bottom with a slime from decayed bark, etc., causing them to rot very rapidly and become absolutely worthless. In the fisheries of Oscoda, Au Sable, and vicinity trout are the most abundant fish taken with gill nets and hooks, while whitefish and herring are the principal fish caught in pound nets. A few sturgeon, pike perch, and other fish are also taken in pound nets in the spring fishery. The average weight of the whitefish taken in gill nets is 4 to 6 pounds, though many fish weighing from 20 to 22 pounds (dressed) are caught. In the pound nets the average weight of whitefish is 2½ to 3 pounds. During the past two or three years a great many small fish have been secured in pound nets. In the fisheries of East Tawas and Tawas City, in this county, there have, according to Mr. William Brashau and Mr. Joseph Trudell, been unmistakable signs of good results from whitefish propagation. Notwithstanding the deleterious influence of large quantities of sawdust and other mill refuse thrown on the fishing-grounds from mills at Oscoda, Au Sable, East Tawas, and Tawas City, a larger run of small whitefish has been observed than in many years.

The principal fish taken in the important fisheries of Saginaw Bay are herring, perch, catfish, pike, pike perch, suckers, trout, and whitefish, of which the pike and pike perch combined are the most important. All of the principal fishermen in this region are ardent advocates of artificial propagation as a means of keeping up and increasing the supply of fish. Many of the fishermen in this locality are desirous of having the supply of "pickerel" (pike perch) increased by fish-culture.

Messrs. C. Porter, James McCoy, I. S. Osborn, of Au Sable; Joseph Lixey, of Oscoda, and other prominent fishermen of Iosco County, have seen unmistakably good results from artificial propagation in their section, but think that whitefish will never be very abundant again until the throwing of mill refuse into the lake is prevented and the taking of small, immature fish is prohibited.

In the fisheries of Huron County, which borders partly on Saginaw Bay and partly on the lake, herring and pike perch are the most prominent fish, although whitefish and other species are also taken, and in the offshore gill-net fishery from Port Hope and in the set-line fishery trout are obtained. The herring and whitefish resort to the shores in October and November, when most of the catch is taken. The pike perch are found in greatest abundance in spring, but there is also a good run in fall. While trout are uncommon, the fish are large, averaging 10 or 12 pounds in weight. The weights of the other fish are as follows: Whitefish, 4 to 5 pounds; herring, one-half or three-fifths of a pound; pike perch, 3 to 9 pounds. A great many smaller pike perch are also taken and sold as second-quality fish.

Along the shores of this lake south of Saginaw Bay the most abundant fish is the herring. It is most numerous during the months of October, November, and December, and is taken in pound nets; its average weight is three-fifths of a pound. It appears to be much more abundant than in 1885, judging by the quantity taken and sold. Next in value are sturgeon, pike perch, trout, and whitefish, although the fishery for none of these is important as compared with that in the upper part of the lake. The sturgeon have an average weight of 40 pounds, when dressed; the pike perch weigh 2 pounds, the trout 5 pounds, and the whitefish 4 or 5 pounds.

Apparatus and methods.—The pound net is the principal kind of apparatus employed in the fisheries of this lake. It is used in every county, except one, bordering on the lake, and takes larger quantities of fish than all other means combined. The nets are constructed and operated similarly to those in other lakes, and the fishery presents no peculiarities which merit special mention.

Among the fishing interests of the lake there is a general agitation of the question of the size of mesh in the pound nets. The principal fishermen think the mesh should be made large enough to let small fish pass through. While in some places, in the past few years, an advance has taken place in this matter—the mesh being changed from 2½ to 3½ inches—it is held that after the shrinking, which ensues when the twine has been in use for some time, a 3½-inch mesh becomes reduced in size to a 2½-inch mesh; and it is urged by the most thoughtful fishermen that the mesh should be large enough originally to remain at least 3½ inches after shrinking, some even recommending a 4-inch mesh.

Many of the fishermen of Saginaw Bay advocate a law which will prohibit the bringing ashore and offering for sale, by fishermen or dealers, of whitefish and pike perch under a certain size, and which will prevent the fishermen from using small-mesh nets; they would also like to see it made it obligatory on the fishermen to scoop out of their nets and liberate all small whitefish and pike perch which they catch.

Gill nets are generally used in the American waters of the lake, and are especially prominent as a means of capture in Alpena and Presque Isle counties, where the larger quantity of the fish is thus taken, and in Chippewa, Huron, and Iosco counties, where the gill-net catch is a conspicuous part of the yield of the fisheries. The length of the nets varies from 200 to 800 feet, averaging about 500 feet; the depth is usually 5 to 6 feet; and the mesh in the whitefish and trout nets is about 4½ inches. The average cost of the nets is $10.

In proportion to the extent of its fisheries, fewer fishing steamers are owned in Lake Huron than in any other lake, and the gill-net fishery carried on with steamers is now rather less extensive than in 1885. In that year 7 tugs were employed in operating gill nets in addition to 1 other engaged in collecting fish. At the time of the last inquiry, however, only 3 fishing steamers belonging in the lake were found, while 4 vessels were ascertained to be in the collecting trade. In addition to these, 2 tugs from Detroit fished in this lake a part of the season, making their headquarters at Alpena. It has been considered advisable to credit these to Detroit, where owned, especially in view of the fact that they were also operated in another lake during part of the year; their catch in Lake Huron amounted to about 274,000 pounds of trout and whitefish, valued at $13,700.

In the vessel gill-net fishery only trout and whitefish are caught; of these, trout are much more valuable. Statistics show that in the year covered by the inquiry, 335,775 pounds of trout were caught, while only 71,300 pounds of whitefish were taken; these were worth, respectively,

$11,899 and $2,502. The larger catch of trout is attributable to the facts that trout is the fish principally sought, and that the fishing is carried on mostly in the deeper water, where that fish is naturally more abundant.

Set lines in this lake are used in commercial fishing only in the counties of Huron, Iosco, and Sanilac. Trout is the only fish taken. Herring, caught mostly in seines, are used for bait. The most important set-line fishery is in Iosco County, where set lines are fished mostly in April and May, and again between September 15 and November 15. A few are also used in winter, when the weather and ice will permit. In Huron County, while gill-net fisheries are ordinarily the most important, during cold winters, when the ice forms along the shore and remains stationary, a considerable amount of set-line fishing is done, especially when herring bait is plentiful. The fishing depends to a great extent upon the weather and the supply of bait, and is done whenever the men can venture upon the ice and bait is obtainable. In Sanilac County most of the hook fishing is done from Port Sanilac by men who at other times are also engaged in the pound-net fishery.

Fyke nets are employed only in Saginaw Bay and River and on the shores of Huron County. They are most numerous and take the largest quantities of fish in Saginaw Bay and River. The principal fishing in Saginaw River is done with fyke nets, here called "gobblers," or "hoop nets," which are also set in small numbers in the bay at or near the mouths of the smaller rivers which empty into it. The fyke nets are made after the model of a pound net, with the exception of the pot, which is similar to the pot of a Lake Erie fyke net.

Seine fishing in this lake is unimportant. Seines are used only in Chippewa and Iosco counties, and are there employed only to a limited extent. The single seine operated in Chippewa County took only small quantities of pike and pike perch; in Iosco County, 5 seines were hauled for whitefish, trout, perch, pike perch, and pike.

Fishing-grounds.—The principal gill-net grounds in that part of the lake adjacent to Detour are about 2 miles south of Drummond Island. The pound nets are set at Hay Point on Drummond Island, among the smaller islands off the north shore of that island, and at Albany Island.

The best gill-net grounds frequented by the fishermen of St. Ignace and Mackinac Island are south of St. Ignace Point and in the vicinity of Mackinac and Round Islands. The best pound-net grounds are in Les Cheneaux and Prentice Bay.

The gill net fishermen of the northern part of Cheboygan County frequent the same grounds as those from St. Ignace. An important gill-net ground is Spectacle Reef, where trout resort to spawn, and are caught with gill nets between October 1 and December 1.

The principal trout grounds frequented by the steam tugs of Alpena are from 40 to 50 miles from shore. Big Reef, 40 miles off Alpena, is an important feeding and spawning ground for trout, which are here found in largest numbers in October and November. The sailboats go out from 10 to 15 miles from shore. Prior to May 1, tugs fish on grounds from 10 to 20 miles from shore; after that date they move the nets to the outside grounds, where they remain until the last of October or the first of November, when they again move their nets to the inside grounds, some vessels going to the trout grounds and some to the whitefish grounds about 8 miles northeast of Thunder Bay Island.

The principal grounds resorted to by the sailboats using gill nets for trout are outside of Thunder Bay and Middle islands, while during the latter part of the season fishing is carried on for whitefish in the immediate vicinity of the islands. The gill-net fishing carried on from rowboats is prosecuted within a few rods of the shores of Middle, Sugar, and Thunder Bay islands, trout being there found in the early part of the season and whitefish during the month of November.

The gill-net grounds in Iosco County are from 6 to 15 miles off shore, the great amount of mill refuse preventing the satisfactory use of gill nets nearer to the shore. The same condition is unfavorable to the use of pound nets, which can be used to advantage only where narrow ridges running out into the lake are kept comparatively clean by the action of the water sweeping up and down the shore.

A few small pound nets are fished in Saginaw River, but the principal fishing-ground for pound nets is the bay. The grounds on which the bay pound nets are set extend all along the east and west shores of that body of water. Pound nets are also fished around the Big and Little Charity islands lying off the mouth of the bay. It is in the latter region that the greater part of the trout are caught. In former years, before lumbering was extensively carried on, this region contained excellent grounds, where whitefish resorted and were caught in large numbers. The present whitefish catch, however, is small in proportion to the large number of nets.

The grounds off the shore of Huron County were formerly among the best whitefish grounds in Lake Huron and, while a great deal of bark from rafts is now scattered along the bottom, these grounds are in good condition as compared with a few years ago, when lumbering was carried on more extensively all along the shore and many sawmills were throwing sawdust, bark, and slabs into the lake. The fishermen think that if large plants of whitefish were now made here the results would be more satisfactory.

Off the shore of Sanilac County the gill-net grounds are in the track of the regular steamers plying up and down the lake, and often after a gale the fishermen will find their nets full of coal clinkers, which have been thrown overboard from steamers and which, when the nets are spread out on the bottom by the force of the current, become entangled in the meshes; the clinkers also cut and destroy the nets. Great injury to the fishing-grounds has naturally been the result of this condition. The grounds off this shore have in past years been very productive; they were, however, destroyed by refuse from sawmills. At the present time the absence of sawmills along this part of the lake makes the fishermen desirous of restoring the productiveness of the grounds, and they are very anxious that fish-culture shall come to their aid. Mr. Tulian, who has had extensive fish-cultural experience, thinks that if small plants of whitefish were made along the shore of this county each spring much better results would be attained than can be expected in the vicinity of Alpena, Oscoda, and East Tawas, for the reason that there appears to be an entire absence of mill refuse along this shore.

Fishing season.—On the north shore, where the principal fishing is done with pound nets, most of the whitefish pounds are operated from about May 1 to November 25, but if the fishing is not satisfactory some of the nets are taken out about July 1 and put in again about September 1. During May and June some of the smaller pound nets are fished for pike and pike perch among islands north of Drummond Island. The larger gill nets, which take mostly trout and occasionally small quantities of whitefish, are fished from May 1 to November 20; the smaller gill nets, which take only trout, are used during October.

The trout gill-net season of Cheboygan County covers parts of the months of October and November; a few trout are also caught in pound nets during the entire open season. Whitefish, which are principally taken in pound nets, are caught from May 15 to November 20, but the best season is between June 15 and August 15. In the gill-net fisheries centering at Cheboygan, trout are caught from May 1 to July 1 in deep water and from October 1 to December 1 on the spawning-grounds. Herring are taken along the shores early in spring and late in fall. Pound nets are operated mostly from the opening of navigation until August 1, although a few are also fished in fall.

In the gill-net fishery of Presque Isle County, the fishing begins about May 1 and extends to July 1; it is resumed September 15 and continues until November 15. When fish are particularly plentiful, some fishing is also done in July and August. Up to November 1 only trout are taken; after that time a few whitefish are caught.

The sailboats fishing gill nets for trout begin operations about May 1 and continue until November 5; during the balance of the season they take whitefish. Gill nets fished from rowboats are set from September 1 to November 1 for trout and from November 1 to November 20 for whitefish. Pound nets along the shore of this county are put in between May 15 and July 1, and remain down continuously until about November 25.

Steam tugs, used in the gill-net fisheries of Alpena County, are employed from early in the spring until the latter part of October. The tugs begin fishing as soon as the ice weakens sufficiently to allow them to force their way through to the open water. Sometimes they go out as early as March 1, but it is often the 1st of April before the season is opened.

In Alcona County pound nets are fished only in October and November for whitefish and herring, and gill nets from the opening of navigation to about June 1 for Menominee whitefish and herring, both kinds of nets being fished by the same persons.

At Tawas and East Tawas, in Iosco County, pound nets are set as soon as possible after the opening of navigation, and are fished continuously until about July 15, when they are taken out; they are again put in operation in the latter part of August and used till the last of November. At Oscoda and Au Sable, however, most of the nets are fished only in October and November, when the herring and whitefish come on the shores; a few pounds are also fished during the early part of the open season, for sturgeon, pike, etc. Gill nets and fyke nets are used from the opening to the closing of navigation. Herring are found in the inshore waters only in fall, and it is only then that they are caught; some whitefish and trout are taken in spring, but the greater part of the catch is in fall; the run of pike perch and sturgeon is almost confined to the spring months.

In the pound-net fisheries of this region whitefish and herring are caught mostly in fall, while numbers of pike perch are taken in spring. The other fish occurring are obtained in greater or less quantities throughout the entire spring and fall fishing season, although larger quantities are taken in spring, for the reason that the bay pound nets are fished only during that time.

Statistics.—In the following tables the extent of the fisheries of each county bordering on this lake is shown. Separate tables are given for the persons engaged; the number and value of vessels, boats, apparatus, etc., employed; the quantity and value of the catch of each important species, and the quantity and value of the products taken with each kind of apparatus.

Three vessels belonging at Detroit, Mich., fished during a part of the year in Lake Huron. They, with the crews and catch, have been included in the statistics for that city. Their combined tonnage was 29.93, and their value, with outfit, was $18,800; their fishing gear consisted of 639 gill nets, 447,300 feet in length, valued at $7,668. Twenty-one men constituted their crews. The quantity of fish taken by them while in Lake Huron was 244,847 pounds of trout worth $12,242, and 29,064 pounds of whitefish valued at $1,453.

Table showing by counties the number of men employed in the fisheries of Lake Huron.

Counties.	How engaged.				
	On fishing vessels.	On transporting vessels.	In shore fisheries.	On shore, in fish-houses, etc.	Total.
Alcona			5		5
Alpena	8	2	44	18	72
Arenac, Bay, Saginaw, and Tuscola		4	273	64	341
Cheboygan			21	6	27
Chippewa			49	6	55
Huron	10	2	48	6	66
Iosco			52	4	56
Mackinac			47	4	51
Presque Isle			9	2	11
St. Clair			23		23
Sanilac			19		19
Total	18	8	590	110	726

Table showing by counties the apparatus and capital employed in the fisheries of Lake Huron.

Designation.	Alcona.		Alpena.		Arenac, Bay, Saginaw, and Tuscola.		Cheboygan.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing			1	$4,500				
Tonnage			15.57					
Outfit				1,500				
Vessels transporting			1	500	2	$1,800		
Tonnage			10.38		19.36			
Outfit				25		65		
Boats	4	$90	26	2,810	196	9,619	20	$995
Apparatus of capture:								
Pound nets	6	750	36	16,300	326	34,165	25	5,050
Gill nets	20	80	915	12,800			185	540
Fyke nets					170	6,075		
Shore property		1,075		39,085		117,015		9,385
Cash capital				15,000		16,350		3,500
Total		1,995		92,520		185,089		19,470

Designation.	Chippewa.		Huron.		Iosco.		Mackinac.	
	No.	Value.	No.	Value.	No.	Value	No.	Value.
Vessels fishing			2	$5,200				
Tonnage			22.37					
Outfit				460				
Vessels transporting			1	500				
Tonnage			11.37					
Outfit				40				
Boats	32	$2,590	30	1,239	30	$1,265	38	$1,825
Apparatus of capture:								
Pound nets	28	6,450	44	8,900	29	5,850	25	5,400
Gill nets	190	1,900	136	1,005	130	720	260	1,900
Seines	1	100			5	500		
Fyke nets			51	310				
Lines				350		200		
Shore property		11,660		12,545		4,875		9,805
Cash capital		2,000		2,050		500		5,000
Total		24,700		32,599		13,910		23,930

Designation.	Presque Isle.		St. Clair.		Sanilac.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing							3	$9,700
Tonnage							37.94	
Outfit								1,960
Vessels transporting							4	2,800
Tonnage							41.11	
Outfit								130
Boats	3	$300	17	$980	14	$595	410	22,308
Apparatus of capture:								
Pound nets			21	3,225	11	2,425	551	88,515
Gill nets	220	2,220			150	500	2,206*	21,665
Seines							6	600
Fyke nets							221	6,385
Lines						220		770
Shore property		1,175		600		1,405		208,625
Cash capital		1,000						45,400
Total		4,695		4,805		5,145		408,858

*Length of gill nets, 1,125,060 feet.

Table showing by counties and species the yield of the fisheries of Lake Huron.

Species.	Alcona.		Alpena.		Arenac, Bay, Saginaw, and Tuscola.		Cheboygan.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass, fresh					28,725	$2,129		
Catfish, fresh					160,738	5,085		
Herring, fresh	7,900	$218	150,000	$3,000	1,430,934	14,302	24,480	$357
Perch, fresh					1,745,892	20,354		
Pike and pike perch, fresh			20,000	500	1,206,807	41,232	1,346	48
Sturgeon, fresh			50,000	1,000	179,000	3,580	1,170	39
Suckers, fresh					1,090,177	15,272		
Trout, fresh			749,000	23,750	151,262	5,911	35,760	1,069
Whitefish, fresh	2,500	170	199,000	6,350	100,868	4,083	224,030	8,243
Other fish, fresh					54,000	1,080		
Total	10,400	388	1,168,000	34,600	6,148,403	113,028	286,786	9,756

Species.	Chippewa.		Huron.		Iosco.		Mackinac.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass, fresh			626	$38				
Catfish, fresh			11,433	343				
Herring, fresh			543,920	4,110	6,000	$20	11,717	$176
Herring, salted					130,700	2,796		
Perch, fresh	2,000	$20	67,736	398	2,000	20		
Pike and pike perch, fresh	30,716	614	152,093	5,503	18,000	730	8,788	263
Sturgeon, fresh	19,972	533	24,173	581	28,350	568		
Suckers, fresh			20,000	100				
Trout, fresh	142,736	4,282	76,627	3,138	153,000	6,270	58,979	1,769
Trout, salted					5,000	300		
Whitefish, fresh	213,634	7,652	24,444	1,143	75,800	3,558	126,978	4,444
Whitefish, salted					1,400	112		
Total	409,058	13,101	921,052	15,354	420,250	14,374	206,462	6,652

Species.	Presque Isle.		St. Clair.		Sanilac.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass, fresh							29,351	$2,167
Catfish, fresh							172,171	5,428
Herring, fresh			130,000	$2,250	78,900	$952	2,383,851	25,385
Herring, salted							130,700	2,796
Perch, fresh							1,817,628	20,792
Pike and pike perch, fresh			43,322	1,870	2,000	74	1,483,072	50,834
Sturgeon, fresh			54,653	2,419	8,400	204	365,718	8,924
Suckers, fresh							1,110,177	15,372
Trout, fresh	101,000	$3,030	9,755	390	22,500	1,133	1,500,619	50,742
Trout, salted							5,000	300
Whitefish, fresh	15,000	450	5,940	297	14,500	745	1,002,694	37,135
Whitefish, salted							1,400	112
Other fish, fresh							54,000	1,080
Total	116,000	3,480	243,670	7,226	126,300	3,108	10,056,381	221,067

Table showing by counties and apparatus the yield of the fisheries of Lake Huron in 1890.

Apparatus and species.	Alcona.		Alpena.		Arenac, Bay, Saginaw, and Tuscola.		Cheboygan.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:								
Black bass, fresh					21,075	$1,364		
Catfish, fresh					155,638	4,932		
Herring, fresh	6,700	$182	150,000	$3,000	1,430,934	14,302	8,480	$117
Perch, fresh					1,226,446	12,563		
Pike and pike perch, fresh			20,000	500	1,104,807	35,112	1,346	48
Sturgeon, fresh			50,000	1,000	179,000	3,580	1,170	39
Suckers, fresh					742,622	8,321		
Trout, fresh			60,000	1,800	151,262	5,911	21,760	649
Whitefish, fresh	1,700	114	20,000	600	100,868	4,083	220,530	8,108
Miscellaneous fish, fresh					13,200	264		
Total	8,400	296	300,000	6,900	5,125,852	90,432	253,286	8,961
Gill nets:								
Herring, fresh	1,200	36					16,000	240
Trout, fresh			689,000	21,950			14,000	420
Whitefish, fresh	800	56	179,000	5,750			3,500	135
Total	2,000	92	868,000	27,700			33,500	795
Fyke nets:								
Black bass, fresh					7,650	765		
Catfish, fresh					5,100	153		
Perch, fresh					519,446	7,791		
Pike and pike perch, fresh					102,000	6,120		
Suckers, fresh					347,555	6,951		
Miscellaneous fish, fresh					40,800	816		
Total					1,022,551	22,596		
Grand total	10,400	388	1,168,000	34,600	6,148,403	113,028	286,786	9,756

Apparatus and species.	Chippewa.		Huron.		Iosco.		Mackinac.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:								
Black bass, fresh			626	$38				
Catfish, fresh			11,433	343				
Herring, fresh			541,570	4,086			11,717	$176
Herring, salted					130,700	$2,796		
Perch, fresh	2,000	$20	28,736	168				
Pike and pike perch, fresh	20,716	414	146,093	5,293	16,000	650	8,788	263
Sturgeon, fresh	19,972	533	24,173	581	28,350	568		
Trout, fresh	7,137	214	9,502	416	43,000	1,815	17,576	527
Whitefish, fresh	207,517	7,438	22,944	1,081	60,200	2,876	123,038	4,306
Total	257,342	8,619	785,077	12,006	278,250	8,705	161,119	5,272
Gill nets:								
Herring, fresh			1,350	14				
Trout, fresh	135,599	4,068	51,775	2,099	85,000	2,975	41,403	1,242
Trout, salted					5,000	300		
Whitefish, fresh	6,117	214	1,300	52	14,600	632	3,940	138
Whitefish, salted					1,400	112		
Total	141,716	4,282	54,425	2,165	106,000	4,019	45,343	1,380
Fyke nets:								
Herring, fresh			1,000	10				
Perch, fresh			39,000	230				
Pike and pike perch, fresh			6,000	210				
Suckers, fresh			20,000	100				
Whitefish, fresh			200	10				
Total			66,200	560				
Seines:								
Herring, fresh					6,000	20		
Perch, fresh					2,000	20		
Pike and pike perch, fresh	10,000	200			2,000	80		
Trout, fresh					1,000	40		
Whitefish, fresh					1,000	50		
Total	10,000	200			12,000	210		
Lines:								
Trout, fresh			15,350	623	24,000	1,440		
Grand total	409,058	13,101	921,052	15,354	420,250	14,374	206,462	6,652

Table showing by counties and apparatus the yield of the fisheries of Lake Huron in 1890—Continued.

Apparatus and species.	Presque Isle.		St. Clair.		Sanilac.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:								
Black bass, fresh							21,701	$1,402
Catfish, fresh							167,071	5,275
Herring, fresh			130,000	$2,250	78,900	$952	2,358,301	25,065
Herring, salted							130,700	2,796
Perch, fresh							1,257,182	12,751
Pike and pike perch, fresh			43,322	1,870	2,000	74	1,363,072	44,224
Sturgeon, fresh			54,653	2,419	8,400	204	365,718	8,924
Suckers, fresh							742,622	8,321
Trout, fresh			9,755	390	9,300	445	329,292	12,167
Whitefish, fresh			5,940	297	14,200	733	776,937	29,636
Miscellaneous fish, fresh							13,200	264
Total			243,670	7,226	112,800	2,408	7,525,796	150,825
Gill nets:								
Herring, fresh							18,550	290
Trout, fresh	101,000	$3,030			4,700	188	1,122,477	35,972
Trout, salted							5,000	300
Whitefish, fresh	15,000	450			309	12	224,557	7,439
Whitefish, salted							1,400	112
Total	116,000	3,480			5,000	200	1,371,984	44,113
Fyke nets:								
Black bass, fresh							7,650	765
Catfish, fresh							5,100	153
Herring, fresh							1,000	10
Perch, fresh							558,446	8,021
Pike and pike perch, fresh							108,000	6,330
Suckers, fresh							367,555	7,051
Whitefish, fresh							200	10
Miscellaneous fish, fresh							40,800	816
Total							1,088,751	23,156
Seines:								
Herring, fresh							6,000	20
Perch, fresh							2,000	20
Pike and pike perch, fresh							12,000	280
Trout, fresh							1,000	40
Whitefish, fresh							1,000	50
Total							22,000	410
Lines:								
Trout, fresh					8,500	500	47,850	2,563
Grand total	116,000	3,480	243,670	7,226	126,300	3,108	10,056,381	221,067

LAKE ST. CLAIR AND THE ST. CLAIR AND DETROIT RIVERS.

General sketch of the fisheries.—While not one of the Great Lakes, Lake St. Clair has fisheries of sufficient importance to entitle it to separate mention, and the lake and its two tributary rivers have a geographical position that is distinct enough to warrant their consideration under one head.

In proportion to the quantity and value of the catch a relatively large number of persons are employed in the fisheries of this section and a comparatively large capital is invested. The disparity is due, on the one hand, to the existence of many semi-professional fishermen, and on the other, to the presence of large wholesale fish-houses, which depend for their receipts on the fisheries of various other sections. Pound nets are the most prominent apparatus used, and seines rank next; fyke nets, lines, and spears complete the list of fishing appliances. The most valuable fish here found is the whitefish, which exists throughout the lake and the two rivers, but is taken in largest quantities in the lake. Perch, sturgeon, pickerel, and herring are the other principal species.

The fishing in the St. Clair River is of slight extent. Important pound-net fishing, maintained at Port Huron, is carried on in Lake Huron, and has been credited to that lake. The principal fishing centers in the river itself are Roberts Landing, Marine City, St. Clair, and Algonac. A few haul seines are fished for wall-eyed pike, but the largest quantities of fish are taken with hand and troll lines. Yellow perch are caught with hand lines and wall-eyed pike and pike by trolling. The line fishery is semi-professional, and is carried on during the months of May, June, July, and August, but chiefly from the middle of June to the middle of July.

The principal fishing in Lake St. Clair is carried on in Anchor Bay and on the shore immediately north of Detroit, the chief apparatus used being pound nets, fyke nets, and haul seines. In Anchor Bay the fishing centers are Fair Haven, Anchorville, and New Baltimore. The fishes of commercial importance found in the lake are yellow perch, suckers, catfish, sturgeon, black bass, wall-eyed pike, pike, herring, and muskellunge. In Anchor Bay there is some winter fishing through the ice with lines and spears, chiefly for perch. The pound-net fishery is much more important than any of the others and yields somewhat more than half the catch of this entire region. The specially prominent fish thus obtained are whitefish, sturgeon, pike, pike perch, and herring, whitefish and herring being most abundant in the lower part of the lake along the shore adjacent to the entrance to the Detroit River.

The fisheries of the Detroit River are at the present time of little value. The only commercial fishing on the American side is carried on with seines from the early part of October to the last of November, the catch being relatively small and consisting chiefly of whitefish, herring, and pike. The fisheries have greatly declined since 1885, when the industry was at a low ebb. In earlier years there was a great abundance of whitefish in this river, and the annual yield was very large. Mr. James Craig, of Detroit, who has for many years engaged in the fish business of that city, informs us that near Fort Wayne, now within the city limits of Detroit, the average catch of whitefish in haul seines was from 18,000 to 21,000 fish, weighing, on an average, from $2\frac{1}{2}$ to $2\frac{7}{8}$ pounds. On November 12, 1871, at one haul of a seine, 3,100 whitefish were caught. With the growth of the city and the increase in the amount of sewage entering the river, the fisheries have declined to their present condition. The number of whitefish taken in the vicinity of Fort Wayne in 1890 was only 3,000, and the output of the entire river was only 35,500 pounds.

Statistics of the fisheries.—In the following tables the fisheries of this region are shown, the extent of the industry in each county being exhibited. Included in the statistics are the vessel fisheries prosecuted from Detroit in lakes Huron and Erie. The vessels are owned in Detroit, to which place the catch is sent. The fact that the vessels fished in more than one lake has made it desirable to treat them as indicated, the quantity of fish taken in each lake being shown in a footnote to the general products tables.

Table showing by counties the number of persons employed in the fisheries of Lake St. Clair and St. Clair and Detroit rivers in 1890.

Counties.	On fishing vessels.	In shore fisheries.	On shore.	Total.
Macomb		350		350
St. Clair		98	13	111
Wayne	28	69	53	150
Total	28	517	66	611

Table showing by counties the yield of the fisheries of Lake St. Clair and the St. Clair and Detroit rivers in 1890.

Species.	Vessel fisheries, Wayne.		Shore fisheries.							
			Macomb.		St. Clair.		Wayne.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass			8,900	$534	186	$10			9,086	$544
Catfish			14,125	365	2,150	51	10,000	$200	26,275	616
Herring	297,934	$2,979	36,000	540	60,000	750	96,400	1,528	192,400	2,818
Perch	29,243	877	636,000	7,790	49,350	753	48,500	740	733,850	9,283
Pike and pike perch	46,276	1,851	116,750	3,860	230,143	7,762	131,500	4,060	478,393	15,682
Sturgeon			93,800	2,355	19,203	539	196,000	4,900	309,003	7,794
Trout	244,847	12,242								
Whitefish	29,064	1,453	54,200	3,260			155,500	10,040	209,700	13,300
Other fish			225,500	1,533			163,000	2,605	388,500	4,138
Total	*647,364	19,402	1,185,275	20,237	361,032	9,865	800,900	24,073	2,347,207	54,175

Species.	Grand total.	
	Pounds.	Value.
Black bass	9,086	$544
Catfish	26,275	616
Herring	490,334	5,797
Perch	763,093	10,160
Pike and pike perch	524,669	17,533
Sturgeon	309,003	7,794
Trout	244,847	12,242
Whitefish	238,764	14,753
Other fish	388,500	4,138
Total	2,994,571	73,577

*Of these fish, 273,911 pounds (244,847 trout and 29,064 whitefish) were taken in Lake Huron and 373,453 pounds (297,934 herring, 46,276 pike perch, and 29,243 perch) in Lake Erie, by vessels owned in Detroit, Mich.

Table showing by counties the apparatus and capital employed in the fisheries of Lake St. Clair and St. Clair and Detroit rivers in 1890.

Designation.	Macomb.		St. Clair.		Wayne.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing					4	$21,000	4	$21,000
Tonnage					38.56		38.56	
Outfit						3,400		3,400
Boats	49	$1,750	77	$1,060	36	1,565	162	4,375
Apparatus of capture, vessel fisheries:								
Gill nets					814	9,418	*814	9,418
Apparatus of capture, shore fisheries:								
Pound nets	9	2,700	5	750	20	6,000	34	9,450
Fyke nets	133	4,010	15	470			148	4,480
Seines	15	4,525	6	490	7	1,225	28	6,240
Lines		300		450				750
Spears	150	350					150	350
Shore property and accessories		4,725		31,957		69,400		106,082
Cash capital		1,500		12,000		31,100		44,600
Total		19,860		47,177		143,108		210,145

*Length of gill nets, 543,550 feet.

Table showing by counties and apparatus of capture the yield of the shore fisheries of Lake St. Clair and St. Clair and Detroit rivers in 1890.

Apparatus and species.	Macomb.		St. Clair.		Wayne.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets:								
Black bass			103	$6			103	$6
Catfish	4,500	$90	525	16	10,000	$200	15,025	306
Herring	36,000	540			30,000	1,200	116,000	1,740
Perch			8,250	124	48,500	740	56,750	864
Pike and pike perch	54,000	1,620	3,280	147	120,000	3,600	177,280	5,367
Sturgeon	88,200	2,205	667	20	196,000	4,900	284,867	7,125
Whitefish	54,000	3,240			120,000	7,200	174,000	10,440
Miscellaneous fish	90,000	450			151,500	2,260	241,500	2,710
Total	326,700	8,145	12,825	313	726,000	20,100	1,065,525	28,558
Fyke nets:								
Black bass	1,500	90	83	4			1,583	94
Catfish	6,375	194	1,625	35			8,000	229
Perch	224,250	2,646	39,600	599			263,850	3,245
Pike and pike perch	46,450	1,640	4,190	174			50,640	1,814
Sturgeon	3,200	88					3,200	88
Whitefish	200	20					200	20
Miscellaneous fish	87,875	578					87,875	578
Total	369,850	5,256	45,498	812			415,348	6,068
Seines:								
Black bass	7,400	444					7,400	444
Catfish	3,250	81					3,250	81
Herring			60,000	750	16,400	328	76,400	1,078
Perch	136,750	1,819					136,750	1,819
Pike and pike perch	16,300	600	143,503	4,274	11,500	460	171,303	5,334
Sturgeon	2,400	62	18,536	519			20,936	581
Whitefish					35,500	2,840	35,500	2,840
Miscellaneous fish	47,625	505			11,500	345	59,125	850
Total	213,725	3,511	222,039	5,543	74,900	3,973	510,664	13,027
Lines:								
Perch	220,000	2,700	1,500	30			221,500	2,730
Pike and pike perch			79,170	3,167			79,170	3,167
Total	220,000	2,700	80,670	3,197			300,670	5,897
Spears:								
Perch	55,000	625					55,000	625
Grand total	1,185,275	20,237	361,032	9,865	800,900	24,073	2,347,207	54,175

Canadian fisheries in which Americans are interested.—The fisheries on the Canadian side of Lake St. Clair and St. Clair River, carried on with property owned in part by citizens of the United States residing at Detroit and Port Huron, are more extensive than those on the American side of the lake. Fishing is done with pound nets, gill nets, and seines, and vessels are employed to collect and transport the fish; one vessel is also used in gill-net fishing. The fish taken are catfish, herring, pike, sturgeon, trout, and whitefish, the last-named being the most important.

Vessels, boats, apparatus, etc., employed in the fisheries of the Canadian side of Lake St. Clair, in which citizens of the United States are interested.

Designation.	No.	Value.
Vessels	6	$25,500
Outfit	......	4,500
Boats	71	5,145
Pile-drivers	3	90
Apparatus of capture:		
Pound nets	62	14,300
Gill nets	420	8,400
Seines	15	2,425
Shore property	......	1,350
Total	......	61,710

Products of the fisheries of the Canadian side of Lake St. Clair in which citizens of the United States are interested.

Species.	Pounds.	Value.
Catfish	14,520	$436
Herring	20,314	204
Pike	483,868	15,855
Sturgeon	355,793	10,299
Trout	365,260	18,112
Whitefish	1,068,153	53,307
Miscellaneous fish	2,759	83
Total	2,310,667	98,296

LAKE ERIE.

Importance and condition of the fisheries.—Although ranking fourth in area, this lake maintains a fishing industry of vast extent and of much greater importance than that of all the other lakes combined, omitting Michigan, which it surpasses by 36 per cent in fishing population, 49 per cent in invested capital, 60 per cent in the quantity of fish taken, and 17 per cent in the value of the catch. The fisheries of Lake Erie are thought to be more important than those of any other body of fresh water in the world, and there are few, if any, lakes which have afforded such a history of prolificness of fish life in proportion to their size. To illustrate the relative productiveness of the American waters of this lake, it may be noted that the average value of the catch per square mile of lake surface is over $200, while in no other lake of this system is the average more than $50, and in three of them is much less.

The fishing population of Lake Erie numbers about 4,500; the amount of capital invested in the fishing industry is $2,816,300; the quantity of fish caught in 1890 was 64,850,000 pounds, having a first value of over $1,000,000.

The prominent aspects of the fisheries of this lake are the large fleet of steam vessels engaged in the gill-net fishery, and the large number of steamers employed in collecting fish from the pound net and other fisheries—phases of the industry which are here more important than elsewhere in the lake system; the enormous amount of gill nets used in the vessel and boat fisheries, the great development of the pound-net fisheries, and the great distances to which connected lines of pound nets extend; the completeness with which the waters of the lake are scoured with fixed and movable appliances of capture; the taking of greater quantities of certain fishes than are obtained in all the other lakes combined; and the extensive trade in lake fish carried on in the cities bordering on the lake.

Of scarcely less importance than the actual extent of the fisheries of the lake, is the serious decline which has recently been observed in some of the most valuable food-fishes. The discussion of the exhaustion of the fish supply of the lake, of the means to check a further diminution, and of the necessity of taking energetic measures for the increase of the fish life has been one of the most noticeable public questions pertaining to the lake fisheries in recent times, and the great interests here at stake have fully warranted the attention already given and deserve much further consideration.

The inquiries conducted by this Commission show that the aggregate yield of the fisheries of the lake in 1890 was probably larger than at any previous time and was considerably larger than in any earlier year for which data were available. The money value of the products was but little less than in 1885 and much greater than in 1880. An examination of the statistics, however, at once discloses the fact that the catch has been maintained and increased only by the use of larger quantities of apparatus and by the capture and utilization of the cheaper species of fish, while even a very marked increase in the quantity of fishing apparatus has not been able to keep up the supply of the whitefish, sturgeon, and pike perches.

Notes on the principal fishes of the lake.—The natural conditions in this lake appear to be unusually favorable to the existence and production of enormous quantities of desirable food-fishes, whose fecundity and physical surroundings have made possible the extensive fishing which this lake has for many years supported. The general shoalness of the lake, while permitting the prosecution of the fisheries under conditions that are the least conducive to the continuance of an unimpaired supply, furnishes a large spawning area and appears to favor the development of a rich and varied fauna and flora having an important bearing on the food supply of the economic fishes.

Several fishes exist in greater numbers in Lake Erie than in any other member of the lake chain; several here of great value scarcely figure in the fisheries of some of the other lakes, while the most important fish, considering the entire lake region as a unit, the lake trout, is less abundant than in any other part of the lake system except Lake Ontario.

The most abundant and important fish now taken in Lake Erie is the lake herring. It is found in all parts of the lake, but is least numerous in the eastern end. It is caught in pound nets, gill nets, and, to a slight extent, in other forms of apparatus; nearly half the yield of the lake is obtained in the pound nets set in the waters of Ohio, and almost the same quantity in the gill nets operated in various parts of the lake, about the same catch resulting from the shore and the vessel gill-net fishery. The total catch was 38,868,283 pounds, having a value of $399,452, these amounts representing respectively considerably more than half the quantity and two-fifths the value of the fisheries of this lake. Compared with 1880 and 1885, a noticeable augmentation in the catch of this fish has taken place. The yield in every part of the lake presents an increase. This has resulted from (1) the use of large quantities of apparatus and (2) an increased demand necessitating the utilization of other fish to replace the diminished yield of common whitefish and other fishes. Only the taking of more than double the quantity of lake herring obtained in 1885 prevented the general fisheries of Lake Erie from showing a serious decline, as every other important species underwent a reduction.

The following table, based on data furnished by Mr. A. J. Stoll, of Sandusky, Ohio, shows the catch of lake herring in the years 1887 to 1890, inclusive, in a large number of pound nets controlled by him and set around the Bass Islands, and indicates the seasonal and yearly changes in abundance of the species. The numbers of nets mentioned in the table refer to those operated by different crews of fishermen, and the catch of the different sets of nets is given separately in order to permit a more detailed comparison of the fluctuations in the production than would be possible with only the aggregate figures at hand.

Table showing the number of pounds of lake herring taken in the fall fishing season (during the ten days preceding the dates given) by certain sets of pound nets located around the Bass Islands, Lake Erie, in 1887–1890.

Sets of nets.	September 20—				September 30—			
	1887.	1888.	1889.	1890.	1887.	1888.	1889.	1890.
I. Eleven nets each year	3,180	6,015	7,330	305	8,430	9,620	30,685	615
II. Eleven nets in 1887–1889, 16 in 1890	....	250	180	....	....	1,155	5,625	70
III. Sixteen nets each year	4,290	6,400	4,090	505	13,140	8,925	25,255	2,015
IV. Thirteen nets each year	150	....	....	....	3,175	1,750	1,595	345
V. Five nets each year	6,020	2,340	1,665	330	9,125	3,815	16,805	1,585
VI. Seven nets each year	....	3,235	215	2,015	14,480	5,130	15,890	3,830
VII. Eight nets in 1888–1890	....	1,095	....	1,005	....	3,290	22,025	1,685
VIII. Five nets in 1887–1889, 6 in 1890	7,370	6,360	155	150	11,765	8,905	6,290	470
IX. Five nets in 1888–1890	....	2,120	1,130	....	....	3,700	5,850	180
X. Four nets each year	....	....	....	....	315	....	5,615	....
Total	21,010	27,815	14,765	4,310	60,430	46,290	135,635	10,795

Table showing the number of pounds of lake herring taken in the fall fishing season (during the ten days preceding the dates given) by certain sets of pound nets located around the Bass Islands, Lake Erie, in 1887–1890—Continued.

Sets of nets.	October 10—				October 20—			
	1887.	1888.	1889.	1890.	1887.	1888.	1889.	1890.
I. Eleven nets each year	17, 350	20, 595	35, 085	5, 930	69, 210	48, 895	61, 485	49, 250
II. Eleven nets in 1887–1889, 16 in 1890	1, 815	3, 910	7, 175	1, 350	13, 660	12, 870	10, 700	9, 590
III. Sixteen nets each year	24, 135	29, 860	35, 255	7, 930	65, 070	140, 175	122, 280	38, 645
IV. Thirteen nets each year	6, 460	10, 865	5, 440	2, 910	53, 050	36, 530	16, 665	8, 370
V. Five nets each year	10, 985	10, 665	21, 110	2, 320	18, 845	22, 700	32, 815	8, 900
VI. Seven nets each year	34, 650	11, 125	23, 785	9, 415	79, 900	15, 520	63, 985	51, 400
VII. Eight nets in 1888–1890	....	17, 000	42, 260	3, 985	....	51, 040	93, 650	100, 060
VIII. Five nets in 1887–1889, 6 in 1890	21, 840	21, 265	9, 635	705	45, 515	36, 955	18, 210	5, 075
IX. Five nets in 1888–1890	....	5, 440	6, 915	1, 215	....	13, 150	14, 725	4, 540
X. Four nets each year	775	....	9, 260	2, 990	4, 530	8, 785	21, 255	6, 730
Total	118, 010	130, 725	195, 920	38, 750	349, 780	386, 620	455, 770	282, 560

Sets of nets.	October 30—				November 10—			
	1887.	1888.	1889.	1890.	1887.	1888.	1889.	1890.
I. Eleven nets each year	96, 805	99, 520	106, 885	87, 205	145, 720	167, 235	201, 810	206, 420
II. Eleven nets in 1887–1889, 16 in 1890	7, 580	59, 260	31, 530	23, 745	84, 165	215, 350	79, 480	92, 800
III. Sixteen nets each year	87, 930	220, 985	162, 855	55, 745	118, 310	310, 940	290, 710	149, 735
IV. Thirteen nets each year	69, 420	68, 830	38, 570	20, 165	95, 950	166, 440	62, 975	40, 920
V. Five nets each year	22, 455	39, 145	66, 790	26, 155	34, 955	61, 600	80, 510	35, 540
VI. Seven nets each year	138, 290	27, 555	95, 610	86, 595	200, 510	29, 760	103, 560	124, 265
VII. Eight nets in 1888–1890	....	78, 090	148, 885	157, 465	....	96, 600	189, 680	240, 340
VIII. Five nets in 1887–1889, 6 in 1890	59, 120	48, 280	26, 370	16, 660	71, 030	59, 145	32, 610	42, 720
IX. Five nets in 1888–1890	....	18, 355	23, 695	11, 585	....	27, 015	29, 660	21, 850
X. Four nets each year	11, 365	20, 265	33, 210	13, 600	15, 905	29, 535	51, 105	24, 235
Total	492, 965	680, 285	734, 400	498, 920	766, 545	1, 163, 620	1, 122, 100	978, 825

Sets of nets.	November 20—				November 30—			
	1887.	1888.	1889.	1890.	1887.	1888.	1889.	1890.
I. Eleven nets each year	223, 455	252, 030	299, 820	272, 620	239, 040	283, 540	326, 855	283, 440
II. Eleven nets in 1887–1889, 16 in 1890	197, 245	366, 270	142, 845	218, 820	282, 315	402, 610	155, 170	311, 030
III. Sixteen nets each year	148. 635	423, 540	350, 930	181, 600	157, 035	426, 630	360, 090	191, 820
IV. Thirteen nets each year	119, 190	206, 180	75, 130	70, 240	129, 080	220, 340	89, 135	72, 360
V. Five nets each year	47, 700	79, 155	98, 455	56, 130	58, 925	110, 130	99, 820	68, 235
VI. Seven nets each year	275, 200	36, 830	115, 950	144, 035	313, 650	45, 395	116, 365	145, 585
VII. Eight nets in 1888–1890	....	117, 090	214, 770	287, 055	....	119, 700	215, 855	295, 100
VIII. Five nets in 1887–1889, 16 in 1890	82, 175	71, 030	43, 965	125, 165	96, 615	73, 465	44, 365	162, 730
IX. Five nets each year	....	37, 960	31, 860	23, 965	....	46, 530	31, 860	24, 215
X. Four nets each year	18, 750	223, 220	201, 500	28. 710	19, 140	54, 940	55, 020	28, 425
Total	1, 112, 350	1, 813, 305	1, 575, 225	1, 408, 340	1, 295, 800	1, 783, 280	1, 485, 535	1, 582, 940

Sets of nets.	Total.			
	1887.	1888.	1889.	1890.
I. Eleven nets each year	803, 190	887, 450	1, 069, 955	905, 785
II. Eleven nets in 1887–1889, 16 in 1890	586, 780	1, 061, 675	432, 705	657, 405
III. Sixteen nets each year	618, 545	1, 567, 455	1, 351, 465	627, 995
IV. Thirteen nets each year	476, 475	710, 935	280, 510	215, 310
V. Five nets each year	209, 010	329, 550	417, 970	199, 195
VI. Seven nets each year	1, 056, 680	174, 550	535, 360	567, 140
VII. Eight nets in 1888–1890	....	483, 905	927, 125	1, 086, 695
VIII. Five nets in 1887–1889, 6 in 1890	395, 430	325, 405	181, 600	353, 675
IX. Five nets in 1888–1890	....	154, 270	145, 695	87, 550
X. Four nets each year	70, 780	336, 745	376, 965	104, 690
Total	4, 216, 890	6, 031, 940	5, 719, 350	4, 805, 440

NOTE.—Only multiples of 5 are observed by the Sandusky dealers in determining the weight of herring handled.

The following recapitulation of the foregoing table shows that the total and average catch in 1887 was less than in the two following years, and that the yield in 1890 was less than in 1888 and 1889, while the average production per net was less than during any of the other years. In view of the prominent position now occupied by the lake herring, these figures possess special interest.

Years.	Number of nets.	Pounds of herring taken.	Average catch per net.
1887	72	4, 216, 890	58, 568
1888	85	6, 031, 940	70, 964
1889	85	5, 719, 260	67, 285
1890	91	4, 805, 440	52, 807

The group of fishes embraced by the general term "pike perch," and including the wall-eyed pike or yellow pike, the variety of wall-eyed pike known as the blue pike, and the sauger, ranks next to the herring in abundance and economic value. These fish are much more abundant in Lake Erie than elsewhere in the Great Lakes, and each is here taken in larger quantities than in all the other lakes combined.

The most important of these fishes is the blue pike, the catch of which in 1890 was about 7,489,000 pounds, worth $148,200. It is found abundantly in all parts of the lake except along the Michigan shore, and is especially prominent in the fisheries of Erie, Pa., and Cleveland and Sandusky, Ohio. It is taken in large numbers in both pound nets and gill nets, but in larger quantities in the latter than in the former, and constitutes a conspicuous element in the vessel gill-net fishing of Erie and Cleveland and the shore gill netting of the former city. Compared with 1885, a slight decrease in the catch has occurred, amounting to 410,000 pounds. The principal decrease has been in the ice fishery of Erie County, Pa., owing to a deficiency of ice, while most places in Ohio present an increased yield.

The species of this group of which the next largest catch is made is the sauger, which is most important in the fisheries of Erie County, Ohio, where more than half the entire output is obtained, although it is also a very conspicuous factor in the fisheries of Ottawa and Lucas counties, Ohio, and Monroe County, Mich. While a few saugers are taken with gill nets, fyke nets, seines, and lines, the great bulk of the catch is obtained in pound nets. The saugers caught in 1890 amounted to 4,179,867 pounds, with a value of $51,721. In 1885 the quantity taken was 5,466,200 pounds.

The wall-eyed pike, while less abundant than the sauger or blue pike, is more valuable than the former and commands a higher price per pound than either. It inhabits shallower water than the blue pike, and is consequently taken in greater quantities in pound nets than by other means. Nearly half the entire output of the lake is obtained in Erie County, Ohio; Ottawa and Lucas counties in the same State and Monroe County in Michigan also have a relatively large catch. The quantity taken throughout the lake in 1890 was 2,105,733 pounds, valued at $90,615. In 1885 the reported yield was 2,694,500 pounds. The principal decrease since has been in Maumee Bay and in Erie County, N. Y., an increased catch being noticed in the vicinity of Sandusky.

In point of value the common whitefish ranks next to the lake herring and the blue pike; but to the fish-culturist, and doubtless to the general fishing public, that species possesses greater interest than any other in Lake Erie. It is the fish which has been the principal subject of fishery controversy and discussion on the lake, and the one whose preservation and increase is most desired by fishermen, dealers, and others.

In 1880 the aggregate yield of this fish was 3,333,800 pounds; the investigation of 1885 disclosed a catch of 3,531,855 pounds in that year; in 1890 the output was 2,341,451 pounds. The decrease in 1890, as compared with 1885, amounting to 1,190,404 pounds, demands careful attention; and it becomes a matter of great importance to note the condition of the fishery in recent years and to determine, if possible, the cause or causes for this serious decline.

In that part of the lake west of Port Clinton, embracing the most important pound-net fisheries of the lake, there has been only a slight decrease in the catch compared with 1885. It is said, however, that the decline since 1888 has been especially marked, which would indicate that between 1885 and 1888 there was a substantial increase, a fact which is borne out by a partial investigation of the region made by this office in the latter year. The extent of the diminution of the catch since 1888 may be judged by the comparative figures which are available for 30 pound nets set off West Sister Island. In 1888 48,000 pounds of whitefish were caught; in 1889 30,000 pounds were taken, while in 1890 the yield was only 20,000 pounds. These figures may be taken as representing the general condition of the whitefish fishery during the period named.

The catch of whitefish in the fisheries of the Bass Islands and other grounds tributary to Sandusky was also smaller in 1890 than in 1885, the decrease amounting to about 110,000 pounds, or 20 per cent. In the fisheries of Ohio east of Sandusky Bay the yield of whitefish was 458,500 pounds in 1885 and 468,577 pounds in 1890.

The whitefish fishery carried on from that part of the lake east of Ohio, viz, in Pennsylvania and New York, is prosecuted chiefly with gill nets, and it is interesting to observe that the catch has decreased phenomenally since 1885, the actual and relative decline being greater than elsewhere in the lake. In 1885 the output of this section was more than that of the entire remaining part of the lake, aggregating 2,149,455 pounds. In 1890 only 1,075,869 pounds were taken.

A study of the statistical returns for 1890 makes evident the fact that the maintenance of the catch of whitefish at present is chiefly accomplished by the employment of larger quantities of apparatus. As an example, the conditions in the region west of Sandusky and the Bass Islands may be cited, though more marked cases could be given.

So few whitefish are taken in this part of the lake in any form of apparatus except pound nets that only the latter need be considered.

Comparing the number set in 1885 with those operated in 1890, the latter year shows an increase of 137 nets, or 26 per cent. The output in the same period declined about 15,000 pounds, or 4 per cent, whereas, other things being equal, there should have been an additional catch of 93,000 pounds.

Coming now to a consideration of the influences which have operated to produce this serious impairment of the whitefish fishery—and the same influences have in a general way affected the other fisheries—it may first be stated that the opinion is quite generally entertained among the fishermen and dealers of some localities that the supply of whitefish is being gradually reduced throughout the entire lake by over-fishing, the effects of which nature and art combined are not able to successfully overcome. Others, it should be said, think the decline is only temporary and simply indicates a fluctuation in the catch entirely dependent on natural conditions.

It is well known that the shoal water everywhere in Lake Erie is very favorable to the capture of the whitefish as well as other species. There is scarcely a spot which affords even temporary shelter to the fish. During the greater part of the year, when the great body of whitefish is found in the eastern end of the lake, they are systematically and persistently sought for with gill nets operated from steam, sail, and row boats. In the early winter, when the fish begin to move toward the western end of the lake for the purpose of spawning, the pursuit with gill nets continues with relentless energy. In the western part new dangers await migrating fish in the thousand or more pound nets. These, in some localities, form impassable barriers between individual islands or between islands and the mainland, while other stands extend in almost unbroken lines from the shore half across the lake. It is therefore not surprising that natural reproduction, which supervenes upon the arrival of the fish off the Michigan shore, should be seriously impaired and that the catch of whitefish should be declining.

Mr. Seymour Bower, the agent who canvassed the major part of the fisheries of Lake Erie in 1885, called attention to the great destruction of whitefish in the gill-net fishery independently of the fish necessarily sacrificed for food. It was stated, on Mr. Bower's authority, that—

> Gilled whitefish soon drown if there is much current, as there generally is at this [the eastern] end of the lake, and then bloating and decomposition ensue in a few hours. The arrangement of the nets is such that each gang is lifted not oftener than once in two or three days, and in summer there is invariably a considerable number of spoiled fish at each lift; not infrequently, when a storm or blow occurs and the lifting is delayed a day or two, more than half the fish are found to be rotten and are stripped out and thrown back into the lake.—(Review of the Fisheries of the Great Lakes in 1885, p. 281.)

This condition of affairs is generally recognized, and, while an accurate determination of the amount of this waste is, of course, impossible, and while even a close approximation is difficult, nevertheless some idea may be gained of the enormous destruction of fish by repeating the opinion of a prominent and thoroughly reliable dealer of Erie, Pa., who in 1885 estimated that the waste in the gill-net fisheries of that city alone was equal to the entire quantity of marketable whitefish landed from gill nets in the region west of Sandusky, or between 800,000 and 1,000,000 pounds. The same conditions obtain to-day, and there is no reason to doubt that this waste continues on fully as large a scale.

Recapitulating the foregoing remarks, it is seen:

1. That the abundance of whitefish in Lake Erie, as determined by the quantity taken, has been diminishing since 1888, and the decrease in the output in 1890, compared with 1885, amounted to over a million pounds.

2. That the decline in the catch has been most marked in the gill-net fishery carried on from the eastern end of the lake.

3. That the market supply from year to year is being maintained chiefly by employing larger quantities of fixed and floating apparatus.

4. That there is no season when the fish may not be taken; and practically the entire catch in pound nets in the western end of the lake in the fall months consists of spawning fish.

5. That there is enormous unnecessary waste of fish in the gill-net fishery owing to the methods in vogue.

The following important remarks on the deterioration of the Lake Erie fisheries emanate from Mr. Seymour Bower, of the U. S. Commission of Fish and Fisheries, who has on two occasions made a personal inspection of the principal fisheries of the lake, and is well qualified to discuss the subject:

I am not at all surprised at the decreased and decreasing catch of fish in Lake Erie. Indeed, under the conditions that prevail, the catch is remarkably well sustained. I doubt if there is another body of water, fresh or salt, of equal area in the world that is so thoroughly, persistently, and exhaustively canvassed. Surely none of the other lakes of the great fresh-water chain affords a parallel, for the reason that their greater depth precludes successful or, at least, profitable operations over comparatively large areas. In a fishing sense, it is wholly within the power of man to literally "clean out" Lake Erie, though, of course, this event is not likely to occur, since the destruction will naturally cease at the point of profitable returns.

The constantly increasing demand for the products of the lake, due to an ever-increasing population and to improved facilities for distribution—and all, of course, without a corresponding increase in the producing area—has stimulated an excessive drain on the source of supply. Without any thought for the morrow, methods that are extremely wasteful are employed, in reckless disregard of the common welfare and the perpetuity of the industry, legislative regulations and restrictions being for the most part evaded, ignored, or defeated.

In the face of all this, however, the catch seems well sustained. This can be accounted for only on the theory—or I might say, the fact—that Lake Erie undoubtedly possesses much greater productive capacity, greater fertility in water life, than the deeper waters of the upper lakes. That "nature is full of compensations" is well illustrated here; the very shoalness that places its higher forms easily within the reach of man is coincident with a degree of warmth highly favorable to a generous development of fundamental water life.

That the work of propagating whitefish has failed to keep up the supply of that species is not to be wondered at. Wasteful instead of rational methods of capturing the species have been practiced. Gill-net fishing in summer is responsible for the absolute waste of hundreds of tons of whitefish. Whitefish in gill nets drown easily in a moderate current and spoil quickly when the water is warm; but, notwithstanding this fact, the arrangements for setting and lifting are such that the nets are raised only once in two to four days, and storms that prevent lifting until the catch is almost a total loss are not uncommon. Of course, on the whole, more salable fish are taken in this way than would be with fewer nets lifted daily, but the plan is a highly improvident and wasteful one and, naturally, a considerable proportion of the catch is thrown on the market in a more or less unwholesome state. Summer gill netting in Lake Erie is an evil that should be abolished on sanitary as well as economic grounds.

A considerable number of small whitefish are also taken in the small mesh or "herring" gill nets, and the claim is freely made that the pound nets from Vermillion to Erie take a good many very small whitefish, but I do not know to what extent this is true.

The pound nets west of Sandusky take no small whitefish; in fact, a specimen of less than a pound weight very rarely occurs in that section. But these nets, also those along the Huron shore, catch immense numbers of fish that are too small for market. I have seen thousands upon thousands of small pike perch and other valuable commercial varieties brought ashore and thrown away. Here is a tremendous waste of raw material, for such of these small fish as do not survive to maturity at least serve the purpose of food supply for the larger ones.

The adoption of measures to correct the evils referred to would, no doubt, practically suspend fishing operations in a few cases or places, and for a time place something of a burden on vested interests, but it seems to be one of those rare cases where the end justifies the means. The perpetuity of the interests directly involved is at stake, and individual interests that survive only at such heavy cost to the common welfare, that are sustained only through flagrant though incidental violation of economic law, have no moral right to exist.

Gill-net fishing, as applied to the capture of spawning fish from the spawning beds and reefs, is regarded by many, particularly the pound-net interests, as peculiarly destructive and reprehensible, but I take precisely the opposite view. Comparatively few fish are now enabled to evade the maze of nets and barriers set to intercept their progress and reach the spawning-grounds. If none were allowed to do so, the reproductive function would be wholly subverted; no spawn would be cast, none would be available for artificial treatment, and the inevitable result would be speedy extermination. On the other hand, it would be far better if every fish could reach the spawning-grounds, even though the last one was captured there, for then most of the spawn would be mature and available for natural or artificial processes. Greater freedom should be given the migratory run of spawning fish by restricting the length and number of pound nets in a stand, also limiting the number and length of gill nets per boat or crew.

As we can not "eat the cake and keep it too," I do not think that there should be any closed seasons for Lake Erie, except during the summer, when a good portion of the "cake" is spoiled and wasted. Nor do I think that any form of apparatus should be favored or abolished by law, except as this might occur incidentally through the enforcement of the paramount point of preventing the wholesale waste of adult and immature fish.

It seems to me that there are no seriously objectionable features incidental to the measures above indicated, nor no insurmountable obstacles in the way of applying them in practice. The main points are a closed season in summer, releasing or permitting the escape of immature fish, and restricting the number and length of nets. These measures, in connection with the saving and return, through the medium of artificial propagation, of what would otherwise be a total loss, should develop and hold up indefinitely the productive capacity of Lake Erie or any other water to its highest practical point.

I do not, however, look for the accomplishment of these results through the medium of State legislation. Local and sectional interests, complicated by the friction and antagonisms existing between the advocates of different forms of apparatus, will doubtless continue to act as a bar to the adoption and enforcement of such impartial and reciprocal measures as are essential to the common welfare. Numerous laws, narrow and sectional in their inspiration and necessarily so in their application, have been enacted by the Commonwealths having or assuming jurisdiction; but the fitful and erratic movements to enforce such laws have generally met with defeat. It is true that the pound-net interests of Ohio have respected the closed season in summer, but there is little merit in this, as the season is unprofitable anyway, owing to the fact that the fish do not run inshore then in paying numbers, and the nets soon rot in the warm water. Very few pound nets would be set in summer in the territory available for that form of apparatus, even if there were no law to prevent. Gill nets, however, are inexpensive, and Canada and Pennsylvania have no closed season in summer, so the gill-net tugs from Cleveland and other Ohio ports fish all summer ostensibly in provincial and Pennsylvania waters. So it is true in the main that State legislation, so far as it applies to Lake Erie, with its five conflicting jurisdictions, has accomplished but little in preventing the capture of fish whenever, wherever, and howsoever it has been profitable to do so.

Under existing conditions I do not look for any improvement, but, on the contrary, a still further decline. If one fact is more conspicuous than another, it is that the arbitrary and intangible lines dividing the lake into several jurisdictions should be obliterated. Rational and effective measures must be based on the fact that in its water life the lake is a unit.

Of the remaining fishes of prominence the sturgeon is the most valuable. It is most abundant in the extreme eastern end of the lake, where more than seven-eighths of the catch is made, and least so along the Michigan shore at the western end. The decreased yield since 1885 has been marked in every region, and has aggregated 2,649,000 pounds, or over 50 per cent. Perch have nearly doubled in quantity, catfish have decreased, and trout, taken only in Pennsylvania and New York, have undergone a slight decrease.

As bearing on the relative abundance of certain fish during a series of years, the following figures showing the average catch during the fall season of some pound nets set at Huron, Ohio, may be presented:

Table showing the average fall catch of fish per net in the pound nets of Messrs. Wickham & Co., of Huron, Ohio, from 1872 to 1890.

Years.	Number of nets.	‡ Hard fish.	‡ White-fish.	§ Soft fish.	Herring.	Years.	Number of nets.	‡ Hard fish.	‡ White-fish.	§ Soft fish.	Herring.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*			*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1872	18	6,300	....	1,700	23,700	1882†	34	1,300	....	2,900	5,400
1873 *	24	4,600	....	1,560	3,340	1883	33	900	....	3,300	20,100
1874	21	9,030	....	3,190	7,421	1884	34	575	....	2,632	7,327
1875	26	2,600	....	3,100	9,231	1885	35	475	....	1,860	28,640
1876	33	3,900	....	1,890	21,900	1886	41	579	....	4,691	20,114
1877	11	2,500	....	3,400	14,100	1887	50	176	693	2,793	14,355
1878	14	4,000	....	3,500	23,800	1888	53	253	562	2,477	15,483
1879	19	1,700	....	3,500	17,300	1889	54	177	395	1,100	14,079
1880	16	4,800	....	3,800	24,700	1890	54	164	334	1,364	14,184
1881	16	4,500	....	7,100	15,700						

* Nets destroyed by a storm October 15.

† Warm season.

‡ Until 1887 the whitefish and other hard fish were combined under the name hard fish, which includes, besides whitefish, black bass, muskellunge, wall-eyed pike, large blue pike, large rock bass, and grass pike. Since 1886 the whitefish have been separately designated.

§ Includes saugers, small blue pike, small wall-eyed pike, sunfish, and small rock bass.

Apparatus and methods.—In the foregoing notes on the fishes of this lake the influence on their abundance of the apparatus and methods employed was discussed at some length, making further reference to that phase of the subject unnecessary in this place. The most noticeable feature connected with the consideration of the apparatus used in the fisheries of this lake is the extraordinarily large increase since 1885 in the numbers of the most prominent nets employed, an increase unequaled in any other lake. In 1885 the pound and trap nets numbered 1,028, which was about 300 more than were found in Lake Michigan, the lake having the next important pound-net fishery, and about two-fifths the entire number of such nets in the Great Lakes basin. In 1890 the number had increased to 1,893, which was 1,050 more than the number in Lake Michigan during the same year and more than half the number set in all the lakes combined. Gill nets to the number of 22,644 were operated in Lake Erie in 1885, while in 1890 49,320 were set, no other lake showing any increase. A less marked increase has also taken place in the quantities of fyke nets employed. The use of seines and lines, however, is less extensive than formerly.

The feature which has long distinguished the pound-net fishery of Lake Erie is the habit of setting the nets in long continuous strings, extending out many miles from the shore. This is made possible by the general shoalness of the lake and the nature of the bottom, which permits the driving of stakes without difficulty.

Aside from the growth of the pound-net fishery in the regions where the nets were already employed in large numbers, there has been a marked development of the fishery in localities in which the nets were comparatively scarce in 1885. In that year it was recorded that—

The pound-net fishery of Lake Erie is at the present time practically confined to that portion of the lake west of Cleveland. East of that city the nets are scattered and comparatively few in number, there being but 7 between Cleveland and Fairport, 14 at Fairport, and 19 at Erie, while west of Cleveland there are no less than 888 pounds, which are located at very short distances and in longer or shorter strings along the entire coast line from Cleveland to the mouth of the Detroit River.

The investigation of 1890 showed a large increase in the number of pound nets and traps operated in the eastern end of the lake. There were found to be 108 such nets used in that part of Ohio east of Cleveland, 200 in Pennsylvania, and 37 in New York.

The use of steam vessels in the fisheries is more extensive in this lake than elsewhere in the lake region, although the number of steamers actually engaged in fishing is less than in Lake Michigan. In 1890 34 vessels, carrying over 19,000 gill nets, were employed in the fisheries of the lake, and 22 additional steamers in transporting fish from the fishing-grounds to the markets. Vessel fishing is most important at Erie, Pa., where 14 vessels were employed in 1890, and at Cleveland, Ohio, where 9 vessels were used. The number of collecting vessels is greatest at Sandusky, where 16 made their headquarters in 1890.

The yield of the vessel fishery in 1890 was 14,079,281 pounds, having a market value of $221,289. The fish of greatest importance, as regards both quantity and value, is the lake herring; over 9,000,000 pounds, worth $102,000, resulted from this fishing in the various parts of the lake. Next in prominence is the blue pike, of which about 2,948,000 pounds, valued at $57,700, were taken. Whitefish is the only other fish of special importance in the vessel fishery; 817,000 pounds of this were secured, with a value of $40,850. The remaining fish obtained are perch, saugers, sturgeon, trout, wall-eyed pike, and a few minor species, all caught in small quantities. The yield of whitefish is largest in the vessel fishery from Dunkirk, N. Y.; herring, blue pike, and trout are most important in Erie, Pa.; perch, saugers, and wall-eyed pike figure most conspicuously in the fisheries of Cleveland, Ohio.

Since 1885 the changes in the vessel fisheries of this lake have consisted in a slight decrease in the number of steam vessels using gill nets, an increase of nearly 100 per cent in the number of collecting steamers, and the introduction of fishing steamers into the fisheries of Dunkirk and Buffalo, N. Y., where they were not previously operated.

Statistics of the fisheries.—The following series of detailed tables illustrates the various features of the extensive fisheries of this lake. The tables, which relate to the counties, show (1) the persons engaged in different capacities; (2) the vessels, boats, apparatus, etc., employed; (3) the quantity and value of the catch; (4) the output of the vessel gill-net fishery; and (5) the quantity and value of the products resulting from the use of each kind of apparatus in the shore and boat fisheries.

Two vessels belonging at Detroit fished during a part of the year in Lake Erie, and took the following quantities of fish, which have been credited to that city: 297,934 pounds of herring, worth $2,979; 46,276 pounds of pike perch, worth $1,851, and 29,243 pounds of perch, valued at $877. The vessels carried 14 men, had a combined tonnage of 19.86, and were worth, with their outfit, $12,800. They used 388 gill nets, having a total length of 245,350 feet, valued at $4,306.

Table showing by States and counties the number of persons employed in the fisheries of Lake Erie in 1890.

States and counties.	Vessel fishermen.	Vessel transporters.	Shore fishermen.	Shoresmen.	Total.
New York:					
Erie	4		883	80	967
Chautauqua	17		107	18	142
Total	21		990	98	1,109
Pennsylvania:					
Erie	92	3	250	58	403
Ohio:					
Ashtabula	7		51		58
Lake	7		71	10	88
Cuyahoga	62	4	63	99	228
Lorain			62	9	71
Erie	29	77	749	301	1,156
Ottawa			389	186	575
Lucas		6	348	208	562
Total	105	87	1,733	813	2,738
Michigan:					
Monroe		7	225		232
Grand total	218	97	3,198	969	4,482

Table showing by States and counties the vessels, boats, apparatus, and capital employed in the fisheries of Lake Erie in 1890.

States and counties.	Vessels fishing.				Vessels transporting.				Boats.	
	No.	Tonnage	Value.	Value of outfit.	No.	Tonnage.	Value.	Value of outfit.	No.	Value.
New York:										
Erie	1	7.50	$2,500	$450					96	$2,485
Chautauqua	3	50.20	10,000	1,538					71	12,615
Total	4	57.70	12,500	1,988					167	15,100
Pennsylvania:										
Erie	14	97.10	41,800	7,420	1	16.76	$2,000	$400	94	32,920
Ohio:										
Ashtabula	1	15.78	4,750	500					30	7,210
Lake	1	6.26	2,200	500					40	8,935
Cuyahoga	9	119.05	40,150	5,500	1	7.30	2,500	300	28	13,295
Lorain									40	10,765
Erie	5	48.53	14,000	2,250	16	900.81	128,700	11,875	436	83,215
Ottawa									248	21,300
Lucas					2	79.97	13,000	550	194	15,260
Total	16	189.62	61,100	8,750	19	988.08	144,200	12,725	1,016	159,980
Michigan:										
Monroe					2	36.08	8,500	900	116	9,750
Grand total	34	344.42	115,400	18,158	22	1,040.92	154,700	14,025	1,393	217,750

States and counties.	Gill nets, vessel fisheries.		Apparatus of capture, shore fisheries.								
			Pound nets and trap nets.		Gill nets.		Fyke nets.		Seines.		Value of lines and spears.
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.	
New York:											
Erie	1,013	$7,740			1,516	$11,345					$1,351
Chautauqua	109	850	37	$4,850	1,944	14,887			5	$125	228
Total	1,122	8,590	37	4,850	3,460	26,232			5	125	1,579
Pennsylvania:											
Erie	10,177	33,512	200	29,270	12,193	39,056					160
Ohio:											
Ashtabula	322	1,076	50	3,750	2,424	6,744					310
Lake	277	952	58	14,340	2,352	6,728					200
Cuyahoga	6,047	20,084	61	22,950	2,221	6,909					
Lorain			88	36,650	981	2,805					
Erie	1,101	3,730	703	304,290	918	2,675	915	$58,850	6	780	1,402
Ottawa			160	36,000	5,600	9,520	145	3,000	11	1,400	1,000
Lucas			303	46,200	125	900	50	1,800	16	2,450	800
Total	7,747	25,842	1,423	464,180	14,621	36,281	1,110	63,650	33	4,630	3,712
Michigan:											
Monroe			233	49,800			65	800	6	550	700
Grand total	*19,046	67,944	1,893	548,100	*30,274	101,569	1,175	64,450	44	5,305	6,151

States and counties.	Shore property.	Cash capital.	Total investment.
New York:			
Erie	$91,317	$391,800	$508,988
Chautauqua	11,033	9,200	65,326
Total	102,350	401,000	574,314
Pennsylvania:			
Erie	46,700	50,000	283,238
Michigan:			
Monroe	12,850		83,850
Ohio:			
Ashtabula	$900		$25,240
Lake	13,850	$10,000	57,705
Cuyahoga	106,225	70,000	287,913
Lorain	10,575	6,000	66,795
Erie	277,200	199,000	1,087,967
Ottawa	82,400	8,000	162,620
Lucas	96,700	9,000	186,660
Total	587,850	302,000	1,874,900
Grand total	749,750	753,000	2,816,302

* Length of gill nets, 12,330,000 feet.

Table showing by States, counties, and species the yield of the fisheries of Lake Erie in 1890.

States and counties.	Black bass.		Blue pike.		Catfish.		Herring.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New York:								
Erie	300	$10	114, 661	$7, 017	188, 700	$4, 274	53, 215	$1, 723
Chautauqua	15, 405	813	173, 289	4, 835	88, 275	2, 193	1, 753, 905	26, 708
Total	15, 705	823	287, 950	11, 852	276, 975	6, 467	1, 807, 120	28, 431
Pennsylvania:								
Erie	19. 990	1, 032	3, 245, 945	70, 406	121, 450	3, 301	8, 012, 510	80, 443
Ohio:								
Ashtabula	5, 600	305	422, 100	9, 150	146, 300	3, 160	970, 500	9, 605
Lake	4, 000	270	430, 000	7, 295	104, 500	2, 745	1, 649, 500	16, 480
Cuyahoga	1, 620	60	1, 804, 230	29, 138	11, 000	220	5, 661, 800	65, 500
Lorain	960	50	381, 050	5, 053	7, 200	144	1, 925, 240	19, 360
Erie	92, 643	4, 701	860, 958	13, 757	528, 632	12, 177	15, 427, 313	152, 235
Ottawa	92, 000	5, 320	56, 670	1, 550	400, 000	8, 850	1, 243, 300	11, 115
Lucas	6, 500	390	....	....	150, 000	3, 950	1, 011, 000	7, 583
Total	203, 223	11, 096	3, 955, 008	65, 943	1, 347, 632	31, 246	27, 888, 653	281, 878
Michigan:								
Monroe	9 500	570	....	....	180, 000	4, 900	1, 160, 000	8, 700
Grand total	248, 418	13, 521	7, 488, 903	148, 201	1, 926, 057	45, 914	38, 868, 283	399, 452

States and counties.	Perch.		Saugers.		Sturgeon.		Trout.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New York:								
Erie	17, 350	$755	....	....	1, 425, 110	$48, 932	....	....
Chautauqua	31, 270	760	....	....	284, 554	11, 745	39, 420	$1, 903
Total	48, 620	1, 515	....	....	1, 709, 664	60, 677	39, 420	1, 903
Pennsylvania:								
Erie	208, 540	5, 420	31, 150	$410	105, 750	3, 265	82, 000	3, 280
Ohio:								
Ashtabula	32, 890	556	....	....	8, 100	270	....	....
Lake	71, 585	967	23, 500	205	17, 535	465	....	....
Cuyahoga	733, 692	8, 451	172, 500	1, 405	8, 400	280	....	....
Lorain	140. 000	1, 230	174, 620	1, 580	20, 700	690	....	....
Erie	1, 099, 880	8, 008	2, 223, 847	24, 410	139, 758	6, 436	....	....
Ottawa	230, 200	1, 902	594, 250	11, 311	24, 000	480	....	....
Lucas	175, 000	1, 075	654, 000	8, 820	12, 000	240	....	....
Total	2, 483, 247	22, 189	3, 842, 717	47, 731	230, 493	8, 861	....	....
Michigan:								
Monroe	130, 000	1, 175	306, 000	3, 580	33, 000	900	....	....
Grand total	2, 870, 407	30, 299	4, 179, 867	51, 721	2, 078, 907	73, 703	121, 420	5, 183

States and counties.	Wall-eyed pike.		Whitefish.		Other fish.		Turtles and frogs.	Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Value.	Pounds.	Value.
New York:									
Erie	17, 671	$1, 236	23, 150	$1, 388	3, 800	$114	....	1, 843, 957	$65, 449
Chautauqua	53, 406	1, 622	294, 700	14, 347	63, 340	1, 345	....	2, 797, 564	66, 271
Total	71, 07 7	2, 858	317, 850	15, 735	67, 140	1, 459	....	4, 641, 521	131, 720
Pennsylvania:									
Erie	125, 190	5, 620	758, 019	36, 157	154, 300	1, 788	....	12, 864, 844	211, 122
Ohio:									
Ashtabula	2, 000	90	44, 300	1, 970	26, 910	339	....	1, 658, 700	25, 445
Lake	9, 800	392	53, 450	2, 425	49 715	408	....	2, 414, 085	31, 652
Cuyahoga	87, 220	4, 212	224, 250	11, 200	311, 308	3, 749	....	9, 015, 420	124, 215
Lorain	69, 030	3, 022	51, 620	2, 490	60, 910	595	....	2, 831, 330	34, 214
Erie	922, 266	41, 067	548, 329	28, 353	1, 252, 344	9, 726	$574	23, 095, 970	301, 444
Ottawa	258. 750	10. 529	165, 333	8, 725	244. 800	1, 748	2, 000	3, 309, 303	63, 530
Lucas	295, 500	12. 075	42, 300	2. 115	261, 000	1, 435	500	2, 607, 300	38. 183
Total	1. 644, 566	71, 387	1, 129, 582	57, 278	2, 206, 987	18, 000	3, 074	44, 932, 108	618, 683
Michigan:									
Monroe	264, 900	10. 750	136, 000	6, 800	193, 000	1, 005	1, 000	2, 412, 400	39, 380
Grand total	2, 105, 733	90, 615	2, 341, 451	115, 970	2, 621, 427	22, 252	4, 074	64, 850, 873	1, 000, 905

Table showing by States, counties, and species the yield of the vessel fisheries of Lake Erie in 1890.

States and counties.	Blue pike.		Herring.		Perch.		Saugers.		Sturgeon.	
	Pounds.	Value.	Pounds.	Value.	Pounds	Value.	Pounds	Value.	Pounds	Value.
New York:										
Chautauqua	37,585	$1,081	424,041	$8,459	5,774	$119				
Erie	5,563	306	28,715	718					52,000	$1,578
Total	43,148	1,387	452,756	9,177	5,774	119			52,000	1,578
Pennsylvania:										
Erie	1,457,562	31,096	3,983,707	39,658	64,345	1,675	5,186	$41		
Ohio:										
Ashtabula	112,500	2,325	315,000	3,125	7,500	150				
Cuyahoga	1,165,909	19,371	3,661,364	41,892	602,620	6,896	20,454	209		
Erie	133,670	2,930	573,350	6,525	10,666	106	6,660	72		
Lake	35,250	619	212,813	2,100	9,900	148				
Total	1,447,329	25,245	4,762,527	53,642	630,686	7,300	27,114	281		
Grand total.	2,948,039	57,728	9,198,990	102,477	700,805	9,094	32,300	322	52,000	1,578

States and counties.	Trout.		Wall-eyed pike.		Whitefish.		Other fish.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New York:										
Chautauqua	12,655	$558	12,529	$361	171,175	$8,489	4,180	$65	667,939	$19,132
Erie			1,855	102	21,650	1,298			109,783	4,002
Total	12,655	558	14,384	463	192,825	9,787	4,180	65	777,722	23,134
Pennsylvania:										
Erie	42,000	1,675	38,868	1,635	451,175	22,148	5,500	110	6,048,343	98,038
Ohio:										
Ashtabula					11,250	525			446,250	6,125
Cuyahoga			53,182	2,597	120,272	6,015	150,108	2,001	5,773,909	78,981
Erie					40,000	2,300	8,320	100	772,666	12,033
Lake			938	38	1,490	73			260,391	2,978
Total			54,120	2,635	173,012	8,913	158,428	2,101	7,253,216	100,117
Grand total.	54,655	2,233	107,372	4,733	817,012	40,848	168,108	2,276	14,079,281	221,289

Table showing by counties, apparatus, and species the yield of the shore fisheries of Lake Erie in 1890.

Apparatus and species.	New York.						Pennsylvania.	
	Erie.		Chautauqua.		Total.		Erie.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets and trap nets:								
Black bass			3,575	$203	3,757	$203	19,990	$1,032
Blue pike			36,300	1,085	36,300	1,085	390,500	9,000
Catfish			25,000	645	25,000	645	121,450	3,301
Herring			12,000	200	12,000	200	227,300	2,940
Perch			9,000	185	9,000	185	58,690	780
Saugers							19,650	310
Sturgeon			162,000	6,600	162,000	6,600	105,750	3,265
Wall-eyed pike			5,500	288	5,500	288	59,190	2,430
Whitefish			7,000	350	7,000	350	76,229	3,775
Other fish			28,000	439	28,000	439	136,100	1,175
Total			288,375	9,995	288,375	9,995	1,214,849	28,008

Table showing by counties, apparatus, and species the yield of the shore fisheries of Lake Erie—Continued.

Apparatus and species.	New York.						Pennsylvania.	
	Erie.		Chautauqua.		Total.		Erie.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Gill nets:								
Black bass	300	$10	5,430	$254	5,730	$264	....	....
Blue pike	11,666	551	98,404	2,609	110,070	3,160	1,383,083	$29,506
Catfish	500	10	....	....	500	10	....	....
Herring	10,000	115	1,317,864	18,049	1,327,864	18,164	3,801,503	37,845
Perch	5,850	105	11,676	258	17,526	363	58,005	1,522
Saugers	....	....	....	....	....	....	6,314	59
Sturgeon	1,175,610	41,429	113,180	4,770	1,228,790	46,199	....	....
Trout	....	....	26,065	1,310	26,065	1,310	40,000	1,605
Wall-eyed pike	3,556	184	32,802	870	36,358	1,054	27,132	1,555
Whitefish	....	....	116,525	5,508	116,525	5,508	230,615	10,234
Other fish	300	9	6,290	95	6,590	104	....	....
Total	1,207,782	42,413	1,728,236	33,723	2,936,018	76,136	5,546,652	82,326
Seines:								
Black bass	....	....	1,700	85	1,700	85	....	....
Catfish	....	....	3,875	155	3,875	155	....	....
Perch	....	....	1,400	35	1,400	35	....	....
Wall-eyed pike	....	....	2,575	103	2,575	103	....	....
Other fish	....	....	24,870	746	24,870	746	....	....
Total	....	....	34,420	1,124	34,420	1,124	....	....
Lines, spears, and grapnels:								
Black bass	....	....	4,700	271	4,700	271	....	....
Blue pike	97,432	6,160	1,000	60	98,432	6,220	14,800	804
Catfish	188,200	4,264	59,400	1,393	247,600	5,657	....	....
Herring	14,500	890	....	....	14,500	890	....	....
Perch	11,500	650	3,420	163	14,920	813	27,500	1,443
Sturgeon	197,500	5,925	9,374	375	206,874	6,300	....	....
Trout	....	....	700	35	700	35	....	....
Wall-eyed pike	12,260	950	....	....	12,260	950	....	....
Whitefish	1,500	90	....	....	1,500	90	....	....
Other fish	3,500	105	....	....	3,500	105	12,700	503
Total	526,392	19,034	78,594	2,297	604,986	21,331	55,000	2,750
Grand total	1,734,174	61,447	2,129,625	47,139	3,863,799	108,586	6,816,501	113,084

Apparatus and species.	Ohio.							
	Ashtabula.		Lake.		Cuyahoga.		Lorain.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets and trap nets:								
Black bass	5,600	$305	4,500	$270	1,020	$60	960	$50
Blue pike	110,100	2,650	242,000	3,990	334,230	4,788	310,050	4,073
Catfish	28,800	710	31,500	875	11,000	220	7,200	144
Herring	71,500	775	514,500	5,280	1,036,800	12,500	1,658,240	16,650
Perch	14,300	185	26,000	285	33,000	330	71,000	570
Saugers	....	....	23,500	205	147,500	1,150	161,120	1,450
Sturgeon	8,100	270	17,535	465	8,400	280	20,700	690
Wall-eyed pike	2,000	90	4,800	192	17,220	812	66,030	2,902
Whitefish	12,800	545	45,500	2,035	72,250	3,600	51,620	2,490
Other fish	24,500	290	42,500	300	62,000	620	55,410	510
Total	277,700	5,820	952,335	13,902	1,723,240	24,360	2,402,330	29,529
Gill nets:								
Blue pike	119,500	4,175	152,750	2,681	304,091	4,979	71,000	980
Herring	584,000	5,705	922,187	9,100	963,636	11,108	267,000	2,710
Perch	11,090	221	35,685	534	98,072	1,225	69,000	660
Saugers	....	....	....	....	4,546	46	13,500	130
Wall-eyed pike	....	....	4,062	162	16,818	803	3,000	120
Whitefish	20,250	900	6,460	317	31,728	1,585	....	....
Other fish	2,410	49	7,215	108	99,200	1,128	5,550	85
Total	817,250	11,050	1,128,359	12,902	1,518,091	20,874	429,000	4,685
Lines, spears, and grapnels:								
Catfish	117,500	2,450	73,000	1,870	....	....	....	....
Grand total	1,212,450	19,320	2,153,694	28,674	3,241,511	45,234	2,831,330	34,214

Table showing by counties, apparatus, and species the yield of the shore fisheries of Lake Erie—Continued.

Apparatus and species.	Ohio.							
	Erie.		Ottawa.		Lucas.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Pound nets and trap nets:								
Black bass	44,758	$2,247	20,000	$1,000	4,500	$270	81,338	$4,202
Blue pike	529,128	6,477	......	......	......	......	1,525,508	21,983
Catfish	85,882	2,237	70,000	1,750	60,000	1,500	294,382	7,436
Herring	13,960,643	135,955	580,000	4,350	990,000	7,425	18,811,683	182,935
Perch	758,710	4,128	95,000	550	135,000	675	1,133,010	6,723
Saugers	1,644,792	15,010	410,000	4,100	540,000	5,400	2,926,912	27,315
Sturgeon	139,758	6,436	24,000	480	12,000	240	230,493	8,861
Wall-eyed pike	575,106	23,787	150,000	6,000	270,000	10,800	1,085,156	44,583
Whitefish	461,664	23,253	34,000	1,475	40,000	2,000	717,834	35,398
Other fish	275,319	2,276	140,000	700	176,000	1,010	775,729	5,706
Total	18,475,760	221,806	1,523,000	20,405	2,227,500	29,320	27,582,045	345,142
Gill nets:								
Black bass	......	......	......	......	......	......	......	......
Blue pike	186,660	4,000	56,670	1,550	......	......	970,671	18,365
Catfish	......	......	......	......	......	......	......	......
Herring	893,320	9,755	663,300	6,765	21,000	158	4,314,443	45,301
Perch	21,334	214	90,000	900	......	......	325,181	3,754
Saugers	13,340	148	167,400	6,696	......	......	198,786	7,020
Sturgeon	......	......	......	......	......	......	......	......
Trout	......	......	......	......	......	......	......	......
Wall-eyed pike	......	......	83,600	3,344	......	......	107,480	4,429
Whitefish	46,665	2,800	131,333	7,250	2,300	115	238,736	12,967
Other fish	16,780	200	......	......	......	......	131,105	1,570
Total	1,178,099	17,117	1,192,303	26,505	23,300	273	6,286,402	93,406
Fyke nets:								
Black bass	42,085	2,104	40,000	2,400	......	......	82,085	4,504
Catfish	236,250	4,620	90,000	1,800	20,000	500	346,250	6,920
Perch	238,670	1,790	20,000	200	25,000	250	283,670	2,240
Saugers	338,655	3,150	12,200	366	10,000	300	360,855	3,816
Wall-eyed pike	291,860	14,220	17,800	734	5,500	275	315,160	15,229
Other fish	926,925	6,550	40,000	400	40,000	200	1,006,925	7,150
Total	2,074,445	32,434	220,000	5,900	100,500	1,525	2,394,945	39,859
Seines:								
Black bass	5,800	350	32,000	1,920	2,000	120	39,800	2,390
Blue pike	11,500	350	......	......	......	......	11,500	350
Catfish	16,500	570	140,000	2,800	30,000	750	186,500	4,120
Perch	10,500	250	25,200	252	15,000	150	50,700	652
Saugers	15,400	460	4,650	149	104,000	3,120	124,050	3,729
Wall-eyed pike	26,000	1,300	7,350	451	20,000	1,000	53,350	2,751
Other fish	25,000	600	64,800	648	45,000	225	134,800	1,473
Total	110,700	3,880	274,000	6,220	216,000	5,365	600,700	15,465
Lines, spears, and grapnels:								
Catfish	190,000	4,750	100,000	2,500	40,000	1,200	520,500	12,770
Perch	60,000	1,520	......	......	......	......	60,000	1,520
Saugers	205,000	5,570	......	......	......	......	205,000	5,570
Wall-eyed pike	29,300	1,760	......	......	......	......	29,300	1,760
Total	484,300	13,600	100,000	2,500	40,000	1,200	814,800	21,620
Miscellaneous:								
Turtles and frogs	......	574	......	2,000	......	500	......	3,074
Grand total	22,323,304	289,411	3,309,303	63,530	2,607,300	38,183	37,678,892	518,566

Table showing by counties, apparatus, and species the yield of the shore fisheries of Lake Erie—Continued.

Apparatus and species.	Michigan. Monroe. Pounds.	Michigan. Monroe. Value.	Total for lake. Pounds.	Total for lake. Value.
Pound nets and trap nets:				
Black bass	7,500	$450	112,403	$5,887
Blue pike			1,952,308	32,068
Catfish	30,000	750	470,832	12,132
Herring	1,160,000	8,700	20,210,983	194,775
Perch	70,000	350	1,270,700	8,038
Saugers	280,000	2,800	3,226,562	30,425
Sturgeon	33,000	900	531,243	19,626
Wall-eyed pike	250,000	10,000	1,399,846	57,301
Whitefish	136,000	6,800	937,063	46,323
Other fish	138,000	730	1,077,829	8,050
Total	2,104,500	31,480	31,189,769	414,625
Gill nets:				
Black bass			5,730	264
Blue pike			2,463,824	51,031
Catfish			500	10
Herring			9,443,810	101,310
Perch			400,712	5,639
Saugers			205,100	7,079
Sturgeon			1,288,790	46,199
Trout			66,065	2,915
Wall-eyed pike			170,970	7,038
Whitefish			585,876	28,709
Other fish			137,695	1,674
Total			14,769,072	251,868
Fyke nets:				
Black bass	500	30	82,585	4,534
Catfish	30,000	750	376,250	7,670
Perch	20,000	200	303,670	2,440
Saugers	8,000	240	368,855	4,056
Wall-eyed pike	3,500	175	318,660	15,404
Other fish	25,000	125	1,031,925	7,275
Total	87,000	1,520	2,481,945	41,379
Seines:				
Black bass	1,500	90	43,000	2,565
Blue pike			11,500	350
Catfish	40,000	1,000	230,375	5,275
Perch	25,000	250	77,100	937
Saugers	18,000	540	142,050	4,269
Wall-eyed pike	3,000	150	58,925	3,004
Other fish	30,000	150	189,670	2,369
Total	117,500	2,180	752,620	18,769
Lines, spears, and grapnels:				
Black bass			4,700	271
Blue pike			113,232	7,024
Catfish	80,000	2,400	848,100	20,827
Herring			14,500	890
Perch	15,000	375	117,420	4,151
Saugers			205,000	5,570
Sturgeon			206,874	6,300
Trout			700	35
Wall-eyed pike	8,400	425	49,960	3,135
Whitefish			1,500	90
Other fish			16,200	608
Total	103,400	3,200	1,578,186	48,901
Miscellaneous:				
Turtles and frogs		1,000		4,074
Grand total	2,412,400	39,380	50,771,592	779,616

Canadian fisheries of Lake Erie controlled by Sandusky dealers.—The growing demand for fishery products, and the failure of the American fisheries to supply all the fish required for the trade of the Sandusky dealers, has, during the past ten years, led to an extension of the operations of the Sandusky fishermen into Canadian waters. Several firms now control important pound-net fisheries on the northern shore of Lake Erie. Over 100 pound nets are there employed, and 3 steamers are engaged in transporting the catch to Sandusky. Herring constitutes more than two-thirds of the weight and over one-half the value of the yield. The following tables relate to these fisheries:

Persons employed.

How engaged.	Number.	
	1890.	1891.
In fishing pound nets	130	132
On collecting vessels	26	26
Total	156	158

Vessels, boats, apparatus, etc., employed.

Items.	1890.		1891.	
	Number.	Value.	Number.	Value.
Steamers	3	$36,000	3	$36,000
Boats	68	9,030	70	9,300
Pile-drivers	28	5,035	29	5,210
Pound nets	109	34,960	111	35,650
Shore property		1,200		1,200
Total		86,225		87,360

Products in 1890.

Species.	Pounds.	Value.
Whitefish	117,010	$5,850
Herring	2,492,667	21,659
"Hard" fish	142,185	5,686
"Soft" fish	106,330	1,020
Perch	142,040	722
Black bass	55,215	3,540
Catfish	19,420	485
Sturgeon	23,400	1,560
Total	3,098,267	40,522

The yield of these fisheries during the ten years ending in 1890 is shown in the following table. It appears that during 1887, 1888, and 1889 the output was larger than in any other years. The figures are from the official customs-house records, and show separately the fish brought in free and those subject to a duty.

Fish imported at Sandusky, Ohio, from 1881 to 1890, taken in fisheries on the Canadian side of Lake Erie controlled by Sandusky dealers.

Years.	Free of duty.		Dutiable.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1881	1,113,647	$16,493	13,486	$535	1,127,133	$17,028
1882	1,288,831	20,201	194,981	5,721	1,483,812	25,922
1883	1,024,100	20,446	859,536	11,763	1,883,636	32,209
1884	1,010,289	18,637	722,504	6,517	1,732,793	25,154
1885	1,962,521	19,088	60,547	8,191	2,023,068	27,279
1886	927,027	12,948	346,779	2,267	1,273,806	15,215
1887	3,024,984	37,211	1,109,441	12,094	4,134,425	49,305
1888	4,609,155	54,539	912,186	13,577	5,521,341	68,116
1889	5,135,152	46,428	796,456	9,463	5,931,608	55,891
1890	2,204,463	27,698	893,804	12,824	3,098,267	40,522
Total	22,300,169	273,689	5,909,720	82,952	28,209,889	356,641

Notes on the fish trade of Ohio.—At Cleveland, Sandusky, Toledo, Port Clinton, and other places in Ohio important wholesale trade in fish is carried on. The business is larger than in any other State bordering on the lakes. While most of the supply comes from Lake Erie, important consignments are also received from the other lakes.

The following table is a detailed exhibition of the extent of the wholesale fish trade of Ohio in 1890. The number of persons engaged in connection with the receipt, preparation, and sale of the fish was over 800; the capital devoted to the industry amounted to over $830,000 exclusive of collecting vessels and other property properly included under the statistics for the fishery; the quantity of fish handled was over 46,000,000 pounds, having a value of more than $1,490,000.

Table showing by counties the wholesale fish trade of Ohio in 1890.

Items.	Cuyahoga.	Erie.	Lake.	Lorain.	Lucas.	Ottawa.	Total.
Number of establishments	12	23	3	2	7	4	51
Number of persons employed	99	301	10	9	208	186	813
Value of property	$104,500	$265,900	$9,850	$9,000	$74,000	$68,500	$531,750
Cash capital	$70,000	$199,000	$10,000	$6,000	$9,000	$8,000	$302,000
Fish handled in wholesale trade:							
Fresh ... lbs	3,722,270	14,034,145	1,512,550	850,823	2,234,000	1,612,000	23,965,788
Value	$125,470	$427,050	$40,487	$21,289	$92,710	$74,560	$781,566
Frozen ... lbs	1,647,000	7,986,643	....	....	2,031,000	887,000	12,551,613
Value	$56,005	$270,486	....	....	$76,630	$34,030	$437,151
Salted ... lbs	2,641,000	3,734,218	603,000	740,000	400,000	394,000	8,512,218
Value	$67,590	$100,103	$19,875	$23,950	$10,000	$10,830	$232,324
Smoked ... lbs	128,000	272,800	9,500	....	52,500	....	462,800
Value	$10,800	$20,860	$1,140	....	$2,200	....	$35,000
Total quantity handled, pounds	8,138,270	26,027,806	2,125,050	1,590,823	4,717,500	2,893,000	45,492,449
Value	$259,865	$818,503	$61,502	$45,239	$181,540	$119,420	$1,486,071
Fish utilized in canning ... lbs	....	520,000	....	....	....	....	520,000
Value paid	....	$5,850	....	....	....	....	$5,850
One-pound cans prepared	....	140,000	....	....	....	....	140,000
Value	....	$8,200	....	....	....	....	$8,200
Two-pound cans prepared	....	36,000	....	....	....	....	36,000
Value	....	$3,240	....	....	....	....	$3,240
Secondary products prepared:							
Caviar ... lbs	1,700	56,100	3,100	....	31,000	1,100	96,600
Value	$375	$11,260	$654	....	$10,850	$330	$23,989
Isinglass ... lbs	....	1,500	60	....	600	20	2,180
Value	....	$2,250	$90	....	$900	$30	$3,270
Oil ... galls	....	....	....	....	400	50	450
Value	....	....	....	....	$100	$13	$113

NOTE.—In Ashtabula County, 3,600 pounds of caviar, valued at $520, were prepared.

Sandusky has the distinction of maintaining the largest trade in fresh-water fish of any city in the country. Most of the trade shown for Erie County in the preceding table represents the fish business of that city. The following special statistics relating to the salt-fish and frozen-fish trade of that place are more detailed than those contained in the previous table for the entire State of Ohio:

Statistics of the salt fish handled in the wholesale trade of Sandusky, Ohio, in 1890.

Trade names.	Pounds.	Value.
"Herring"	1,336,756	$33,297
"No. 1 whitefish"	6,130	398
"Ciscoes" (herring split in belly)	314,352	7,504
"Family whitefish" or "No. 2 whitefish" (large herring)	316,650	12,786
"No. 1 pickerel"	16,105	235
"No. 2 pickerel" (saugers, etc.)	220,035	5,107
"Medium pickerel" (blue pike)	45,540	1,456
"Shad" (suckers, etc.)	75,764	1,490
Skinned catfish	570	40
Total	2,331,902	62,313

Statistics of the fish frozen by Sandusky wholesale dealers in 1890.

Species.	Pounds.	Value.
Whitefish	162,487	$12,832
Herring	5,194,487	155,306
Blue pike	56,005	2,785
Saugers	151,366	4,539
White bass	6,742	270
Perch	62,994	1,549
Shad, suckers, etc	12,583	316
Miscellaneous "hard" fish	13,726	1,094
Total	5,660,390	178,691

LAKE ONTARIO.*

General importance of the fisheries.—The present relative unimportance of the fisheries of this lake, as compared with the extent of the industry in other lakes, is coexistent with a decrease since 1880 in two of the most important fishes that has been unparalleled in the history of the lake fisheries. The scarcity of fishes that were formerly abundant and the possibility of further reduction in the fish supply have drawn to the fisheries of Lake Ontario more attention than has been accorded to the industry in any other lake except Lake Erie, and have resulted in a very extensive movement on the part of legislators, sportsmen, fish-culturists, and the general public, having for its object the preservation and increase of the valuable fishery resources of the lake. While a few persons express the opinion that there has been no actual diminution in the abundance of fish life, and that the small yield is due to natural causes, there seems little ground for doubt that the lake has been overfished, that some of the best fishes have not had proper protection during the spawning period, and that artificial propagation has not been resorted to on a sufficiently large scale to offset or overcome the depletion caused by man.

The previous abundance of fish in the lake shows that the waters are capable of sustaining much more important fishing than has been carried on for a number of years. While it is possible that the vast quantities of alewives now found in the lake may affect in some indirect way the growth of young fish and the increase in the numbers of marketable fish, it is extremely improbable that the natural conditions have undergone any marked changes that militate against the renewal of fisheries of as great extent as have ever existed. The U. S. Commissioner of Fish and Fisheries has stated that "it is not only possible, it is entirely practicable, to restore and maintain these fisheries by adequate resort to means and agencies entirely within our control"—the "means and agencies" consisting of the application of well-known fish-cultural principles, which, under similar conditions in other waters, have been satisfactorily applied.

The principal fishing centers in this lake are Cape Vincent, Sacketts Harbor, Oswego, and Wilson. Much the largest fishing interests are located in Jefferson County, which occupies the eastern part of the lake and includes most of the important fishing-grounds. Oswego County, which joins Jefferson on the west, and Niagara County, at the extreme western limit of the State, also have relatively valuable fisheries. In the remaining counties of Cayuga, Wayne, Monroe, and Orleans, however, the fisheries are of slight extent.

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* A report on the fisheries of this lake, prepared by the present writer, has already appeared in the Bulletin of the U. S. Fish Commission for 1890. It contains some information that it is not necessary to incorporate in this article, and may be consulted by those especially interested in the fisheries of this lake.

Notes on the commercial fishes.—The fish now of greatest economic value in Lake Ontario does not occupy a corresponding rank in any other lake, although of great prominence in other parts of the Great Lakes basin; this is the wall-eyed pike, locally known also as the pickerel and yellow pike. Its relative as well as its actual importance has greatly increased of late years, owing to the scarcity of whitefish and trout, which requires the fishermen to take other fish in order to make their business remunerative. The fish is always in demand, at higher prices than are commanded by any other fishes, and throughout the eastern end of the lake its abundance determines the financial success of the fishermen. Fishermen who formerly sought only whitefish and trout, now confine their attention to the wall-eyed pike, and it is of the utmost consequence to the fishing interests that the supply of this fish be maintained. Fortunately the spawning season is such as to insure the almost uninterrupted completion of the reproductive function before the opening of the fishing operations. The fish spends the winter in the deeper parts of the lake. In April it appears in the inshore waters and then and there undergoes the spawning process. In early summer it frequents the shoals in the lake, where the principal part of the catch is taken; and on the approach of cold weather it again retires to the deep water. The fish subsist in large part on the alewive (*Clupea pseudoharengus*) and are reported to have increased in size as the result of the abundant food furnished by the presence of that exotic species. The fish is taken chiefly in the trap nets set in the eastern part of the lake. In Jefferson County, where most of the traps are owned, it constitutes one-third the total quantity of the catch, and yields three-fifths the income of the fishermen. Small numbers are taken with gill nets, seines, and lines. The average weight of the fish is 4 pounds and the maximum about 14 pounds.

The subspecies of the wall-eyed pike, generally known as the blue pike, which is a prominent fish in Lake Erie, is not very common in this lake. In 1891, however, it was found in very large numbers in the vicinity of Oswego, attaining greater abundance than at any previous time in many years. The other species of pike perch, the sauger, which is also a conspicuous factor in the fisheries of the adjoining lake, does not occur in commercial abundance in Lake Ontario.

The sturgeon, which occupies the second position in this lake, is likewise far from having the same relative importance in other parts of the lake region. While the fish is manifestly scarcer than formerly, the present supply is about the same as in 1880, owing to the increased efforts made by the fishermen to keep up the output as a result of steady demand and good prices. It is taken chiefly with gill nets and set lines, and is most abundant in the eastern end of the lake, although considerable quantities are also taken on set lines in Niagara and Orleans counties, which occupy the western shore line.

Three species of whitefishes have commercial importance in this lake. The common whitefish has been of late years so scarce that it has had little economic value, although less than ten years ago it was the principal fish taken. The decrease in the catch in a single decade was over 86 per cent, a change that is without precedent in any other lake. The fish is now taken almost wholly in Jefferson County. The grounds chiefly resorted to are Charity Shoal and the vicinity of the Duck Islands. These islands are in Canada, and support the most extensive whitefish fishery now carried on in the lake. The scarcity of whitefish on the American side of the lake is not without precedent, although the length of the period of scarcity is greater than ever before recorded. The lake herring or cisco is abundant in this lake, although it is much less plentiful than formerly. The largest quantities are now taken in Jefferson County in gill nets. In fall and winter the fish resort to the shore for the purpose of spawning, and it is then that the principal fishing is done. Since the longjaw or bloater whitefish became prominent in the fisheries of this lake, the cisco has occupied a gradually diminishing importance, and in some places where it was formerly the principal fish it is now taken in only one-tenth the quantity that the longjaw is. The latter, known also by the names bloater, ciscoette, silver whitefish, etc., is now the most abundant whitefish inhabiting the lake. It frequents the deepest water and is taken only in gill nets.

The lake trout deserves mention not because of its present importance, but because of its former abundance and marked decrease. In 1880 it was, next to the whitefish, the most prominent fish of this lake; now it has less value than any fish of sufficient importance to be separately designated in the accompanying statistical tables. The decrease since 1880 has been even more pronounced than in the case of the whitefish, amounting to nearly 93 per cent. In many places in which trout were formerly taken in large quantities they are now rarely observed. The decline of the trout, coincident with that of the whitefish, and the apparent supplanting of these fish by others respectively similar in habits—the wall-eyed pike and the long-jaw whitefish—constitute the most prominent features of this lake and demand careful consideration. While some fishermen think the decrease in the abundance of these fish has been only apparent, as shown by the large catches made on the Canadian side of the lake, the most plausible explanation seems to be that the fish have not had any protection immediately prior to and during the spawning season, and that the fish-cultural operations undertaken have not been sufficiently extensive to overcome the destruction of eggs and breeding fish.

Among other fishes of the lake of some commercial value, but not worthy of separate discussion, are, in order of importance, catfish, eels, pike, yellow perch, suckers, and black bass.

Notes on apparatus and methods.—The fishing apparatus in this lake which represents the largest investment is the trap net, which is practically restricted to Jefferson County at the eastern end of the lake. The trap net here used is similar in construction to the one in common use in the southern New England States. It is smaller than the ordinary lake pound net, is held in position by means of weights and buoys instead of poles, and the escape of the fish from the bowl is prevented by a top of netting.

The use of trap nets is more extensive in this lake than in any other member of the lake system. The explanation is that the stony character of the bottom in the most favorable fishing regions prevents or makes difficult the driving of pound-net poles, and that legal enactments have prohibited the setting of such apparatus in the inshore waters in most places.

The important advantages which the trap net has over the pound net are that it may be readily moved from place to place to correspond with the movements of the fish, and that an entire net may be taken ashore from time to time, repaired, cleaned, and dried. It is comparatively inexpensive, and individual fishermen can afford to operate as many as 8 or 10 at one time. It is set on the bottom in water from 10 to 25 feet deep, and is drawn daily or less frequently, according to the abundance of fish, the condition of the weather, state of the market, etc. It is well adapted to the capture of whitefish, lake trout, sturgeon, perch, suckers, and wall-eyed pike. More trout and wall-eyed pike are thus taken than with all other appliances combined. A form of trap with a finer mesh, known as an eel trap, is used in some numbers for eels, which are thus caught in larger quantities than with any other apparatus except fyke nets.

A few pound nets are operated by fishermen of Three-Mile Bay, Black River Bay, and Sacketts Harbor, about a dozen nets being used annually in recent years. They are of small size, and are set close inshore, catching herring and other fish that resort to the shores.

Gill nets rank next to traps in value and surpass them in the quantity and value of the catch. They are generally used throughout the lake, but are most extensively employed in Jefferson and Niagara counties. Whitefish and trout gill nets have a 3-inch mesh; 20 or 22 rods of rigged netting represent 1 pound of twine. The usual complement of a boat in the eastern part of the lake, where most of the whitefish and trout are caught, is 100 to 600 rods. Herring and long-jaw gill nets have $1\frac{5}{8}$-inch mesh; when ready for fishing 1 pound makes 14 to 20 rods of netting. The price of a fully rigged net ranges from $4 to $6 per pound, depending on various circumstances. In the important long-jaw fisheries of Niagara County each gill-net boat employs about 50 pounds of netting in a season, about 12 pounds being in the water at one time. These nets, fitted for deep-water fishing, cost $6 per pound when fully rigged. In the eastern end of the lake the quantity of netting used by a boat varies from 100 to 600 rods, the average being about 300 rods. The gill nets fished for sturgeon have a 6-inch mesh, bar measure; 1 pound of the twine makes a net about 120 feet long. In some places only 9 to 12 pounds are fished by a single boat, but in the eastern end of the lake the sturgeon nets are very long, single boat crews operating several hundred rods of netting.

The principal fish taken in gill nets are lake herring, long-jaw whitefish, and sturgeon, all of which are thus caught in larger quantities than with any other kind of apparatus. The gill-net catch of black bass and whitefish is also larger than by other means.

Fyke nets are the most important of the remaining forms of apparatus employed in this lake. In the eastern part of the lake they are, to a great extent, operated by trap-net fishermen, and in other sections of the lake very few nets are used by men not engaged in other fisheries. Fykes are mostly set for catfish, which constitute nearly half the catch, the other fish of importance being pike, pike perch, eels, and suckers. Trawl lines are sparingly used at a number of places, but are not an important means of capture. They take chiefly sturgeon. Seines and dip nets, which complete the list of apparatus, are unimportant and capture mostly suckers.

Fishing-grounds.—The grounds resorted to by the gill-net fishermen of this lake extend 10 miles offshore. Whitefish and trout are taken mostly in deeper water, but lake herring, sturgeon, and pike are caught chiefly in the inshore waters. The fishery for the long-jaw whitefish, which is most extensive in the western counties of the lake, is carried on in deep water at a distance of 3 to 10 miles from shore.

Trap nets are operated only in the eastern part of the lake, being set principally in the vicinity of Charity Shoal and around the islands which are favorite resorts for the whitefish, trout, and pike perch.

Fyke nets are fished in the numerous bays, ponds, and creeks along the shores of the lake where catfish, eels, perch, pike, and suckers, to the capture of which the fyke net is especially adapted, naturally resort. The principal fyke-net grounds are in Jefferson and Oswego counties.

The set-line fishing-grounds for sturgeon are chiefly in Jefferson and Oswego counties, in the eastern part of the lake, and in Monroe, Orleans, and Niagara counties, in the western part.

In addition to the suckers taken incidentally in trap and fyke nets, there is a special fishery for them with dip nets and small seines in creeks in Niagara County, to which the fish resort in the early spring for the purpose of spawning.

Statistics of the fisheries.—The following series of tables illustrates the extent of the various phases of the fishing industry in Lake Ontario. The tables relate to persons employed, apparatus, boats, and vessels used, and quantity and value of the catch, the figures being by counties.

Table showing by counties the number of persons employed in the fisheries of Lake Ontario in 1890.

Counties.	In vessel fisheries.	In shore fisheries.	On shore.	Total.
Jefferson	4	152	16	172
Oswego	5	53	4	62
Cayuga	2	11	2	15
Wayne		41		41
Monroe		28		28
Orleans		17		17
Niagara		54		54
Total	11	356	22	389

Table showing by counties the vessels, boats, apparatus, and capital employed in the fisheries of Lake Ontario in 1890.

Designation.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels, with outfits	1	$5,880	1	$3,300	1	$405		
Boats	202	15,700	48	1,390	13	595	54	$2,245
Apparatus of capture:								
Gill nets ... feet	696,425	10,911	57,180	792	18,315	296	66,591	935
Pound nets and traps	286	24,455					2	122
Fyke nets	458	6,850	140	2,100	26	315	39	365
Seines	3	60	4	240			2	60
Set lines ... feet	17,182	35	37,200	75			1,210	4
Miscellaneous apparatus		45		4				
Shore property		18,882		3,980		260		1,525
Cash capital		12,390		500				
Total		95,208		12,381		1,871		5,256

Designation.	Monroe.		Orleans.		Niagara.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels, with outfits							3	$9,585
Boats	20	$472	11	$305	25	$870	373	21,577
Apparatus of capture:								
Gill nets ... feet	42,240	434	76,395	1,775	146,799	2,967	1,103,945	18,110
Pound nets and traps							288	24,577
Fyke nets	21	192					684	9,822
Seines	4	48			14	248	27	656
Set lines ... feet			59,200	296	24,840	80	139,632	490
Miscellaneous apparatus								49
Shore property		606		71		453		25,777
Cash capital								12,890
Total		1,752		2,447		4,618		123,533

Table showing by counties and species the yield of the fisheries of Lake Ontario in 1890.

Species.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	11,855	$1,058	6,201	$340	2,676	$148	3,993	$231
Catfish	315,711	8,360	108,650	2,173	15,100	302	16,030	757
Eels	247,490	8,396	3,600	188	910	44	2,890	173
Herring	369,334	14,199	24,525	981	1,600	48	26,210	776
Perch	241,520	2,383	70,600	1,765	3,960	109	33,985	715
Pike	39,950	1,595	61,795	3,361	10,370	463	15,060	753
Pike perch	296,832	26,955	24,673	1,245	3,454	172	1,900	76
Sturgeon	374,235	14,949	22,532	1,083			2,330	70
Suckers	168,820	1,960	51,115	935	4,865	72	5,410	113
Trout	40,400	2,048	500	30				
Whitefish	143,771	6,517	3,550	213			720	72
Other fish	166,540	1,782	67,880	1,697	4,498	72	9,480	124
Total	2,416,458	90,142	445,621	14,011	47,433	1,430	118,008	3,860

Species.	Monroe.		Orleans.		Niagara.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	2,800	$224	3,000	$210	2,567	$153	33,092	$2,364
Catfish	11,564	653	1,500	30	3,400	169	471,955	12,444
Eels	2,300	112					257,190	8,913
Herring	10,960	438	6,000	120	160,349	4,374	598,978	20,936
Perch	4,115	245	1,150	35	3,617	116	358,947	5,368
Pike	2,000	100			315	12	129,490	6,284
Pike perch					4,143	281	331,002	28,729
Sturgeon			90,675	3,830	51,980	2,359	541,752	22,291
Suckers	7,420	312	910	27	40,630	1,219	279,170	4,578
Trout					110	11	41,010	2,089
Whitefish					730	73	148,771	6,875
Other fish	2,753	129	440	13	3,500	98	255,091	3,915
Total	43,912	2,213	103,675	4,265	271,341	8,865	3,446,448	124,786

Table showing by counties, apparatus, and species the yield of the fisheries of Lake Ontario in 1890.

Apparatus and species.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Gill nets:								
Black bass	5,625	$450	5,283	$290	2,676	$148	3,300	$190
Herring	364,220	14,056	18,500	740	1,600	48	25,000	740
Perch					2,110	61	26,400	528
Pike			24,100	1,210	6,250	253	9,300	465
Pike perch			21,606	1,072	3,454	172	1,350	54
Sturgeon	344,329	13,784	8,710	450			2,330	70
Suckers			6,250	125	2,200	32		
Trout	10,027	525	500	30				
Whitefish	75,379	3,510	2,000	120			720	72
Other fish					1,218	20	4,610	50
Total	799,580	32,325	86,949	4,037	19,508	734	73,010	2,169
Pound nets and trap nets:								
Black bass	6,230	608					258	15
Catfish	49,010	1,222						
Eels	196,204	6,550						
Herring	5,114	143					610	18
Perch	149,100	1,390					1,875	37
Pike							520	26
Pike perch	296,832	26,955					300	12
Sturgeon	26,075	992						
Suckers	93,800	938						
Trout	30,181	1,513						
Whitefish	68,392	3,007						
Other fish	118,690	1,260					1,660	18
Total	1,039,628	44,578					5,223	126
Fyke nets:								
Catfish	260,374	7,000	105,000	2,100	15,100	302	14,265	704
Eels	46,636	1,660	3,600	188	910	44	2,890	173
Perch	92,420	993	68,800	1,720	1,850	48	3,460	105
Pike	37,450	1,520	28,000	1,400	4,120	210	4,200	210
Suckers	47,080	434	18,665	280	2,665	40	4,410	98
Other fish	47,850	522	67,200	1,680	3,280	52	2,300	46
Total	531,810	12,179	291,265	7,368	27,925	696	31,525	1,336
Seines:								
Catfish			3,400	68			935	28
Herring			6,025	241			600	18
Perch			1,800	45			1,250	25
Pike			820	41			640	32
Pike perch			885	53			250	10
Suckers			3,250	65			1,000	15
Whitefish			1,550	93				
Other fish			680	17			910	10
Total			18,410	623			5,585	138
Lines:								
Black bass			918	50			435	26
Catfish	1,767	47	250	5			830	25
Eels	4,650	186						20
Perch							1,000	20
Pike			8,875	710			400	
Pike perch			2,182	120				
Sturgeon	3,621	167	13,822	633				
Suckers			1,250	25				
Trout	192	10						
Total	10,230	410	27,297	1,543			2,665	91
Minor apparatus:								
Catfish	4,560	91						
Pike	2,500	75						
Sturgeon	210	6						
Suckers	27,940	478	21,700	440				
Total	35,210	650	21,700	440				
Grand total	2,416,458	90,142	445,621	14,011	47,433	1,430	118,008	3,860

Table showing by counties, apparatus, and species the yield of the fisheries of Lake Ontario—Continued.

Apparatus and species.	Monroe.		Orleans.		Niagara.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Gill nets:								
Black bass	2,860	$224	3,000	$210	600	$35	23,284	$1,547
Catfish	6,030	275	1,500	30	1,000	25	8,530	330
Herring	10,960	438	6,000	120	160,349	4,374	586,629	20,516
Perch			1,150	35	550	24	30,210	648
Pike	2,000	100			90	4	41,740	2,032
Pike perch					560	32	26,970	1,330
Sturgeon			43,425	1,880	30,125	1,423	428,919	17,607
Suckers	3,920	158	910	27	300	9	13,580	351
Trout					110	11	10,637	566
Whitefish					150	15	78,249	3,717
Other fish	1,200	36	440	13	1,500	58	8,968	177
Total	26,910	1,231	56,425	2,315	195,334	6,010	1,257,716	48,821
Pound nets and trap nets:								
Black bass							6,488	623
Catfish							49,010	1,222
Eels							196,204	6,550
Herring							5,724	161
Perch							150,975	1,427
Pike							520	26
Pike perch							297,132	26,967
Sturgeon							26,075	992
Suckers							93,800	938
Trout							30,181	1,513
Whitefish							68,392	3,007
Other fish							120,350	1,278
Total							1,044,851	44,704
Fyke nets:								
Catfish	5,534	378					400,273	10,484
Eels	2,300	112					56,336	2,177
Perch	4,115	245					170,645	3,111
Pike							73,770	3,340
Suckers	3,500	154					76,320	1,056
Other fish	1,553	93					122,183	2,393
Total	17,002	982					899,527	22,561
Seines:								
Black bass					1,967	118	1,967	118
Catfish					2,400	144	6,735	240
Herring							6,625	259
Perch					3,067	92	6,117	162
Pike					225	8	1,685	81
Pike perch					3,583	249	4,718	312
Sturgeon					2,480	78	2,480	78
Suckers					40,330	1,210	44,580	1,290
Whitefish					580	58	2,130	151
Other fish					2,000	40	3,590	67
Total					56,632	1,997	80,627	2,758
Lines:								
Black bass							1,353	76
Catfish							2,847	77
Eels							4,650	186
Perch							1,000	20
Pike							9,275	730
Pike perch							2,182	120
Sturgeon			47,250	1,950	19,375	858	84,068	3,608
Suckers							1,250	25
Trout							192	10
Total			47,250	1,950	19,375	858	106,817	4,852
Minor apparatus:								
Catfish							4,560	91
Pike							2,500	75
Sturgeon							210	6
Suckers							49,640	918
Total							56,910	1,090
Grand total	43,912	2,213	103,675	4,265	271,341	8,865	3,446,448	124,786

III.—THE FISHERIES CONSIDERED BY STATES.

Explanatory note.—In the foregoing chapter, the fisheries have been considered primarily by lakes, and secondarily by States and counties. To facilitate the comprehension of the extent of the fisheries in each State, the following statistics have been prepared, consisting (1) of a series of general tables by States, and (2) of special tables, by lakes, for the States having a frontage on two or more lakes; these are Michigan, Wisconsin, and New York. The figures are presented without detailed explanatory notes, which previous discussions render unnecessary.

Statistics.—The figures show that in the matter of persons employed Michigan takes precedence over all other States; more than one-third of the entire fishing population of the Great Lakes is here employed. The other States in the order of their rank are Ohio, New York, Wisconsin, Pennsylvania, Illinois, Indiana, and Minnesota. The number of vessel fishermen and of shore fishermen is greatest in Michigan, while the number of shoresmen is greatest in Ohio.

Ohio leads in the matter of invested capital, closely followed by Michigan; after which come New York, Wisconsin, Illinois, Pennsylvania, Minnesota, and Indiana. The number of fishing vessels, boats, gill nets, and pound nets is greatest in Michigan; the number of collecting vessels, fyke nets, and the amount of shore property and cash capital are greatest in Ohio.

The value of the fisheries of Michigan is greater than that of any other State, although the quantity of products taken is greatest in Ohio. The rank of the States, based on the value of the catch, is Michigan, Ohio, Wisconsin, New York, Pennsylvania, Illinois, Indiana, and Minnesota. The largest catch of bass, lake herring, and pike perch is taken in Ohio. Perch, trout, and whitefish are caught in largest quantities in Michigan. The yield of sturgeon is greatest in New York.

Table showing by States the number of persons employed in the fisheries of the Great Lakes.

States.	On fishing vessels.	On transporting vessels.	In shore fisheries.	On shore, in fish-houses, etc.	Total.
New York	26	6	1,346	120	1,498
Pennsylvania	92	3	250	58	403
Ohio	105	87	1,733	813	2,738
Michigan	226	24	2,693	400	3,343
Indiana	5	....	89	....	94
Illinois	12	....	309	65	386
Wisconsin	126	....	956	143	1,225
Minnesota	6	13	17	15	51
Total	598	133	7,393	1,614	9,738

Table showing by States the apparatus and capital employed in the fisheries of the Great Lakes.

Designation.	New York.		Pennsylvania.		Ohio.		Michigan.		Indiana.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing	5	$15,300	14	$41,800	16	$61,100	38	$126,850	1	$1,200
Tonnage	71.39	....	97.10	....	189.62	....	521.01	....	5.51	....
Outfit	......	2,488	......	7,420	......	8,750	......	19,703	......	420
Vessels transporting	2	5,280	1	2,000	19	144,200	8	32,800	......	....
Tonnage	32.48	....	16.76	....	988.08	....	199.27	....	......	....
Outfit	......	1,005	......	400	......	12,725	......	2,645	......	....
Boats	536	36,677	94	32,920	1,016	159,980	1,481	96,076	52	3,370
Apparatus of capture, vessel fisheries:										
Gill nets	1,172	8,790	10,177	33,512	7,747	25,842	12,796	95,229	363	1,640
Apparatus of capture, shore fisheries:										
Pound nets and trap nets	325	29,427	200	29,270	1,423	464,180	1,460	333,950	32	11,800
Gill nets	5,755	44,142	12,193	39,056	14,621	36,281	16,547	102,443	390	2,165
Fyke nets	684	9,822	......	....	1,110	63,650	446	12,030	......	....
Seines	32	781	......	....	33	4,630	58	9,010	......	....
Lines, spears, dip nets, etc	......	2,118	......	160	......	3,712	......	4,982	......	309
Shore property	......	128,127	......	46,700	......	587,850	......	455,591	......	645
Cash capital	......	413,890	......	50,000	......	302,000	......	169,600	......	....
Total	......	697,847	......	283,238	......	1,874,900	......	1,460,909	......	21,549

Designation.	Illinois.		Wisconsin.		Minnesota.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing	2	$7,000	20	$68,200	1	$2,000	97	$323,450
Tonnage	40.11	....	261.29	....	11.23	....	1,197.26	....
Outfit	....	485	....	10,155	....	900	....	50,321
Vessels transporting	....	....	....	....	1	25,000	31	209,280
Tonnage	....	....	....	....	165.62	....	1,402.21	....
Outfit	....	....	....	....	....	7,000	....	23,775
Boats	33	1,280	478	30,510	16	835	3,706	361,648
Apparatus of capture, vessel fisheries:								
Gill nets	550	2,650	7,257	37,124	200	2,000	40,362	206,787
Apparatus of capture, shore fisheries:								
Pound nets	10	3,750	299	77,380	1	200	3,750	949,957
Gill nets	95	475	11,369	64,517	223	2,230	61,193	291,309
Fyke nets	....	....	728	11,366	....	....	2,968	96,868
Seines	3	380	28	2,435	....	....	154	17,236
Lines, spears, dip nets, etc	....	315	....	1,207	....	249	....	13,052
Shore property	....	248,210	....	115,080	....	52,668	....	1,634,871
Cash capital	....	165,000	....	63,400	....	20,300	....	1,184,190
Total	....	429,545	....	481,374	....	113,382	....	5,362,744

Products of the fisheries of the Great Lakes.

Species.	New York.		Pennsylvania.		Ohio.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	48,797	$3,187	19,990	$1,032	203,223	$11,096
Herring	2,406,098	49,367	8,012,510	80,443	27,888,653	281,878
Perch	407,567	6,883	208,540	5,420	2,483,247	22,189
Pike and pike perch	819,519	49,723	3,402,285	76,436	9,442.291	185,061
Sturgeon	2,251,416	82,968	105,750	3,265	230,493	8,861
Trout	80,430	3,992	82,000	3,280	....	....
Whitefish	466,621	22,610	758,019	36,157	1,129,582	57,278
Other fish	1,607,521	37,776	275,750	5,089	3,554,619	52,320
Total	8,087,969	256,506	12,864,844	211,122	44,932,108	618,683

Species.	Michigan.		Indiana.		Illinois.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	97,987	$5,109	5,393	$270	....	....
Herring	6,393,756	87,437	160,408	3,206	88,375	$1,768
Perch	3,029,464	40,380	106,064	3,184	511,009	14,009
Pike and pike perch	2,639,891	86,677	....	....	....	....
Sturgeon	1,480,256	45,073	70,716	2,780	16,480	640
Trout	8,542,952	309,616	154,733	7,730	71,660	3,479
Whitefish	7,725,105	312,411	66,901	2,951	27,835	1,400
Other fish	2,912,578	47,302	75,278	1,572	107,035	2,540
Total	32,871,989	934,005	639,493	21,693	822,394	23,836

Species.	Wisconsin.		Minnesota.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	87,696	$4,379	....	....	463,086	$25,073
Herring	3,798,220	57,502	5,329	$102	48,753,349	561,703
Perch	1,008,137	21,195	....	....	7,754,028	113,260
Pike and pike perch	481,118	19,141	....	....	16,835,119	417,038
Sturgeon	134,648	4,779	....	....	4,289,759	148,366
Trout	3,820,178	175,334	138,488	4,519	12,890,441	507,950
Whitefish	2,187,667	84,467	39,605	1,617	12,401,335	518,891
Other fish	1,978,633	32,888	....	....	10,511,414	179,487
Total	13,496,312	399,685	183,422	6,238	113,898,531	2,471,768

Michigan.—This State abuts on four of the Great Lakes, as well as on Lake St. Clair and the St. Clair and Detroit rivers. The fisheries in Lake Michigan have the greatest extent, followed by those in lakes Huron, Superior, St. Clair, and Erie.

Table showing by lakes the number of persons employed in the fisheries of Michigan.

How employed.	Lake Erie.	Lake St. Clair.*	Lake Huron.	Lake Michigan.	Lake Superior.	Total.
On fishing vessels	....	28	18	149	31	226
On transporting vessels	7	....	8	9	....	24
In shore fisheries	225	517	590	1,040	321	2,693
In fish-houses, etc	....	66	110	180	44	400
Total	232	611	726	1,378	396	3,343

*Includes St. Clair and Detroit rivers.

Table showing by lakes the apparatus and capital employed in the fisheries of Michigan.

Designation.	Lake Erie.		Lake St. Clair.*		Lake Huron.	
	No.	Value.	No.	Value.	No.	Value.
Vessels fishing			4	$21,000	3	$9,700
Tonnage			38.56		37.94	
Outfit				3,400		1,960
Vessels transporting	2	$8,500			4	2,800
Tonnage	36.08				41.11	
Outfit		900				130
Boats	116	9,750	162	4,375	410	22,308
Apparatus of capture, vessel fisheries:						
Gill nets			814	9,418	324	3,933
Apparatus of capture, shore fisheries:						
Pound nets	233	49,800	34	9,450	551	88,515
Gill nets					1,882	17,732
Fyke nets	65	800	148	4,480	221	6,385
Seines	6	550	28	6,240	6	600
Lines, spears, and dip nets		700		1,100		770
Shore property		12,850		106,082		208,625
Cash capital				44,600		45,400
Total		83,850		210,145		408,858

Designation.	Lake Michigan.		Lake Superior.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Vessels fishing	26	$78,950	5	$17,200	38	$126,850
Tonnage	382.85		61.66		521.01	
Outfit		10,643		3,700		19,703
Vessels transporting	2	21,500			8	32,800
Tonnage	122.08				199.27	
Outfit		1,615				2,645
Boats	605	43,883	188	15,760	1,481	96,076
Apparatus of capture, vessel fisheries:						
Gill nets	10,612	66,304	1,046	15,574	12,796	95,229
Apparatus of capture, shore fisheries:						
Pound nets	552	161,850	90	24,335	1,460	333,950
Gill nets	11,928	58,302	2,737	26,409	16,547	102,443
Fyke nets	8	285	4	80	446	12,030
Seines	10	1,115	8	505	58	9,010
Lines, spears, and dip nets		853		1,559		4,982
Shore property		88,269		39,765		455,591
Cash capital		44,600		35,000		169,600
Total		578,169		179,887		1,460,909

* Includes St. Clair and Detroit rivers.

Table showing by lakes and species the yield of the fisheries of Michigan.

Species.	Lake Erie.		Lake St. Clair.*		Lake Huron.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	9,500	$570	9,086	$544	29,351	$2,167
Herring	1,160,000	8,700	490,334	5,797	2,514,551	28,181
Perch	130,000	1,175	763,093	10,160	1,817,628	20,792
Pike and pike perch	570,900	14,330	524,669	17,533	1,483,072	50,834
Sturgeon	33,000	900	309,003	7,794	365,718	8,924
Trout			244,847	12,242	1,505,619	51,042
Whitefish	136,000	6,800	238,764	14,753	1,004,094	37,247
Other fish	373,000	6,905	414,775	4,754	1,336,348	21,880
Total	2,412,400	39,380	2,994,571	73,577	10,056,381	221,067

Species.	Lake Michigan.		Lake Superior.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	50,050	$1,828			97,987	$5,109
Herring	2,129,181	42,140	99,690	$2,619	6,393,756	87,437
Perch	318,743	8,253			3,029,464	40,380
Pike and pike perch	103,270	3,712	7,980	268	2,689,891	86,677
Sturgeon	732,711	26,292	39,824	1,163	1,480,256	45,073
Trout	4,673,726	175,625	2,118,760	70,707	8,542,952	309,616
Whitefish	4,281,921	173,315	2,064,326	80,296	7,725,105	312,411
Other fish	772,580	13,148	15,875	615	2,912,578	47,302
Total	13,062,182	444,313	4,346,455	155,668	32,871,989	934,005

***Includes St. Clair and Detroit rivers.**

Wisconsin.—This State has a frontage on lakes Superior and Michigan. The fisheries in the latter lake are much more important than those of the former.

Table showing by lakes the persons employed in the fisheries of Wisconsin.

How employed.	Lake Michigan.	Lake Superior.	Total.
On fishing vessels	118	8	126
In shore fisheries	777	179	956
In fish-houses, etc	124	19	143
Total	1,019	206	1,225

Table showing by lakes the apparatus and capital employed in the fisheries of Wisconsin.

Designation.	Lake Michigan.		Lake Superior.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Vessels fishing	19	$64,700	1	$3,500	20	$68,200
Tonnage	243.10		18.19		261.29	
Outfit		8,155		2,000		10,155
Boats	362	23,130	116	7,380	478	30,510
Apparatus of capture, vessel fisheries:						
Gill nets	7,285	36,260	72	864	7,357	37,124
Apparatus of capture, shore fisheries:						
Pound nets	250	67,480	49	9,900	299	77,380
Gill nets	9,673	48,118	1,696	16,399	11,369	64,517
Fyke nets	723	11,031	5	335	728	11,366
Seines	17	1,985	11	450	28	2,435
Lines and spears		667		540		1,207
Shore property		97,635		17,445		115,080
Cash capital		48,800		14,600		63,400
Total		407,961		73,413		481,374

Table showing by lakes and species the yield of the fisheries of Wisconsin.

Species.	Lake Michigan.		Lake Superior.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Bass	87,696	$4,379			87,696	$4,379
Herring	3,704,118	55,607	94,102	$1,895	3,798,220	57,502
Perch	1,008,137	21,195			1,008,137	21,195
Pike and pickerel	462,751	18,275	18,382	866	481,133	19,141
Sturgeon	126,990	4,541	7,658	238	134,648	4,779
Trout	3,464,048	162,359	356,130	12,975	3,820,178	175,334
Whitefish	1,078,422	41,393	1,109,245	43,074	2,187,667	84,467
Other fish	1,978,035	32,874	598	14	1,978,633	32,888
Total	11,910,197	340,623	1,586,115	59,062	13,496,312	399,685

New York.—New York maintains fisheries in lakes Erie and Ontario. The fishing population and the invested capital are much greater in Lake Erie, but the value of the catch is about the same in both. The most prominent fish in waters of Lake Erie under the jurisdiction of the State is the sturgeon, while in Lake Ontario the wall-eyed pike takes precedence.

Table showing by lakes the number of persons employed in the fisheries of New York.

How employed.	Lake Ontario.	Lake Erie.	Total.
On fishing vessels	5	21	26
On transporting vessels	6	....	6
In shore fisheries	356	990	1,346
In fish-houses, etc	22	98	120
Total	389	1,109	1,498

Table showing by lakes the apparatus and capital employed in the fisheries of New York.

Designation.	Lake Ontario.		Lake Erie.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Vessels fishing	1	$2,800	4	$12,500	5	$15,300
Tonnage	13.69	....	57.70	....	71.39	....
Outfit	....	500	....	1,988	....	2,488
Vessels transporting	2	5,280	....	....	2	5,280
Tonnage	32.48	....	....	....	32.48	....
Outfit	....	1,005	....	....	....	1,005
Boats	373	21,577	167	15,100	540	36,677
Apparatus of capture, vessel fisheries:						
Gill nets	50	200	1,122	8,590	1,172	8,790
Apparatus of capture, shore fisheries:						
Gill nets	2,295	17,910	3,460	26,232	5,755	44,142
Pound nets and trap nets	288	24,577	37	4,850	325	29,427
Fyke nets	684	9,822	....	....	684	9,822
Seines	27	656	5	125	32	781
Lines, spears, and grapnels	....	490	....	1,579	....	2,069
Other apparatus	....	49	....	....	....	49
Shore property	....	25,777	....	102,350	....	128,127
Cash capital	....	12,890	....	401,000	....	413,890
Total	....	123,533	....	574,314	....	697,847

Table showing by lakes and species the yield of the fisheries of New York.

Species.	Lake Ontario.		Lake Erie.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	33,092	$2,364	15,705	$823	48,797	$3,187
Catfish	471,955	12,444	276,975	6,467	748,930	18,911
Eels	257,190	8,913	....	....	257,190	8,913
Herring	598,978	20,936	1,807,120	28,431	2,406,098	49,367
Perch	358,947	5,368	48,620	1,515	407,567	6,883
Pike	129,490	6,284	....	....	129,490	6,284
Pike perch	331,002	28,729	359,027	14,710	690,029	43,439
Sturgeon	541,752	22,291	1,709,664	60,677	2,251,416	82,968
Trout	41,010	2,089	39,420	1,903	80,430	3,992
Whitefish	148,771	6,875	317,850	15,735	466,621	22,610
Other fish	534,261	8,493	67,140	1,459	601,401	9,952
Total	3,446,448	124,786	4,641,521	131,720	8,087,969	256,506

IV.—COMPARATIVE STATISTICS OF THE FISHERIES OF THE GREAT LAKES.

Perhaps the most useful purpose which the statistics now available serve is the opportunity afforded for making comparisons with 1880 and 1885. The following tables give a detailed contrast, by lakes, of the principal phases of the fishing industry in the three years named, and are self-explanatory. In view of the attention now being devoted to the fisheries of this region, such comparisons will doubtless furnish suggestive information.

Comparative table showing the number of persons employed in the fisheries of the Great Lakes in 1880, 1885, and 1890.

Lakes.	1880.	1885.	1890.
Superior	414	914	653
Michigan	1,578	3,379	2,877
Huron	470	892	726
St. Clair	356	272	611
Erie	1,620	4,298	4,482
Ontario	612	600	389
Total	5,050	10,355	9,738

Comparative table showing the vessels, boats, apparatus, and other property employed in the fisheries in the Great Lakes in 1880, 1885, and 1890.

Lakes and years.	Steamers.		Other vessels and boats.		Pound nets and trap nets.	
	No.	Value.	No.	Value.	No.	Value.
Superior:						
1880	4	$9,400	157	$16,840	43	$14,950
1885	15	68,100	504	32,635	230	67,520
1890	8	61,300	320	23,975	140	34,435
Michigan:						
1880	30	63,400	806	69,975	476	185,425
1885	82	267,600	1,320	100,726	715	253,840
1890	50	194,668	1,052	71,663	844	244,880
Huron:						
1880	3	7,000	108	13,905	189	49,425
1885	10	41,300	551	31,646	586	113,350
1890	3	11,660	414	25,238	551	88,515
St. Clair:						
1880	2	3,000	50	5,000	....	....
1885	2	1,150	213	6,307	57	12,550
1890	4	24,400	162	4,375	34	9,450
Erie:						
1880	9	38,400	593	45,480	758	233,600
1885	53	178,200	1,483	120,557	1,028	259,785
1890	56	302,283	1,393	217,750	1,893	548,100
Ontario:						
1880	1	3,600	166	9,500	34	14,000
1885	2	4,800	465	15,648	350	19,445
1890	2	9,180	374	21,982	288	24,577
All lakes:						
1880	49	124,800	1,880	160,700	1,500	497,400
1885	164	561,160	4,536	307,519	2,966	726,490
1890	123	603,491	3,715	364,983	3,750	949,957

Comparative table showing the vessels, boats, apparatus, and other property employed in the fisheries in the Great Lakes in 1880, 1885, and 1890—Continued.

Lakes and years.	Gill nets.		Seines.		Value of all other apparatus.	Shore property and cash capital.	Total investment.
	No.	Value.	No.	Value.			
Superior:							
1880	4,630	$25,280	32	$2,010	$200	$12,700	$81,380
1885	7,557	78,082	43	2,920	1,155	177,521	427,933
1890	5,974	63,476	19	955	2,763	179,778	366,682
Michigan:							
1880	24,599	124,740	19	2,040	1,455	104,100	551,135
1885	58,516	326,902	87	6,950	13,457	788,356	1,757,831
1890	40,896	215,914	30	3,480	13,460	693,159	1,437,224
Huron:							
1880	3,360	20,600	28	5,600	3,500	3,700	103,730
1885	3,444	35,333	......	....	23,100	140,620	385,349
1890	2,206	21,665	6	600	7,155	254,025	408,858
St. Clair:							
1880	180	1,080	42	6,000	1,500	24,000	40,580
1885	23	160	34	8,825	3,819	218,270	251,081
1890	814	9,418	28	6,240	5,580	150,682	210,145
Erie:							
1880	5,775	22,500	18	2,800	8,645	163,675	515,100
1885	22,644	75,507	71	8,320	72,205	847,564	1,562,138
1890	49,320	169,513	44	5,305	70,601	1,502,750	2,816,302
Ontario:							
1880	6,000	20,000	9	1,950	....	5,000	54,050
1885	4,722	23,952	69	3,177	12,627	56,100	135,749
1890	2,345	18,110	27	656	10,361	38,667	123,533
All lakes:							
1880	44,544	214,200	148	20,400	15,300	313,175	1,345,975
1885	96,906	539,936	304	30,192	126,363	2,228,431	4,520,081
1890	103,800	498,096	154	17,236	109,920	2,819,061	5,362,774

Comparative table showing the primary products of the fisheries of the Great Lakes in 1880, 1885 and 1890.

Lakes and years.	Whitefish.	Trout.	Herring.	Sturgeon.	All others.	Total.*	
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Value.
Superior:							
1880	2,257,000	1,464,750	34,000	....	60,875	3,816,625	$118,370
1885	4,571,947	3,488,177	324,680	182,760	258,416	8,825,980	291,523
1890	3,213,176	2,613,378	199,121	47,482	42,835	6,115,992	220,968
Michigan:							
1880	12,030,400	2,659,450	3,050,400	3,839,600	1,562,025	23,141,875	668,400
1885	8,682,986	6,431,298	3,312,493	1,406,678	3,684,693	23,518,148	878,788
1890	5,455,079	8,364,167	6,082,082	946,897	5,586,041	26,434,266	830,465
Huron:							
1880	2,700,778	2,084,500	246,800	204,000	1,969,195	7,205,273	195,277
1885	1,425,380	2,539,780	1,265,650	215,500	6,010,860	11,457,170	276,397
1890	1,004,094	1,505,619	2,514,551	365,718	4,666,399	10,056,381	221,067
St. Clair:							
1880	77,922	....	250,700	998,500	523,805	1,850,927	36,273
1885	41,125	....	1,208,150	227,780	708,740	2,185,795	40,193
1890	238,764	244,847	490,334	309,003	1,711,623	2,994,571	73,577
Erie:							
1880	3,333,800	26,200	11,774,400	1,970,000	11,982,900	29,087,300	474,880
1885	3,531,855	106,900	19,354,900	4,727,950	23,734,912	51,456,517	1,109,096
1890	2,341,451	121,420	38,868,283	2,078,907	21,440,812	64,850,873	1,000,905
Ontario:							
1880	1,064,000	569,700	611,217	545,283	849,800	3,640,000	159,700
1885	90,711	20,510	403,585	386,974	1,496,686	2,398,466	95,869
1890	148,771	41,010	598,978	541,752	2,115,937	3,446,448	124,786
All lakes:							
1880	21,463,900	6,804,600	15,967,517	7,557,383	16,948,600	68,742,000	1,652,900
1885	18,344,004	12,586,665	25,869,458	7,147,642	35,844,307	99,842,076	2,691,866
1890	12,401,335	12,890,441	48,753,349	4,289,759	35,563,647	113,898,531	2,471,768

* Does not include oil, caviar, isinglass, and other secondary products.

V.—FISH PROPAGATION IN THE GREAT LAKES.

Since the inception of practical fish-culture in behalf of the commercial fisheries of the United States, the Great Lakes have been a favorite and favorable field for the practice of artificial methods for the preservation and increase of the supply, and more extensive operations have here been carried on than in any other part of the country.

The fishes to which the most attention has been devoted are those caught in largest quantities and having the greatest food value, viz, the common whitefish, the lake trout or salmon trout, and the wall-eyed pike. Besides these there are others of growing importance, the artificial increase of which should be considered, chief of which is the sturgeon.

The propagation of other fish besides those now cultivated is desired by fishermen and dealers of the several lakes. The increase of fishes not hitherto extensively propagated will not only be for the immediate benefit of the industry, but will indirectly inure to its advantage by diverting some attention from fishes whose abundance has been depleted and afford them an opportunity to reproduce with less molestation. In Lake Ontario the fish now most important to the fishing interests is the wall-eyed pike; the decline in the fisheries for whitefish and trout have brought this fish into great prominence, the supply is inadequate for the demand, and the increase of the fish by artificial means is earnestly sought.

The growing demand for sturgeon, for both its flesh and eggs, has in several of the lakes resulted in a noticeable diminution in the abundance of the fish within a comparatively short time, and there seems no reason to believe that the supply will, under natural conditions and present methods, be much longer maintained in lakes Erie, St. Clair, Michigan, and, doubtless, all the other lakes.

In the foregoing pages some references have been made to the results of propagation in the different lakes. It now remains to illustrate the extent of the efforts made to replenish the lake fisheries, and to record some general observations on fish-culture in the Great Lakes.

The following table represents the fish-cultural work in the Great Lakes accomplished by the U. S. Commission of Fish and Fisheries to and including the year 1890–91. It shows for each lake the number of fry of each species deposited in the lake waters.

Table showing the number of whitefish, lake trout, and pike-perch fry deposited in the waters of the Great Lakes by the U. S. Commission of Fish and Fisheries from 1876 to 1891, inclusive.

Species and years.	Lake Superior.	Lake Michigan.*	Lake Huron.	Lake Erie.†	Lake Ontario.	Total.
Whitefish:						
1876	....	130,000	....	1,000,000	....	1,130,000
1881	....	5,000,000	2,000,000	2,250,000	....	9,250,000
1882	....	7,500,000	2,000,000	4,750,000	3,500,000	17,750,000
1883	4,000,000	11,000,000	16,000,000	7,000,000	9,000,000	47,000,000
1884	6,000,000	20,000,000	27,500,000	12,000,000	6,000,000	71,500,000
1885	4,000,000	25,000,000	34,000,000	25,000,000	....	88,000,000
1886	6,000,000	29,000,000	30,000,000	15,000,000	12,000,000	92,000,000
1887	....	17,000,000	30,000,000	12,000,000	3,000,000	62,000,000
1888	....	1,000,000	15,000,000	....	2,912,000	18,912,000
1889	8,000,000	3,000,000	20,320,000	40,700,000	4,595,000	76,615,000
1890	24,850,000	6,000,000	24,400,000	31,028,000	3,800,000	90,078,000
1891	13,830,000	7,000,000	14,560,000	10,000,000	3,312,000	48,702,000
Total	66,680,000	131,630,000	215,780,000	160,728,000	48,119,000	622,937,000
Lake trout:						
1890	935,000	....	....	....	....	935,000
1891	538,000	....	....	192,000	....	730,000
Total	1,473,000	....	....	192,000	....	1,665,000
Pike perch:						
1889	3,000,000	....	....	....	....	3,000,000
1890	12,580,000	....	....	....	....	12,580,000
1891	100,000	....	....	2,800,000	....	2,900,000
Total	15,680,000	....	....	2,800,000	....	18,480,000
Grand total	83,833,000	131,630,000	215,780,000	163,720,000	48,119,000	643,082,000

*Includes Mackinac Strait. †Includes Detroit River.

The U. S. Commission of Fish and Fisheries has also made large plants of fish fry in the waters of the Great Lakes through the various State commissions, to which eggs were donated and by which the eggs were hatched and the fry deposited. While considerable numbers of the fry thus obtained by the State commissions were not deposited in the Great Lakes but in the interior waters, it is not possible to separate the plants, and in the following table the aggregate donations are shown:

Table showing the number of whitefish and pike-perch eggs donated by the U. S. Commission of Fish and Fisheries to the fish commissions of the States bordering on the Great Lakes.

Species and years.	Minnesota fish commission.	Wisconsin fish commission.	Ohio fish commission.	Pennsylvania fish commission.	New York fish commission.	Total.
Whitefish:						
1880	250,000	....	....	....	....	250,000
1882	5,000,000	....	....	2,000,000	1,000,000	8,000,000
1883	5,000,000	....	....	....	1,000,000	6,000,000
1884	20,000,000	....	....	....	1,000,000	21,000,000
1885	15,000,000	....	....	16,500,000	1,000,000	32,500,000
1886	10,000,000	....	....	10,000,000	1,000,000	21,000,000
1887	10,000,000	....	....	15,000,000	1,000,000	26,000,000
1888	....	5,000,000	....	24,400,000	....	29,400,000
1889	....	6,000,000	....	10,000,000	1,000,000	17,000,000
1890	....	10,000,000	47,500,000	14,000,000	4,000,000	75,500,000
Total	65,250,000	21,000,000	47,500,000	91,900,000	11,000,000	236,650,000
Pike perch:						
1890	....	....	....	18,000,000	1,000,000	19,000,000
1891	....	....	....	58,000,000	....	58,000,000
Total	....	....	....	76,000,000	1,000,000	77,000,000
Grand total	65,250,000	21,000,000	47,500,000	167,900,000	12,000,000	313,650,000

Reference should also be made to the efforts of the State fish commissions to replenish the fish supply of this region. Michigan, Wisconsin, Pennsylvania, New York, and Ohio have done excellent propagation work and hundreds of millions of fry of food and game fishes have been deposited in the lake waters. The fisheries department of Canada has also engaged extensively in the culture of the native fish of the lake region.

The importance of the efforts made to maintain and increase the abundance of food-fishes is very generally recognized among the fishing interests of the lakes, and the fish-cultural operations meet with the hearty indorsement of fishermen, fish-dealers, and the public. Reliance on the efficacy of artificial methods in preserving the fishery resources of the lakes is almost universal in the important fishing districts, and there are few well-informed persons practically interested in the lake fisheries who are not willing to accord praise to fish-culture for the results achieved in arresting a diminution in the supply or in maintaining a profitable industry in the face of an enormous annual catch, a great increase in the amount of apparatus used, and the prosecution of fishing under circumstances that are extremely unfavorable for the natural increase of the fishes taken.

In the extreme western end of Lake Erie, to which region the whitefish naturally resorts for the purpose of spawning, the supply is almost wholly cut off by the multiplication of nets in other parts of the lake. Here the fishermen are beginning to depend on other fishes for their catch, and are desirous of having the supply of species with more localized habits increased. Writing in 1891 on the Maumee Bay and Monroe sections, Mr. Seymour Bower said:

> As to the intrinsic merits of artificial propagation as a factor in multiplying water life, the fishermen of this section, almost without exception, believe in it; but, so far as whitefish are concerned, the opinion is quite prevalent that, under the circumstances, the interests of this section are practically debarred from participating in the benefits. Naturally, therefore, there is some indifference regarding the propagation of whitefish, but a growing interest in behalf of any means to increase the supply of sturgeon, catfish, and pike perch.

The foregoing comparative statistics of the products of the fisheries show that in nearly every lake the catch of whitefish—the species having the greatest interest to fish-culturists—has decreased since 1885. No well-informed person, however, will argue from this that fish-culture in the Great Lakes is a failure. The repeated successes which have attended the culture of the lake fishes in some smaller bodies of water, where the natural conditions were certainly not superior to those of the Great Lakes, demonstrate the feasibility of the propagation of the lake fishes and afford a suggestive example. The absence of more conspicuous results in the Great Lakes may be regarded in the light of the following considerations:

1. Owing to the large size of these lakes, it is possible that the fish-cultural operations have not been sufficiently extensive to overcome the destruction by man of fish and undeposited spawn. The planting of a

billion fry annually in a body of water as large as Lake Michigan would be equivalent to only one fish to every 600 square feet of lake surface, and when the great natural destruction of fry, by natural enemies and unfavorable physical conditions, is taken into account, the disparity of this proportion is vastly increased.

2. Assuming that the plants of fry are sufficiently large to compensate for the capture of fish now going on, the fish-cultural work may not do more than maintain an already diminished supply and may be inadequate, owing to previous depletion and present methods, to produce a substantial increase in the abundance of a given fish.

3. Artificial propagation may be extensive enough to counteract the influence of previous overfishing and permit the continuance of fisheries of great magnitude under proper conditions, but the methods followed may be so destructive to the adult fish prior to and during the spawning season and so deleterious to the growth of young fish that the natural tendency to multiply may be made abortive and even enormous fish-cultural operations be rendered nugatory.

INDEX TO REPORT ON FISHERIES OF THE GREAT LAKES.

5.—NOTES ON THE OYSTER INDUSTRY OF NEW JERSEY.

PREFATORY NOTE.

The oyster is the most important product of the United States fisheries, and its collection, cultivation, and sale constitute the most extensive fishery industry of the country. In a number of States the oyster has greater economic value than all other water products combined. Oyster fishing and oyster cultivation have received fully as much attention from the general public as any other subject connected with the American fisheries, but it was only at a comparatively recent date that some of the States most vitally interested in the preservation and increase of the oyster supply realized the importance of dealing with the subject in the light of modern experiment and experience.

The Commission, through its several divisions, has aimed to keep well informed regarding the status, methods, and relations of the oyster industry in every region, and has, from time to time, published numerous reports on the subject to meet the very active demand for oyster literature in every part of the country.

The great diversity of the physical conditions of the extensive tidal areas in which the oyster exists, and the extreme variations in the legislative enactments for the protection, regulation, and encouragement of the oyster industry, occasion a greater multiplicity of methods of capture and cultivation than is found in any other fishery industry, and necessitate the institution of special studies in each State in order to thoroughly cover the subject.

The present report deals with a State whose oyster interests are inferior in value only to those of Maryland, New York, and Virginia. The great extent of the oyster business of the State is alone sufficient to warrant the detailed consideration which is accorded it in the present paper. It has been many years since an attempt was made to present in one paper an approximately complete account of the subject. The changes which have ensued since 1880, the year to which the last report relates, have in some instances been marked, and render the present discussion opportune in view of the great attention now being bestowed on the oyster industry in the Middle Atlantic States. It is probable that very few persons in New Jersey appreciate the large interests depending on the State oyster supply and the enormous annual income from this source.

The methods and conditions here observed are, in some respects, dissimilar to those of any other State, and there are many phases of the subject which afford suggestive information of great value to other States, not only to those in which the artificial production of oysters has recently been taken up, but those in which successful cultivation has long been practiced.

The paper has been prepared by Mr. Ansley Hall, field agent in the Division of Statistics and Methods of the Fisheries, and is based entirely on original inquiries conducted by him in 1892. In the course of his work he visited every part of the State having an oyster fishery, and made a careful study of the conditions and methods in each locality, giving special attention to the methods of planting and cultivation.

The oyster industry of the State is here considered by geographical divisions. In each bay, river, county, or center, as the case may be, the subject is discussed with the fullness which the extent of the business warrants. Detailed statistics covering the years 1889 to 1892 are presented. Mr. Hall's inquiries show that, in 1892, 4,351 persons were directly engaged in the oyster industry of the State; $1,593,892 was invested; and 1,097,228 bushels of marketable oysters were taken, the value of which was $1,220,878.

HUGH M. SMITH,
Assistant in charge of Division of Statistics and Methods of the Fisheries.

NOTES ON THE OYSTER INDUSTRY OF NEW JERSEY.

By Ansley Hall,
Statistical Agent, U. S. Fish Commission.

INTRODUCTORY.

The system of oyster-culture practiced in New Jersey does not embrace any artificial methods for the reproduction of oysters from the spat or egg. The seed oysters are derived chiefly from the natural beds. These areas are gradually becoming less productive, and in order to supply the demand considerable quantities of oysters for planting are purchased annually from other States.

The depleted condition of the beds in some sections of the State has become more apparent recently, and the great question is how to restore their original productiveness. The only care that has ever been bestowed upon them was such as could be secured by certain forms of restrictive legislation. The principal regulations imposed were provisions for close seasons and for culling.

In the State of Rhode Island, when the oyster-planting industry was established, the waters abounded in rich natural oyster beds; but protective legislation failed of its purpose, and the beds have finally become almost wholly depleted, and the planters have for many years past purchased their seed elsewhere, chiefly from the State of Connecticut. The natural oyster beds of New Jersey are yet far from being wholly depleted, but that some better methods should be adopted for their care is plainly evident.

If the natural beds are to be restored to their original productive condition, it is scarcely reasonable to assume that it can be accomplished with less expense or by less effective methods than would be necessary to achieve like results upon private areas. The practice of planting shells or other suitable materials on private beds is being operated successfully in Connecticut by planters engaged in the business of seed-growing. If it is practicable for the State to inaugurate a system whereby the same methods, aided by proper culling and close-time regulations, can be faithfully applied to the public grounds, there seems to be no reason why equally good results might not be obtained.

In New Jersey the natural oyster-grounds have always been carefully exempted from private ownership, and any system of oyster cultivation involving proprietary rights in them has been unfavorably regarded. The planters have succeeded in acquiring a legal right to hold non-producing areas, for the purpose of planting oysters, as against the individual citizen, but not as against the State; and even this advantage has, in some sections, been gained in the face of strenuous opposition.

The following notes are not intended to deal with every phase of the oyster industry of the State, but relate chiefly to the planting and cultivating business, and to the methods and conditions under which it is conducted in the more important localities. The tabulated statistics apply to the years 1889, 1890, 1891, and 1892.

I.—THE NORTHERN COAST OF NEW JERSEY.

That part of New Jersey lying within or west of Sandy Hook maintains an oyster industry of great extent. The importance of the business is owing to the valuable planting-grounds which exist off the shores of this part of the State, to the favorable conditions, and to the proximity of New York, Brooklyn, Jersey City, and other large cities which furnish a constant market. The industry is centered in the cities of Perth Amboy and Keyport, and in the Navesink and Shrewsbury rivers.

HUDSON AND UNION COUNTIES.

These counties, bordering on Newark Bay and the upper part of Staten Island Sound, have no oyster-cultivating industry, but are quite extensively interested in the taking of oysters from the natural grounds. The gathering of the small native oysters found in the waters named is participated in by citizens of Middlesex and other counties as well as by those of Hudson and Union counties, and constitutes an important business, furnishing employment to a large number of persons, most of whom are not otherwise engaged in the oyster industry.

In these waters oysters were formerly very abundant. The crop derived from these grounds in 1892 by citizens of New Jersey was, approximately, 100,000 bushels, and was worth about $60,000. The product is almost wholly utilized as seed by the planters of New Jersey and other States. For a number of years considerable quantities of small-sized oysters from this section have been purchased by New York dealers for shipment to San Francisco, to be planted chiefly in San Francisco Bay.

PERTH AMBOY.

Perth Amboy, in Middlesex County, is the most northerly point in New Jersey where the oyster-planting industry is systematically conducted. The town has about 10,000 inhabitants, and is situated on Staten Island Sound, about one-fourth of a mile from its southern entrance, and on the north side of the Raritan River, which empties into Raritan Bay. Oyster-planting was begun in this locality about fifty years ago. The business is not now as extensive as it was in former years, but is still of considerable importance.

The planting-grounds.—The grounds in the vicinity of Perth Amboy used for oyster-planting are located at the southern extremity of Staten Island Sound, in the head waters of Raritan Bay, and comprise an area of about 300 acres, more or less, lying off Ferry Point, and extending from the point in a SE. by S. direction to Great Beds Light. The general shape of the grounds is oblong, narrowing somewhat as they approach the light. The length is about a mile and the average width a little less than half a mile. The average depth of water is about 5 feet. The grounds have various kinds of bottom. In some places it consists of hard mud, made so by a substratum or intermixture of sand; on others the mud seems to predominate and the bottom is softer, while others have a natural shell bottom where, at some time in the remote past, there have undoubtedly been natural oyster beds. This natural shell bottom is considered superior to any other for oyster cultivation, and is correspondingly valuable.

In addition to these grounds, the oystermen occupy limited areas (probably 50 acres) in New York waters, lying off the shores of Staten Island, between Ward Point and Princess Bay light. These grounds are long and narrow, have a hard bottom, with an average depth of water of about 6 feet, and are used for transplanting oysters preparatory to being taken up for market.

It must not be understood that the entire area above described is planted, or has oysters on it every year; some tracts of bottom are more desirable than others, and are used in preference, while the whole is considered available.

Planting methods.—Each planter divides and stakes off his planting grounds into rectangular sections or lots of various sizes, governed in number by the necessities of his business, and also to some extent by his individual opinions as to the most advantageous arrangement of them. The number therefore varies somewhat with different planters, but usually four, five, or more lots are necessary. The reason for this division is that when a lot is planted with small oysters it is customary to allow them to lie undisturbed until they have reached a stage of maturity sufficient for commercial purposes, when they are shifted to another lot to remain one season, or from early spring to September, before being taken up for market. Hence it is necessary to have a number of lots in order to afford space for planting and transplanting or shifting each season.

The growing period, which intervenes between the first planting and final shifting of the oysters, is ordinarily three years, but is not strictly confined to that length of time. It depends upon the size of the seed when planted, the rate of growth, and, within certain limits, the option of the planter. If the seed is large it will require less time to mature. If the quality of the ground is good the rate of growth is more rapid. The longer the oysters are allowed to grow the greater will be the proportion of box (large) oysters among them, and the crop will consequently yield larger returns. The more prosperous planters therefore frequently extend the period of growth in order to achieve the most profitable results, while others find it necessary to market their oysters as soon as practicable.

A planter requires to have at least one lot, and generally more, reserved as a shifting-ground. The work of shifting the oysters begins about March 1, or as soon after as the weather permits, and is completed between that time and July 1. It consists in taking up the oysters intended for shipment in the fall, and which have grown to marketable size on soft-bottom grounds where they were originally planted, and transplanting them to hard bottom. While the oysterman is not, as a rule, guided by scientific knowledge, he has learned by experience to proceed to a certain extent on scientific principles. He may not know anything of the diatoms, desmids, or other microscopic forms of life found usually in greater abundance upon mud flats, or what is in his vernacular termed "soft bottom," than on sand or gravel (hard bottom), but has developed by actual experiment the fact that the oyster grows faster and does better there than elsewhere. The shifting to hard bottom also proves beneficial to the oyster by freeing it from mud or other extraneous substances, improving its color and possibly its flavor, and giving an opportunity for separating the clusters, when necessary, into single oysters. On the whole, it seems to be a requisite part of the process of perfecting the condition of the oyster for market.

After the oysters have been shifted, the grounds from which they are taken are again planted with seed. The supply of seed is obtained principally from the natural beds in the Raritan River, which extend from the railroad bridge connecting Perth Amboy and South Amboy for a distance of about 5 miles up the river to Sayreville. The oystermen begin taking seed oysters as soon as practicable in the spring and continue until the close of the season. The work is resumed in the fall when the season opens. The natural beds being in close proximity to the cultivated ones, the oystermen sell their catch to the planters, carry it to the grounds, and plant it directly from their skiffs. Seed oysters are also obtained from Staten Island Sound.

Personnel, wages, etc.—The labor in connection with the oyster-planting industry, which is comprised in the planting of seed oysters in spring and fall, the transplanting or shifting of mature oysters in early spring, and taking them up for market after September 1, and various other work incidental to the business, is performed by the oystermen of the neighborhood at the rate of $2.50 per day for each man, including his oyster skiff, tongs, etc. Nearly every man who engages with any degree of regularity in the oyster fishery owns a skiff and one or more pairs of oyster tongs. The planters also have from one to three skiffs and a number of pairs of tongs each, and if at times it is necessary to hire a man who is not so provided, and furnish him, the rate of wages is $2 per day. There are 220 men in the locality engaged in the oyster fishery, 16 of whom are planters, and the remaining 204 are hired for a portion of the year to work on the cultivated grounds. They also engage in taking seed oysters from the natural beds, and a few of them fish for clams. At other times of the year they find employment in various occupations on shore. They are all American-born citizens and residents of the State.

Preparation of the oysters for market.—The season for taking up the oysters from the shifting-grounds for market begins September 1. The work is usually completed by December 1. After the oysters are caught and culled they are placed on board small sloop-rigged vessels, which the planters own for the purpose of transporting their products, and carried to Rahway River, where they are put in floats and allowed to remain in the brackish water at the entrance of the river during one tide, when they are again loaded on the decks of the vessels and taken to New York. This process is termed "drinking" the oysters. The object of drinking is to give them an opportunity to "spit out" the sand that may have found lodgment in the folds of their gills, and also to bloat them, which temporarily improves their appearance and makes them open to better advantage, their flesh being whitened and size slightly increased. When they arrive in New York they are counted and graded into two sizes, and sold to the wholesale dealers by the thousand. The larger size is termed "box" oysters and the smaller "cullens." The box oysters sell usually for $7 and the cullens for $3.50 per thousand.

The greater part of the oysters are marketed in this manner, but limited quantities are shipped in barrels by rail or steamboat when it is not convenient to transport them in vessels or their destination is other than New York, which is the principal market for the planters of this section.

KEYPORT.

This town, with a population of about 3,500, is located on Raritan Bay, in Monmouth County. It is more extensively interested in the oyster industry than any other place in the State outside of Delaware Bay. The oyster-planting operations of the entire section east of Perth Amboy center here, and the important grounds lying off this part of the State are utilized by Keyport planters.

The oyster-grounds.—A survey made in 1886, by George Cooper, a civil engineer of Red Bank, showed the area of the grounds devoted to oyster cultivation in Princess Bay to be $2\frac{1}{2}$ square miles, or 1,600 acres. The remainder of the waters of the bay inside of Sandy Hook (outside of Shrewsbury River bar) belonging to New Jersey form the great field of operations for the extensive clam fisheries centering at Keyport, Port Monmouth, and other localities in the vicinity, and comprise an area of $37\frac{1}{4}$ square miles, or 23,840 acres. A comparatively small proportion, therefore, of the entire area of bottom ($39\frac{3}{4}$ square miles, or 25,440 acres) within these limits is utilized for the cultivation of oysters, although it is thought that the larger part is well adapted to oyster-planting.

There has been considerable friction, however, between the oyster-planters and the clam fishermen relative to the acquirement and holding of grounds for planting purposes. The clam fishermen, refusing to recognize the right of the planters to the possession of bottom for private enterprise, have at various times trespassed upon the cultivated beds under the pretext of taking clams, and numerous cases of litigation have ensued, which have usually terminated in favor of the oystermen. Out of these difficulties grew the necessity for the organization and incorporation of what is known as the Oystermen's Protective Association. This association maintains a watch-boat, with a crew of two men, whose duty it is to patrol the locality where oysters are planted and report to the members of the association any person who may be found trespassing upon the grounds. There is also a watch-house, where one man is stationed for a similar purpose. The expense and difficulty of securing protection in the prosecution of the industry has doubtless, in some degree, retarded its progress.

The planting-grounds are located directly opposite the town and within a short distance of the shore. The depth of the water varies from 2 to 16 feet. The central and northeasterly sections consist of mud or soft bottom, while the marginal portions have hard bottom. The soft bottom is utilized for planting small seed oysters and the hard bottom for the large oysters from southern waters, and also as transplanting-grounds for oysters that have been matured on soft bottom.

Planting methods.—Each planter designates the boundaries of his grounds by stakes, which usually serve to identify them, but if the stakes are carried away by storms or ice, or are hidden by high tides, ranges are resorted to as a sure method of determining their location. They are divided into lots in a manner similar to that already described for Perth Amboy. When oysters are being planted or transplanted, these lots are subdivided and staked off in small squares as an assistance to the planter in distributing the proper quantities on the ground. This system of planting lacks the element of completeness practiced by agriculturists. The farmer measures both the seed and the ground on which it is to be sown, and distributes a specific number of bushels to the acre. The oysterman decides the question by the eye. He may possibly know the number of bushels of seed he intends to plant, but generally he does not know the number of acres of ground on which it is to be planted. When the oysters have been planted, the small stakes which have been used for subdividing the lots into squares are removed.

Both native and southern oysters are used for seed. The native oysters are chiefly from the natural beds in the Raritan River, Newark Bay, and Staten Island Sound (Arthur Kill). These are termed "hard oysters," and cost on an average 50 cents per bushel. They are planted on soft bottom in deep water, where they lie from two to three years before being shifted to hard bottom. They usually require a considerable amount of culling when shifted, before being replanted. This the oystermen term "handling." The dead oysters and shells are removed and the clusters separated. After remaining on hard bottom one season they are taken up for market. It is estimated that not more than one-fourth of the entire quantity of seed used are native oysters. The remaining three-fourths are from the Chesapeake Bay region, from points in Maryland and Virginia. Large quantities of them come from Hampton Bar and the Rappahannock and James rivers, the Choptank River, Tangier Sound, etc. They are designated by the general term "Virginias." A part of these oysters is the product of the natural beds of the Chesapeake, but large quantities come from cultivated beds where they have grown to maturity. They vary in price from 20 cents to 60 cents per bushel, according to size and quality. In addition to the cost of the oysters, the planter is also at an expense of about $300 per each vessel load, of perhaps 2,500 bushels, for transportation, and about $48 for unloading them from the vessel and planting them on the beds. The transporting vessels are sent south for oysters early in March, and the planting is completed in April. The large "Virginias" are planted directly on hard bottom, whence they are taken up for market the same season without being shifted.

Natural enemies of the oyster.—The only important natural enemies to the oysters in recent years have been drills, winkles, and occasionally crabs, but the loss from these causes has not been great. Fifteen or twenty years ago considerable trouble was experienced from the depredations of fish. The drumfish was the most troublesome species. It is said that they became so abundant at times as to destroy whole beds of oysters. Means were resorted to for frightening them away. One method was to anchor buoys over the beds and attach to them a line with a shingle at the end of it and a weight, either a brick or stone, to carry it to the bottom. The shingle swayed to and fro with the motion of the water, and served to scare the drumfish away. This was called "shingling" the beds. But for the past few years no serious destruction by drumfish has occurred.

Persons, compensation, and lay.—The number of persons engaged in the oyster-planting industry at Keyport, exclusive of crews on vessels, is 112. There are 23 proprietors or oyster-planters and 89 men who are employed by them at daily wages. Of the 23 planters, 11 are occupied largely with work on shore pertaining to the business, and may be classed as shoresmen, and the remaining 12 engage in the practical labor of tonging oysters. The men are all American citizens, 92 white and 20 colored. The colored men come chiefly from Virginia.

The rate of wages paid by the planters is $2 per day to each man, whether engaged in tonging oysters on the beds or "drinking" them in the creek (for the same men do both), or any other work necessary in preparing the products for market. The planters furnish skiffs, tongs, and all apparatus. When employed planting southern oysters ("Virginias") it is customary to pay each man $3 per day, and usually about 16 men are required to unload each cargo from the transporting vessel.

The dredging vessels are hired with their crews at $7 per day for sail vessels and $25 per day for steamers. If it becomes necessary for the men to work overtime, as is not infrequently the case, in order to have the oysters ready at the proper time to fill the buyers' order, they receive extra pay, and thus amicable relations are maintained between employers and employés.

The average length of time which the planting business in all its branches is estimated to afford employment each year is about six months.

The oyster boats.—The boats in use are of two kinds, designated, respectively, as skiffs and scows. The skiffs are used as tonging boats and the scows in the various processes of handling the oysters after they are taken from the beds, either for carrying them ashore from the grounds or in connection with operations in the creek.

The oyster skiff is a style of row boat different from that used in any other branch of the fisheries, and is designed especially to meet the needs of the oyster business. It is clinker-built, has a square stern, rounding sides, with moderate sheer, raking stem and stern, and flat bottom. The bottom is about 18 inches wide amidships, and converges with a gradual curve fore and aft, coming to a point at the stem and stern. The object of the flat bottom is for convenience in hauling the boat on the beach, in order that it may be handled easily and lie without listing. The timbers are of white oak and the planking is cedar. The length is 26 feet over all and 22 feet on the bottom. The width is 6 feet. A smaller skiff is also used, being 21 feet long over all, 18 feet on the bottom, and 5 feet wide. The skiffs are ceiled on the inside with white pine, to make a smooth surface for shoveling oysters. The cost of the larger size when new is about $140, and of the smaller size from $100 to $120. The larger size has two thwarts forward of the ceiling and is used as a double skiff, while the smaller size has only one thwart and is used as a single skiff.

The scows are square-ended and very strongly built. They are usually 40 feet in length with a depth of 2 feet inside. The width outside is 8 feet 4 inches on top, and 8 feet on the bottom. The sides and bottom are constructed of white-pine planks and the ends of white oak. The thickness of the sides is 3½ inches at the top and 4½ at the bottom; that of the ends is 2 inches and of the bottom about 4 inches. A keelson, 8 inches high and 5 inches wide, runs through the center, and not only adds strength to the scow, but also forms a partition, which may be used for keeping different grades of oysters separate from each other. At each end there is a platform 4 feet wide, flush with the top. The scows cost when new about $140 each. They are propelled either by being sculled with an oar or pushed with an oar or pole. The average value of skiffs and scows, new and old together, is estimated to be not more than $75.

Taking oysters up for market.—The oysters are taken up for market chiefly with tongs. The planters own the tongs, skiffs, scows, and all other apparatus necessary to the fishing operations, and furnish them to the men they hire. Some of the skiffs are operated by one man and others by two. Those having one man are termed single skiffs, and those having two, double skiffs. Sails are not used on the skiffs, as the grounds are near at hand and rowing is more convenient. When the oysters become so scattering that the men can not secure a good day's catch with the tongs, dredging vessels are brought into requisition to (as the oystermen term it) "clean up the beds," that is, to catch the remainder of the oysters on them. Some of the vessels are propelled by sails and others by steam. They are not owned by the planters, but are hired, with their crews, by the day. On the sail vessels the dredges are hauled by hand, one dredge to each man, except in one or two instances, where small winches or "winders" are used. Hauling dredges by hand is extremely laborious, but is more speedy than with hand winders, and is therefore preferred. On the steam vessels a steam winch is used for hauling the dredges. The oysters taken with dredges are brought ashore in scows, but the skiffs land their own catch. Dredging vessels in this region, being owned by men frequently not otherwise interested in the oyster business, and making a specialty of dredging oysters, are not necessarily confined in their operations to any particular locality, but find employment wherever it can be obtained. Their services are usually required for only a short time in the fall.

Preparing the oysters for market.—The oyster-planters have their shore houses or shops for storing implements, such as tongs, baskets, forks, shovels, barrels, etc., located on either side of a small winding stream, designated on the charts of the U. S. Coast Survey as Middletown Creek. This creek is used as a place for drinking the oysters, and is claimed to be exceptionally well adapted for that purpose. Its banks are supported by a perpendicular bulkhead constructed of planks and piling. The bottom of the creek, on both sides, is divided into lots by a row of stakes in the center, which also serve to subdivide the lots into small squares to accommodate different grades of oysters, and each planter either owns or hires a lot in front of the shop he occupies.

When the oysters are brought in from the grounds they are first culled and graded into box oysters, cullens, and cullentines. They are then put overboard in the creek to "drink," the several grades being kept separate by placing them in different squares. This is usually done at slack high water, and they are allowed to remain overboard until low water. Experiments have frequently been made in drinking the oysters at other times of tide, but slack high water is, as a rule, believed to yield the most satisfactory results.

The reason for drinking the oysters at this particular time of tide rests upon the theory that, while it is requisite for them to have fresh or slightly brackish water, it would be injurious to bring them in contact with it too abruptly. At low tide the water of the creek is as fresh as that of any other fresh-water stream. As the tide rises the fresh and salt waters mingle with each other and become brackish at first, but gradually more salt as the tide continues to flow and force back the fresh water until it slacks. Its density is then but slightly lessened by the influence of the fresh water of the creek. The ebbing tide reverses the order of these conditions. The greatest degree of saltness possible to the water in the creek attains at full flood tide, and as the tide ebbs the salinity of the water diminishes. This diminution is supposed to be rendered more gradual by the salt water, on account of its greater specific gravity, remaining at the bottom.

High water is, therefore, considered to be the most favorable time for drinking the oysters, as it not only removes the danger possibly consequent upon introducing them too suddenly into fresh water, but also facilitates their drinking. They might be placed in the water two or three hours sooner, but the only effect would be to lengthen the time they would have to remain there, which is not generally thought necessary. As no floats are used, and the oysters are spread directly on the bottom, they can not be taken up conveniently until low water. The depth of water in the creek does not then average more than 10 or 12 inches, and sometimes less, during neap tides. The men go into the creek with rubber boots on and take the oysters up with forks and put them in baskets. The time of day for doing the work in the creek is governed by the tide and also the time when the oysters are to be shipped. It frequently happens when shipments are to be made early in the morning that the oysters are given a drink during the night. Whether they drink as copiously in the night as in the day may not have been definitely determined, but that they do so to a degree sufficient to freshen their flavor, and in other respects answer the purpose for which drinking is intended, there is no doubt.

Marketing the oysters.—The season for shipping the oysters opens about the 1st of June and closes in November. During the months of June, July, and August shipments are made regularly to the various seaside resorts along the coasts south of Sandy Hook. This "summer trade," as it is termed, has been steadily increasing and has reached considerable proportions, but does not, even through these months, equal the trade with New York. The oysters are put in barrels and shipped by rail to points along the coast, while those for the New York market are sent in baskets by the regular steamboat plying between Keyport and New York, or in bulk on the transporting vessels. After the hotels close in September the oysters are all sold in New York.

The "box oysters" and "cullens" are sold by count, and range in price from $7 to $7.50 per thousand for boxes, and $3 to $3.50 per thousand for cullens. The "cullentines," which are the smallest oysters sold, are not counted, but are usually disposed of at about 50 cents per bushel. When the oysters are sold without being assorted into different grades, as is sometimes the case, they are said to be "rough-culled." The usual price for "rough-culled" oysters is $1 per bushel.

NAVESINK AND SHREWSBURY RIVERS.

Shrewsbury River is the general name frequently applied to the two rivers designated on the charts of the U. S. Coast Survey as the Navesink and Shrewsbury rivers, which empty their waters by a common outlet into Sandy Hook Bay. The Navesink, or northern branch, is known locally as the Shrewsbury, or North Shrewsbury, and the Shrewsbury, or southern branch, as the South Shrewsbury. Oyster cultivation is carried on in both rivers, but more extensively in the Navesink or northern branch.

Planting-grounds.—The extent of the planted area in these rivers can not be definitely stated. In the Navesink the beds are located on both sides of the river, and frequently reach across it, from the railroad bridge at Red Bank (immediately above the town) to Claypit Creek, just below Oceanic, a distance of about 4 miles. It is not probable that more than 400 acres are utilized for oyster-planting. In the South Shrewsbury the planting-grounds lie in the vicinity of Little Silver, Oceanport, and Branchport, and also in the locality known as Pleasure Bay, a small indentation below Branchport. Their extent is small, and the oyster business is conducted on a comparatively limited scale.

The bottom in both branches of the river is usually soft mud, and is in some localities covered with eelgrass. Near the banks of the river, where there is more sand, the bottom is harder than it is farther off in the bed of the stream, but the water is usually shallow. The softness of the bottom is one of the greatest difficulties with which the planters have to contend, as the oysters are liable to become submerged with mud. There are no natural oyster beds.

Oyster-planting.—The season for planting oysters corresponds with that in other localities already discussed, but the methods of cultivation vary in accordance with the natural conditions of the bottom. The scarcity of hard bottom, in sufficient depth of water to allow the oysters to remain safely through the winter, precludes the practicability of planting large quantities of seed oysters; consequently the greater part of the oysters have to be of marketable size, or nearly so, when planted. On the Navesink there is only one firm of planters who use small seed extensively; the others, without exception, buy large oysters and plant them in the spring and take them up for market in the fall. The planters claim that very little and perhaps nothing is gained in quantity by the growth of the oysters; that while they increase in size individually a great many of them die, and the increase from the one cause does not more than offset the loss from the other.

When small oysters are planted they are generally allowed to lie three years, and are then shifted to hard bottom, which is found only in narrow strips near the banks of the river in shoal water. This is done in the spring, and in the fall of the same year they are taken up for market.

A part of the oysters for planting are unculled stock from the natural beds in the Hudson River, and are termed "North river roughs." They usually cost about 15 cents per bushel, and consist of oysters and shells together. The proportion of oysters to the entire quantity of oysters and shells is estimated to be not more than one-fourth. Large oysters are obtained quite generally from South Amboy, where they have lain two years on the cultivated beds, and cost from 50 cents to 90 cents per bushel; the general price is 86 cents per bushel, which includes the cost of transportation and planting. It is not now customary to plant Chesapeake Bay oysters in the Navesink. In the South Shrewsbury they are used quite extensively. "North river roughs" are also used. During recent years there has been a set of spat on the beds, which has to some extent reduced the necessity of obtaining seed elsewhere. At Pleasure Bay, however, Chesapeake oysters are planted regularly every year; this is believed by the oystermen of Little Silver and Oceanport to be the cause of the set of spat on the various artificial oyster beds in the river. An opinion prevails among them that the spawn of the southern oysters is more liable to fixation than that of the native oysters from the Hudson or Raritan rivers.

Mr. George B. Snyder, of Fair Haven, is authority for the statement that a set of spat occurred in the Navesink in 1869, when a load of Chesapeake oysters was planted there.

Enemies of the oyster.—The principal enemies of the oysters are the borers, hard-shell crabs, and the toadfish or oyster-fish (*Batrachus tau*), which is known locally among the oystermen as the "sally growler," a name applied to it probably on account of the savage disposition which it exhibits if molested while guarding its young. The borers are especially destructive to the young oysters. They do more or less damage every year, but occasion great loss some seasons. The crabs and toadfish undermine or burrow holes in the hard bottom into which the oysters drop and are smothered. Aside from these causes there is generally no serious loss, except such as may ensue at times in consequence of freshets of water washing the mud over the beds. Great care has to be exercised to select locations for planting-grounds that will not be too much exposed to alluvial deposits.

Another menacing feature, arising from natural conditions, which endangers the life of the oyster in the Navesink, is pointed out by Prof. Julius Nelson in the bulletin of the New Jersey Experiment Station of April, 1889. He says:

> In the upper part of the river in July a sort of fermentation of the bottom takes place by which a poisonous scum is produced that kills the oyster. One planter at the head of the tidal area lost $10,000 worth through this cause, combined with the coming on of a freshet of water. This "fermentation" needs more careful study. It is probably not all due to simple decay of vegetation, though that in itself is a process due to the action of living germs, and thus a biological phenomenon.

The condition above referred to probably occurred in 1888. It is said by the oystermen to be present in the river not oftener than once in eight or ten years, and is believed by them to be precipitated by heavy freshets of water during the warm weather in the latter part of July.

An aquatic mowing-machine.—Eelgrass grows abundantly in some parts of the Navesink River, and, as in other localities where it is found, acquires in due time full possession of the areas where it grows, rendering them useless for oyster-culture. In combating this enemy of the oyster-planting industry, Mr. Charles T. Allen, of the firm of Snyder & Allen, Oceanic, N. J., has achieved a degree of success heretofore unequaled. After expending much fruitless labor in efforts to mow the eelgrass with a scythe, a method which proved impracticable because the water was sometimes too deep and also on account of the difficulty of cutting grass growing under water, he invented in 1885, and has since used, a device which may be termed an aquatic mowing-machine. The machine is rigged on a square-ended scow 20 feet long by 8 feet wide. On the forward end of the scow is suspended, by a framework, a double set of knives, each set being similar to those of mowing-machines used by agriculturists. The object in having double knives is to enable the machine to cut when moving backward as well as when moving forward, thus avoiding the necessity of having to turn the scow around when the end of the swath is reached. The knife bar is 12 feet long and consequently cuts a swath 12 feet wide. The power for propelling the machine is supplied by a six-horse power, high pressure, condensing engine, which is located in the middle of the scow. A line 1,000 feet in length is passed with three turns around a winch-head, and drawn taut by an anchor at each end, placed a short distance beyond the extreme boundaries of the area to be mowed. It is held in position by a fair-leader or chock, having a shive on each side similar to the shive of an ordinary tackle-block. The shives facilitate the passage of the line through the leader by lessening the friction, and correspondingly decrease the wear upon it. The leader or chock is placed on the forward end of the scow, and not only serves to hold the line in position but also keeps the scow straight in its course.

When the engine is started the winch-head revolves, and the pressure of the line, encircling it in three turns tightly drawn, forces the scow through the water. The rate of speed at which it can be operated is 1,000 linear feet in 5 minutes, thus enabling it to mow an area of 2,000 square feet or more per minute, or 1 acre in from 20 to 22 minutes, making allowance for time spent in moving anchors or otherwise adjusting the machinery.

When fitted for work, with coal and water, and manned with 3 men, including an engineer, which is the number requisite to operate the machinery and attend to shifting the anchors, the draft of the scow is about 8 inches of water. When the anchors have once been adjusted several swaths can be mowed before they require to be shifted over toward the uncut grass, as the line can not easily be drawn so taut, nor does it need to be, as not to allow the scow to be moved (pushed with a pole) sidewise for a short distance. When necessary the anchors are shifted by the use of a small boat. Thus the scow is guided back and forth across the lot, cutting the grass with equal facility in both the forward and backward movements. When the grass is cut, it floats to the surface of the water and is carried away by the current. The knives are set in motion by a vertical iron shaft which passes through a horizontal cogged wheel. This wheel is geared to a pulley which is run by a belt from the engine. The vertical shaft is so arranged as to slip up or down in order to gauge the machine to any depth of water within the range of its capacity. The extreme depth of water in which mowing can be successfully done, as it is now adjusted, is about 8 feet. It could doubtless be so arranged as to operate in deeper water.

If there are no obstacles in the way the grass can be cut within 1 inch of the bottom. If there are oysters on the ground some allowance for that fact has to be made, and while the grass can not be sheared so close to the bottom, it can be mowed sufficiently close to the oysters to answer all practical purposes. The only thing requisite is to mow it short enough to preclude the possibility of any large quantity of sediment settling in it and choking the oysters. This object is easily attained, as grass a few inches long will not injure the oyster crop. It is when its length is measured by feet, and it is filled with sediment, that it becomes dangerous.

In the locality where this machine is used the water is about 6 feet deep. It has been customary to mow the oyster beds quite frequently, five or six times perhaps during the growing season, from the first of May to the last of October. The result has been that tracts of bottom that would have otherwise been worthless for oyster-growing purposes have been converted into beds as productive as any in the river. The cost of building a similar machine is estimated by Mr. Allen to be from $450 to $500.

Persons, wages, etc.—The planters, as a rule, are also prosperous farmers, having comfortable homes pleasantly located in the various small towns and villages on the banks of the rivers, the more important of which are Red Bank, Fair Haven, and Oceanic on the southwesterly, and Middletown on the northwesterly side of the Navesink; Little Silver on the northwesterly, and Oceanport and Branchport on the southwesterly side of the Shrewsbury.

The men hired to work in connection with the oyster business are, in many instances, primarily employed on the farms and are transferred from one branch of labor to the other as occasion may require. The rate of wages paid to men while engaged in the oyster fishery is usually $2 per day. The planters furnish them with boats, tongs, and other apparatus. The total number of men engaged in the business is 92, including proprietors or planters. Eight at Pleasure Bay are employed as shoresmen, two of whom are colored; the remainder are white men, and all are American citizens.

The business is not so large as formerly, and the number of men engaged in it is correspondingly reduced. At Little Silver and Oceanport it is not customary to hire help. The planters do the work themselves. On the Navesink there are 32 men who are proprietors of grounds and plant oysters. Some of them, however, do a very small business.

Boats.—The boats used in the oyster fishery are a small, square-stern, flat-bottom, clinker-built row boat of the bateau kind. The largest of them are 22 feet in length over all with an extreme width of 5 feet on top, and have a carrying capacity of about 40 to 50 bushels of oysters. Some of them are smaller, being not more than 19 feet in length. They cost when new from $40 to $50.

Marketing the oysters.—The only thing requisite in the preparation of the oysters for market, after being caught, is to cull and grade them into two sizes. The large ones are called "box oysters," and the small ones "cullens" or "cullings." They are not placed in the brackish water to drink as at Perth Amboy and Keyport, the waters of these rivers not being considered sufficiently salt to render that process necessary.

Floats are used to some extent for keeping the oysters in good condition while they are being prepared for market or held on hand awaiting the buyer's orders. If the planter is not supplied with floats for this purpose, the oysters are laid on the shore, in shoal water, until required for shipment.

The average price which the producers receive for box oysters is $8 and for cullens $4 per thousand. They are shipped in flour and sugar barrels. A flour barrel will hold about 650 box oysters or 1,000 cullens and a sugar barrel about 900 box or 1,200 cullens. New York is the principal point of shipment, although a great many are marketed within the State, especially during the summer when the hotels along the coast are open. The oysters are all sold in the shell, except at Pleasure Bay, where about 3,000 to 4,000 bushels per year are opened and sold by the thousand, the greater part being sent by express to Chicago.

Two steamboats, running regularly in summer between Red Bank and New York, furnish means of transportation for about one-half of the oyster products of the river, and the remainder are shipped by rail.

II.—THE OCEAN SIDE OF NEW JERSEY.

Description of the coast.—The northern part of the coast of New Jersey is singularly destitute of indentations suitable for the existence or cultivation of oysters. Proceeding southward from Sandy Hook, the first inlet of any importance is Shark River, in which there is a limited oyster business. With this exception there is no oyster industry on the Atlantic coast of the State north of Barnegat Bay.

From the head of Barnegat Bay (in Ocean County) southward the coast is skirted by desolate sand beaches, broken into sections by numerous inlets which connect the waters of the inside bays with those of the ocean. Of these inlets the principal are Barnegat, New, Absecon, Great Egg Harbor, Townsend, and Hereford. The general contour of the coast is quite regular, forming a graceful curve (the convexity seaward) from Sandy Hook to Cape May. These sand beaches serve as a sort of natural breastwork, protecting the inside bays, which lie between the outer beaches and the mainland, from the violent storms of the ocean, and rendering them favorable localities for the operations of the oyster-planters. The sheltered location of these bays imparts to them some resemblance to Long Island Sound or the sounds along the coast of North Carolina.

Next to Barnegat Bay, the most important indentations on this section of the coast are Little Egg Harbor, Great Bay, and Great Egg Harbor. The inside coast or shore of the mainland is irregular and indented by creeks and mouths of rivers and small streams, and is usually low and marshy.

Oyster boats.—The boats used in the oyster fisheries of this section are of several varieties. Those of large size are propelled by sails exclusively, while the smaller ones are generally provided with sails and oars, either of which may be brought into requisition whenever the occasion demands. The kind of boat most used in tonging oysters is the one known as a "garvey," which is a small, square-ended, flat-bottomed scow, with raking ends and flaring sides. It is about 20 feet in length over all, and 16 feet on the bottom. The width is usually about 5 feet at the top and 4 feet at the bottom. It costs approximately $30 when new. This type of boat is more numerous than any other. It is not designed for speed, but is well adapted and serviceable as a tonging boat in the shallow waters of the inland bays and creeks along the coast. A peculiar-shaped boat is also used for tonging purposes, which is called by the fishermen a "sneak box." Its form resembles that of a pumpkin seed, with the exception that it is more elongated. The convexity of the top is nearly as great as that of the bottom. The stern is square, straight, and moderately wide, and the steering gear is hung outside. These boats vary from 12 to 18 feet in length. The top is decked over, leaving an open space or manhole in the center, the size of which varies according to the size of the boat, but is usually about 4 feet long and 2½ feet wide. Some of these boats are quite expensive, costing $45 or more when new. They are ordinarily propelled by oars, but are also provided with a sprit sail, and have a scimitar-shaped centerboard. The mast is placed well forward, as in a cat-rigged boat. Their carrying capacity is from 10 to 20 bushels of oysters. They were designed originally for a gunning boat in which to hunt ducks or other sea fowl, and seem to be more suitable for that purpose than for oyster tonging. They are not much used in the oyster fisheries, except at Barnegat.

Large sail boats are used for towing the tonging boats and carrying oysters. The majority of these are cat boats about 23 feet in length, and similar in construction to those used in the New England States. They cost about $500 each. Sloop-rigged boats are used for the same purpose. They are usually 25 feet in length, and sometimes cost as high as $800. The cat and sloop boats have a round bottom with centerboard. In addition to these there are a number of sharpies (found chiefly at Barnegat) of the Connecticut pattern, about 23 feet long and costing $200 each. They are propelled by sails mostly, but frequently with oars. Some of the larger cat boats and sloops are used during the summer for carrying pleasure parties at Atlantic City. The tonging boats are not strictly confined to the "garvey" and "sneak box" types, but sharpies and other sailboats are used for that purpose, when not too large.

SHARK RIVER.

Shark River is a broad, shallow stream connecting with the ocean by a narrow inlet at Belmar. It was, at one time, considered important on account of its natural adaptability for the cultivation of oysters, but in recent years the shifting sands of the coast have had a gradual tendency to fill up the inlet, thus impeding the free circulation of tide waters, until the river has degenerated into what is now little more than a large pond. Sometimes the inlet closes and the water becomes almost stagnant.

The character of the bottom is diversified. There are extensive flats of mud, smaller tracts of sand, and considerable areas of natural oyster beds. The oystermen believe that if the inlet were dredged to a depth sufficient to admit light-draft vessels, and properly secured by bulkheads to prevent the sand from drifting in again, the river would become very valuable for oysters and fish.

An act was passed by the legislature in 1861 providing that the freeholders of the county (Monmouth) should appoint commissioners whose duty it should be to survey the bottom of the river, within certain specified boundaries, and stake it off in lots or subdivisions not exceeding 2 acres each, and lease them at public sale to the highest bidder for the purpose of planting and growing oysters; that no person should own more than 2 acres, and no company more than 5, for a period of not less than one year or exceeding five years; that after the necessary expenses imposed on the commissioners by the act and compensation for their services had been paid, the residue of the money received by them from rents, if any, should be paid to the board of freeholders and forwarded to the trustees of the State school fund to be used in the support of the public schools. In 1870 this act was supplemented by another extending the original boundaries and the term of the lease from five to ten years. These regulations are still in force, and the grounds are rented by the planters at rates varying from 50 cents to $5 per acre, according to quality and desirability for oyster-planting purposes. In 1881 the first section of the act of 1861, relating to the boundaries, was amended, and the board of freeholders were authorized to possess the oyster-grounds of the river to let for oyster-planting purposes for an additional term of twenty years, or until March 14, 1901.

Although there is a comparatively large number of persons engaged in planting oysters, the business has declined to very small proportions, and the planters derive less income from it than from farming and other branches of industry.

The greater part of the seed oysters used is obtained from the river, being either the product of the natural beds or of the set of spat secured by artificial means on the cultivated grounds. Considerable quantities are also brought from Barnegat Bay. These are planted in September.

One of the most interesting features of the system of oyster cultivation practiced in this river is the use of tin cans as spat-collectors. For the past two or three years many wagonloads of tin cans have been distributed every season upon the cultivated grounds with results that have been gratifying to the oystermen. The cans possess the advantage not only of being successful spat-collectors, but also, when having served that end, of disintegrating and leaving the beds unencumbered. Shells are also planted for a similar purpose. The river being closed to navigation, except for small boats, the need of cheaper means of transportation than by rail causes considerable difficulty in obtaining shells for planting, and was no doubt instrumental in suggesting the use of tin cans, but these can not be procured in quantities large enough to supply the demand. A fairly good set occurs quite regularly in the river every year on the natural beds and also on the cultch planted on the cultivated grounds, due probably to the favorable conditions afforded by the warm water and muddy bottom for breeding food for the oysters.

Most of the oysters are taken up for market in October, November, and December. They are graded into two sizes, "box oysters" and "cullens," and sold at an average price of $7 per thousand for box oysters and $3.50 for cullens. The annual yield is not more than from 4,000 to 5,000 bushels. They are taken with tongs in small boats, which are either the kind known in this region as "garveys" (a small square-ended scow), which are about 15 feet in length and cost when new from $8 to $10, or small bateaux which cost from $20 to $30 each. There are 90 men engaged to a very limited extent in the planting operations, all of whom are native American citizens. The extent of area utilized for oyster cultivation does not probably exceed 200 acres.

BARNEGAT BAY.

Description.—This bay is the largest and perhaps the most important of the bays along this section of the coast. It is about 27 miles long and 1 to 4 miles wide, and its waters are shallow. Immediately to the south and adjoining it is Little Egg Harbor, which is a continuation of Barnegat Bay. These two bodies of water extend the entire length of the shores of Ocean County, and are the field of an extensive clam fishery and of oyster fisheries of considerable importance.

Natural oyster beds.—Originally the natural oyster beds of the bay were quite productive, but in recent years they have been of less importance, although still producing a considerable quantity of small oysters suitable for planting. From the Pennsylvania Railroad bridge, which spans the bay at Seaside Park on the ocean beach, connecting that village with Island Heights Junction on the south bank of Toms River on the mainland, they are more or less important throughout the entire length of the bay to Little Egg Harbor inlet.

Cultivated grounds.—Within this region, also, there have been taken up and marked by stakes areas of ground for oyster-planting purposes. They are located chiefly at Cedar Creek, Forked River, Barnegat, Manahawken and vicinity, West Creek, Parkertown, and Tuckerton. The area of these grounds is not definitely known, but may be from 1,500 to 2,000 acres, and are held by approximately 300 persons. The planters, however, do not actually operate the entire area held by them. This fact has given rise to a good deal of dispute and bitter feeling between the oyster-planters and persons engaged in the clam fisheries and in taking oysters from the natural beds. The claim is made by those depending entirely on the products of the natural beds that the privilege which the State accords to its citizens of reserving unproductive sea bottom for oyster cultivation is being abused, and that under a pretext of reserving unproductive lands for the cultivation of oysters the planters have fraudulently appropriated many valuable clam beds and natural oyster reefs, thus monopolizing areas which, it is claimed, are being used by them for oyster-planting contrary to law, or in some instances not used for that purpose (except ostensibly), but held illegally in order to secure the natural products of oysters and clams from them, thereby infringing upon the rights of the clam and oyster fishermen who have no private holdings and are confined in their operations to the public domain.

Various remedies for this evil have been suggested by individuals, but no systematic effort has been made to settle the dispute between the contending factions. The result has been that the oyster-planters have met with considerable loss at times from depredations committed upon their beds by those who questioned their right of possession, and persons committing such trespasses have in turn been occasionally subjected to much inconvenience when having to pay the penalty therefor by fine or imprisonment.

One of the most important suggestions, perhaps, that has been made looking toward the satisfactory adjustment of the question is the introduction of some system of taxation which would provide for the imposition of a tax either upon the grounds, or upon the seed oysters annually planted upon them. But the proposition has not been advanced beyond the sphere of contemplation. It would, for obvious reasons, seem to be more tangible to tax the grounds, than the oysters which are planted on them, and this would be more liable to produce the effect desired—that of deterring the planters from taking up more land than they require for immediate use.

That there may be some foundation for the variances above referred to is not improbable, but that it is the source of as much interference with the interests of the clam and natural oyster fisheries as is sometimes supposed by those engaged in them is not so certain. The feeling of insecurity which the existing unsatisfactory conditions engender has doubtless retarded in some degree the prosperity and growth of the planting industry.

The surface of the bottom is generally composed of mud, but not too soft to bear oysters. The adaptations with regard to the abundance of food seem to be more favorable for the production of seed oysters than for fattening those of mature growth for market. A fairly good set of spat can also be secured on shells or other cultch nearly every year, tending to indicate that with skillful management the available tracts of bottom might be turned into a seed-producing region of considerable value. In some localities a very good quality of oysters of marketable size are grown, although they are not large and their growth not rapid, while in others they do not fatten sufficiently every season for market purposes.

Methods.—The methods of conducting the industry are less systematic in this region than in some of the other localities in the State. There is no organization of the oyster-planters except at Barnegat, where an effort was made in 1892 to establish an oystermen's protective association similar to the one existing at Keyport. In this effort the experience common to such movements was met with. Many of the planters did not join the new association, and many of those who did reported a much smaller number of bushels of oysters on their grounds than there really were, in order to diminish the tax levied upon them by the association. The rules of the organization provided for a tax of a few cents per bushel, to be assessed on the oysters held in stock on the grounds, to be paid annually to the treasurer, the fund thus collected to be used for paying watchmen to patrol the grounds, or in the prosecution of persons trespassing upon them. At West Creek there is no protective association, but the oystermen employ a watchman about three months of the year to guard the beds.

While the number of persons engaged in cultivating oysters is quite large, the quantity planted by each is very small. A great many do not plant more than from 200 or less to 500 bushels per year, others from 1,000 to 3,000 bushels, and a few from 5,000 to 14,000 bushels. The average per man would not exceed 500 bushels. The planting is done during the fall and spring, when the seed is being taken from the natural beds. The average cost of oysters for planting, to those who have to buy, is about 25 cents per bushel. Nearly all, if not the whole, of the seed used comes from the natural beds of the bay and from Great Bay. The greater number of the planters, in addition to doing a small cultivating business, engage also in taking oysters from the natural beds, and many of them plant only their own catch, while others buy the necessary supply of seed from oystermen not interested in the industry otherwise than in the catching of natural oysters. Thus the two branches of the industry, the artificial and natural, are inseparably connected with each other, many persons engaging in both at the same time. When the supply of natural oysters exceeds the demand for seed in this immediate locality, as it usually does, the surplus is sold to planters at Shark River and elsewhere.

After the oysters have been planted on the cultivated areas it is customary, as in other sections, to allow them to remain about three years and then shift them to other grounds in order to perfect their condition for market.

Apparatus.—The only method employed for taking oysters, either from the cultivated or natural beds, is that of tonging. The tongs are of the ordinary kind, but generally a cheaper quality is used than in localities where the business is more extensive. Their cost when new is about $5 per pair. The law does not permit the use of dredges on the natural beds of the State (except in Delaware Bay) and the planted areas are not sufficiently large to require them.

Marketing.—Practically the entire product of marketable oysters is taken from the cultivated grounds. The shipping is done in the fall and spring, and to some extent during the summer. In the more important localities, where the business in a measure centralizes, as at West Creek, Barnegat, and Tuckerton, a number of the planters who engage in the business on a larger scale than the rest are also local buyers and shippers. Some of the planters, therefore, who have only small quantities to dispose of, sell them to the shippers. A very small proportion of the oysters are opened, nearly all being shipped in barrels in the shell. The price received averages 80 cents per bushel. The principal markets are New York, Philadelphia, and Atlantic City.

GREAT BAY.

Description.—Directly south of Little Egg Harbor and continuous with it is an extensive sheet of water known as Great Bay. It is inclosed on the north by the shores of Little Egg Harbor Township, formerly a part of Burlington County, but recently of Ocean County, and on the south by Atlantic County. Into it flows a number of small rivers, the largest and most important of which is the Little Egg Harbor, or Mullica. New Inlet connects the waters of the bay with the ocean.

The natural oyster-grounds.—Some of the most extensive and productive natural oyster-grounds to be found on this section of the coast are located in these waters. Among the beds most frequented are those which are termed by the oystermen the "Gravellings," lying at the head of the bay in the mouth of Mullica River, deriving their name probably from the gravelly nature of the bottom. They begin at the head of the bay and extend up the Mullica River for a distance of 6 or 8 miles, to a point just above the mouth of Bass River. On these grounds there is a set of young oysters nearly every year, although more abundant some seasons than in others. Large tracts of bottom in various parts of the bay proper are also quite productive.

The season for taking oysters in this region begins on the 1st day of October. The law provides that for the first ten days no oysters shall be taken except between the hours of sunrise and sunset. These beds probably furnish the greater quantity of native seed oysters used in the adjacent counties, and are visited annually by boats along the coast from West Creek to Somers Point. The large congregation of crafts of so many and varying types and sizes lends an element of interest to the scene which is here presented on the first day of the season. Each succeeding day, however, marks a perceptible decrease in the number, indicating that the oysters are proportionately becoming scarcer. The fishing continues for about six weeks. By that time the crop is well-nigh exhausted, and the fishing becoming unprofitable is consequently abandoned for the season. This is repeated every fall except in occasional years when the set of spat and the growth of oysters has been less successful than usual. In such cases the inducements are not sufficient to attract the oystermen from remote localities and the bay is therefore not visited by so large a number of boats.

In the most abundant seasons many of the boats do not find it profitable to make more than two or three trips to the bay. In making these trips large sailboats with crews of three or four men are used, frequently having in tow a number of garveys or other small boats convenient for the work of tonging oysters. When the large boat is loaded the oysters are carried to the planting-grounds. In many instances the sailboats obtain their freight by purchasing seed from the tongers on the grounds. Thus a great many of the oystermen who do not plant find a ready market for all the seed they can catch. The planters also send vessels to the bay to obtain seed in a similar manner.

The oysters are said to be not so large, or rather the proportion of large ones not so great, as in earlier years. This condition is doubtless due to the persistent and exhaustive manner in which the beds are tonged each season. So large a percentage of their yield is harvested that the crop for the ensuing year has come to be substantially dependent upon the growth of the set, which occurs during the summer next preceding the beginning of the tonging season. If this chances to be unsuccessful, the result will be a small harvest. Under the most favorable conditions the catch must necessarily consist largely of what is termed blister oysters, those of very small size adhering to the old shells. The beds were very productive in 1892, more so, it was believed, than for fifteen years previous.

It would be difficult to determine the annual yield of these beds very closely, but considering the fact that the quantity of natural oysters taken by the residents of Ocean, Burlington, and Atlantic counties combined, in 1892, from the inland waters along the coast, was nearly 200,000 bushels, valued at more than $58,000, and that more than 50 per cent of that quantity was derived from Great Bay, it is evident that the catch must have exceeded 120,000 bushels. The important relation, also, which these seed-producing areas sustain to the existence as well as the development and growth of the cultivating industry of these counties will be apparent when it is remembered to how great an extent the planters are dependent upon them for their annual supply of seed.

Oyster-planting in Great Bay.—Although Great Bay is chiefly valuable for its natural oyster beds, it is not wholly without cultivated areas. In various sections and on both sides of the bay there are grounds staked up which are held and used for oyster-planting. These are not extensive, although a complaint, similar to the one urged against the planters in Barnegat Bay, that they encroach upon the natural beds, and hence infringe upon the rights of other oystermen and clam fishermen, is also heard in this locality. The planting business is small and does not seem to be so prosperous as one would think it should be with natural conditions apparently so favorable.

The entire quantity of seed oysters planted in 1892 did not exceed 39,000 bushels, while that for each of the three years preceding was considerably less. The quantity taken up for market was about 25,000 bushels, valued at $18,000, a small proportion of which was not placed upon the market directly, but was sold to planters in other sections to replant. The grounds are operated chiefly by planters living at New Gretna, in Burlington County, and at Port Republic, in Atlantic County. A few persons living at Tuckerton have planting-grounds there. The planters at New Gretna number about 45, and there are also 9 at Port Republic. The persons engaged in cultivating also participate in the natural fisheries. At New Gretna, which is now the only place in Burlington County where oyster fisheries are prosecuted, there are 76 persons engaged in the natural fishery. Prior to 1892 Tuckerton belonged to this county, but a change in the county line placed it in Ocean.

Green oysters and clams.—Great difficulty was experienced in 1892 by the oystermen and clam fishermen in selling their products. In September a number of ships from Hamburg, Germany, were quarantined at New York on account of cholera infection. The belief soon became prevalent among the people in many localities that débris thrown into the water from the pestilential ships might serve as a medium to convey cholera germs to the shellfish along the shores. It was not long before the fears of this not very probable event began perceptibly to affect the markets, and for a period of about six weeks the demand for clams and oysters was appreciably diminished. Meanwhile, there appeared an unusual viridity of the clams and oysters of Barnegat Bay and Little Egg Harbor, chiefly in the vicinity of Manahawken and Tuckerton. The greenness was first noticed about the 15th of August. It began near Tuckerton, and by the 1st of October had spread over a large area. The parts infected were, so far as the eye could discern, the gills and lips (palps) of the mollusks.

Among the fishermen and others in the section where the phenomenon occurred some persons supposed it to have been caused in part by the extremely dry and hot weather for which the past summer had been more than ordinarily remarkable. It had been noticed, also, that the waters of the bay were unusually clear and that no storms had occurred to disturb the sediment from the bottom and place it in circulation in the water. The extraordinary clearness of the water was therefore considered to indicate a corresponding greater deposit of sediment on the bottom than there would have been under normal conditions. Others thought it might be due to a disease of the oysters and were inclined to regard it as a sort of epidemic, while in the minds of many it became very naturally associated with the current rumors of the supposedly possible infection by cholera germs.

According to the fishermen a similar infection occurred about twenty years ago, and was then attributed by the people to the abundance of seaweed. An idea has also long prevailed in certain localities that when the clams and oysters turn green there must be some poisonous matter in the water, such as copper or Paris green, or that it may be due to pollution by paint or by preparations used for preserving the piling in wharves, in which there is crude petroleum oil or penetrating chemical ingredients. In the present instance, however, there seemed little reason to think that the water had been polluted by any such preparation as above alluded to, but the green color suggested the presence of copper or other mineral substances which might render the oysters unwholesome. Persons entertaining this theory affirmed that the eating of one green oyster had caused them sickness and vomiting, but no evil results followed.

Aside from the objectionable coloration, which served to produce an unpleasant impression on the mind of the consumer and thereby interfere with the sale of the products, the clams and oysters were generally fatter and in better condition for market than they had been for a number of years. For a time the green color was not sufficiently pronounced to be seriously detrimental to the marketing business, but as the season advanced the greenish appearance became so decided that the shippers grew apprehensive lest the trade, and consequently the fishery, might have to be wholly discontinued. This would entail a loss to the community which would be severely felt, especially by the large number of fishermen who were mainly dependent upon the clam and oyster fisheries for a livelihood. A few instances occurred in which the dealers had declined to receive the shipments and had returned them. It was finally deemed advisable that an investigation should be made with a view to ascertaining the cause and nature of the viridity and removing, so far as practicable, false impressions on the part of consumers regarding it. Accordingly the services of Prof. Julius Nelson, PH. D., biologist of the Agricultural College Experiment Station at New Brunswick, N. J., were secured by Messrs. Horner and Austin, wholesale dealers and shippers of oysters and clams at Tuckerton. On October 6 Prof. Nelson made a personal inspection of the grounds and an investigation of the oysters and clams, the results of which were transmitted to Messrs. Horner and Austin, October 18, and published in the Tuckerton Beacon of November 3, 1892. The essential parts of Prof. Nelson's report, as addressed to Messrs. Horner and Austin, are subjoined:

I have examined the clams you sent and have carefully looked over the grounds at Tuckerton, and can report that the color is due to the presence of a species of microscopically-small vegetable organism, which the dryness of the past summer has allowed to multiply in the waters on the beds and which the clams have eaten in large quantities, so that their tissues have become stained by the color of their food. The dye is perfectly harmless. Numerous tests and analyses made by several scientists, both of this country and Europe, show that copper is not present; neither does microscopical examination show any disease nor any parasites present. Oysters affected in a similar way are in special demand in Europe, not for their color, but because of their careful cultivation, the fine qualities being in no wise deteriorated by the fact that their tissues are stained by their food.

My investigation of the green clams and oysters of Tuckerton Bay brings out the following facts:

(1) The peculiar pea green is for the most part confined to the gills, but some specimens have the so-called "liver" also changed from its natural brownish to a brownish-green tint.

(2) The water taken from the clam beds has a marked greenish color and deposits a green sediment on standing.

(3) This sediment consists of a nearly infinite number of very small vegetable cells or microscopic plants known as algæ, among which are many diatoms, but especially a species of *Botrycoccus*.

(4) The digestive canal of the clams was found crowded with these low organisms in process of digestion, but the color was not changed by the digestive juices.

(5) After the clams are removed from the water the color fades somewhat day by day, and would probably very soon disappear if they could be placed in water free from these algæ.

(6) The "infection" began on the flats, in shoal water, amidst floating eelgrass, which, owing to the dry and stormless summer, was little disturbed and therefore presented the most favorable conditions for the development of this species of food.

(7) The "infection" began in August and has now succeeded in gradually covering the entire bay.

(8) The clams become colored within a very few days after the water in which they live has become impregnated by the algæ in question.

(9) These clams are in as fully excellent condition of fatness and flavor after "infection" as before, owing, doubtless, to the abundant food thus furnished them.

(10) No evil results have followed the free eating of them by persons having even very sensitive stomachs.

(11) The color is naturally suggestive of "copper" or "Paris green" to people ignorant of the true nature of the "infection," but no trace of copper or other injurious substance has been found.

(12) It is not a disease, is not due to parasites, no disease germs are present in the colored tissues.

(13) The dye is readily dissolved out of the algæ in the stomach into the blood, from which it is absorbed, of course, most readily by the most active tissues.

(14) That it has any connection with a cholera epidemic is absurd, although it is probable that the climatic conditions which favor the growth of these low forms of green vegetation are also favorable to the propagation of disease germs whenever the latter may be lodged by winds in places having sufficient moisture.

(15) If any case of sickness has followed the eating of green clams and oysters it should be attributed to any other cause rather than to the harmless vegetable dye.

(16) The advent of wet weather will doubtless soon destroy this food of the clam, and the "infection" will disappear as quickly as it came, not to return until the rare and favorable conditions of last summer are repeated.

(17) It is natural that people who do not know the cause of the unusual color should reject green clams, deeming them disease-causing. Such persons may be assured, not only on our authority but on that of every scientific investigator who has studied the subject, that the clams are wholesome and of good, sometimes of superior, quality.

In addition to being published in the weekly newspaper at Tuckerton, previously alluded to, the foregoing report of Prof. Nelson's investigation was also printed in circular form to be distributed by the oyster and clam shippers among their customers, in order to counteract, so far as possible, by disseminating proper information regarding the harmless character of the green coloration, the damaging effect which it had produced upon the markets. Efforts in that direction were naturally confronted by many obstacles. There was not only the difficulty of reaching consumers over a sufficiently wide area, and convincing them by a presentation of scientific facts that their preconceptions relative to the subject were ill-founded, but there was also the greater difficulty of reversing an unfavorable popular sentiment and eradicating an ingrained prejudice. The shipping season was, however, practically closed early in December, on account of the severity of the weather, and very little opportunity was afforded for testing the effectiveness of the movement.

The greenness continued throughout the entire winter and spring, and did not wholly disappear until the middle of the following May. During the summer of 1893, conditions obtained in the bay similar to those which were present in 1892, indicating a recurrence of the viridity; but this was averted by a heavy storm-tide which disturbed the algæ and cleansed the bottom before the oysters and clams became affected.

ATLANTIC COUNTY.

The oyster centers.—The principal localities in Atlantic County interested in the oyster fishery are Port Republic, on the south side of the Mullica River, opposite New Gretna; Leeds Point, Oceanville, Conovertown, Absecon, Brigantine, Atlantic City, Pleasantville, Smith Landing, Linwood, Steelmanville, Sea View, Somers Point, and Scullville. From Leeds Point to Smith Landing, inclusive, however, is the region where the greater part of the business is conducted.

In all of these localities there are persons who do more or less oyster-planting, although many of them do not plant more than from 25 to 100 bushels per year. Others engage in the business on a larger scale, and plant from 5,000 to 10,000 bushels annually. In 1892 the total number of oyster-planters in the county was 180. The average number of bushels planted by each was less than 800. In addition to planting operations a majority of the planters, together with a large number of other oystermen who do not cultivate, engaged in tonging oysters from the natural beds. The total number of persons thus engaged in 1892 was 443, and the quantity of oysters taken by them was 88,510 bushels, valued at $19,822. The oysters are chiefly used by the planters for seed. A few thousand bushels were picked by hand from the grass or thatch, and are termed "thatch oysters." In all of these localities a majority of the people earn a substantial part of their living by means of one branch or other of the fisheries, the most important of which are the oyster and clam fisheries.

Grounds.—The grounds upon which the oyster-planting operations are conducted are located chiefly in the small inland bays of the county. With the exception of the planters at Port Republic, whose planting-grounds are in Great Bay, the oyster-planting areas are located in the bays between Leeds Point and Great Egg Harbor Inlet. The most important of these are Little Bay, Reed Bay, Absecon Bay, and Lakes Bay. At the southern extremity of Atlantic County, and separating it from Cape May County, is Great Egg Harbor Bay, into which empties the Great Egg Harbor River. This bay and river produce a small quantity of natural oysters, which are used for seed, but have practically no cultivated oyster beds. The bays in which the cultivated grounds are located are interspersed with numerous low, marshy islands. The water is generally very shallow and the bottom soft and muddy. In many regions there are large areas covered with a luxuriant growth of eelgrass.

Methods.—The methods resorted to in the cultivation of oysters in this section are in most respects very similar to those employed elsewhere in the State. The seed oysters are obtained in part directly from the natural beds of the various bays from Great Bay to Great Egg Harbor Bay, inclusive. Considerable quantities, also, of large native oysters, which have laid on cultivated grounds for about two years and become nearly large enough for market, are bought and replanted for one season, when they are taken up and marketed. The small natives cost about 25 cents per bushel and the large ones from 50 to 75 cents. The average cost of native oysters for planting, large and small together, is about 40 cents per bushel. Planters who engage in the business to any great extent generally buy all of their seed from oystermen who operate on the natural beds or from planters who cultivate on a small scale, while those who plant only small quantities usually catch their own seed.

In addition to the native seed there are also planted from 35,000 to 40,000 bushels per year of Chesapeake Bay oysters, which are obtained by means of transporting vessels. They cost on an average about 70 cents per bushel, and, like the large natives, are of nearly marketable size when planted. Large oysters, whether natives or Chesapeakes, are usually planted in the spring and taken up during the summer following, to supply the constantly increasing summer trade of Atlantic City and Philadelphia. It is not generally expected that during the few months they are allowed to remain on the grounds they will increase very much in size; but there is some growth and also some loss, the one usually being sufficient to offset the other. The price received for oysters when marketed is from $1.25 to $1.65 per bushel, or an average of about $1.50. The small native seed is planted in the spring and fall and is allowed to grow about three years before being taken up for market. They are planted in from 2 to 5 feet of water, or as much deeper as may be available.

Deterioration of the oyster supply.—The oyster-planting industry has been prosecuted quite extensively in the waters of Atlantic County from an early date. It apparently reached its climax of prosperity and importance in 1880. Since that time the planting operations have not been attended with so good results as formerly, but the diminution in the yield has been more appreciable since 1888. That the industry is not now so prosperous as in 1880 is doubtless due to a combination of causes.

In the early history of oyster-planting in these bays, Great Bay was a much more productive source of seed supply than it has been in recent years. Natural oysters could also be obtained in considerable quantities in the smaller bays and in the creeks along the shores, whereas they have now become very scarce. Great Egg Harbor Bay and River were also noted for their abundant yield of natural oysters. The beds in these waters were not extensive, but extremely productive, and were annually visited by a large number of boats from Atlantic and Cape May counties. It is said to have been not uncommon for a boat or large scow to be loaded with oysters without having to change its place of anchorage, and that more than 100 bushels were frequently taken by one man in a day. As the beds began to be exhausted they gradually spread over larger areas and the oysters became more thinly distributed. At the present time the yield of these beds is comparatively small, and they are not relied upon to any great extent to furnish seed for the use of the planters.

The most important cause, perhaps, assigned for the decline in the planting industry is the damage and frequently the total destruction of many of the most valuable planting areas by the growth of eelgrass, which is especially abundant in the bays where the planting-grounds are principally located. It would seem that the tendency of the inlets connecting the bays with the ocean to fill up with sand and thus render the circulation of the inside waters more sluggish than they would be with freer intercourse with the sea is highly favorable to the growth of the eelgrass and correspondingly unfavorable to that of the oysters. It is claimed that the grass has extended its area more rapidly since 1880, and for two or three years immediately preceding, than was before noticeable, and that the oysters which have been planted have not yielded so large an increase.

An example which illustrates the rate of growth under favorable conditions, and, at the same time, the damaging effects of the eelgrass, was furnished by a planter operating in Lakes Bay. In 1877 he planted on a small piece of ground, which he estimated to be not more than half an acre, 625 bushels of native seed oysters, at a cost, including the expense of planting, of 30 cents per bushel, amounting to $187.50. They were taken up for market in the fall of 1879 after remaining on the ground two years, and were found to have yielded 1,176 bushels of marketable oysters, which were sold at $1.25 per bushel, aggregating $1,470. In the same fall the ground was again planted with the same kind and quantity of seed (625 bushels), at a cost of 50 cents per bushel, or a total of $312.50. This crop was harvested in 1881, after lying the same length of time as the former one, and yielded 928 bushels of oysters for market, which were sold at $1.25 per bushel, or a total of $1,160. In the spring of 1881 the ground was again planted with 665 bushels of native seed, costing 35 cents per bushel, or $232.75. During the two ensuing years the eelgrass completely covered the ground and destroyed all the oysters. The ground has since been valueless, though it had previously been estimated to be worth not less than $1,000.

Eelgrass becomes especially injurious to the beds from the fact that it facilitates the accumulation of sediment at the bottom. It has the effect of keeping the water calm and thus allowing large quantities of sea cabbage, mud, and various sorts of débris to settle down upon the oysters and smother them.

It is claimed by the oystermen that the oysters (native seed) do not grow so rapidly nor yield so abundantly as they did formerly. It was not unusual in earlier years for planters to receive a largely increased number of bushels as the result of planting, while at present it is seldom that they take up a greater quantity than they plant. The profits of the business are said to arise from the increase of the oysters in value rather than in quantity. It used to be customary to allow them to lie on the grounds about two years, but it has now become necessary to extend the period to three years, and sometimes longer. From the time the oysters are planted until they are taken up for market they are in constant danger of being destroyed. During the first year they frequently (as near as can be determined) double in quantity. In the second and third years a large proportion of them die, so that for the three years the loss in numbers is not more than compensated for by the increase in size.

These losses are not wholly due to eelgrass. The formation of ice during the winter season also causes considerable damage. Heavy and continued winds often blow the water out of the bays to an extent sufficient to perceptibly lessen its depth. These are called by the oystermen "blow-out winds." If the ice forms immediately after one of these storms, the oysters in some instances become attached to it and are carried away when it breaks up in the spring. Some of the grounds also, in very shallow water, become dry at low tide and the oysters are destroyed by the extreme cold weather. But these conditions have always prevailed and are not probably more destructive now than in former years. There is also some destruction caused by borers and winkles, but it is not very considerable.

CAPE MAY COUNTY.

The principal localities on the east or Atlantic Ocean side of Cape May County where oysters are planted are Ocean City, Beesley Point, Clermont, Townsend Inlet, Swain Station, Holmes Landing, Cape May C. H., Rio Grande, and Cold Spring. In 1892 the total number of planters or proprietors of planting-grounds in all of these localities was 97. This number does not include help employed by the planters. The business in most instances is conducted on a very limited scale. Many of these planters plant less than 100 bushels of oysters per year, while comparatively few plant more than 1,000 bushels annually. The greater part of the seed oysters used are brought from the Chesapeake Bay, by transporting vessels, during the month of April. These vessels usually make about three or four trips to the Chesapeake each spring. The quantity of seed planted is about 46,000 bushels. Of these, fully 40,000 bushels are southern oysters and the remainder are native seed.

The grounds utilized for oyster-planting are located in the numerous coves and thoroughfares along the shores inside of the sand beaches which front the ocean. These inside waters are in most cases very shallow. The work incidental to the planting operations is done in small boats, and the oysters are taken with oyster tongs. The total quantity of oysters taken from these grounds for market in 1892 was 40,775 bushels, valued at $46,456. This crop was not in any considerable measure related to the planting done in the spring of the same year, but resulted chiefly from oysters planted two or three years previously. The greater part of the seed is small when planted and requires from two to three years to grow to marketable size. The methods of conducting the industry do not differ essentially from those practiced in the counties of Ocean and Atlantic. The dredging vessels owned in Cape May County operate in Maurice River Cove.

III.—THE NEW JERSEY SIDE OF DELAWARE BAY (MAURICE RIVER COVE).

The oyster-grounds.—That part of Delaware Bay subject to the jurisdiction of New Jersey is the State's most extensive and most productive oyster region and is generally designated as Maurice River Cove. Originally Maurice River Cove was considered to embrace the waters at the mouth of Maurice River, lying inside of East Point on the south and Egg Island Point on the north, and comprised the greater part of the area which, in the early history of the oyster industry in this section, was used for planting purposes. At an early period, however, the name "Maurice River Cove" was applied not only to the cove proper, but also to the adjacent waters of the bay, and has become, in common usage, a general term to designate the waters of Delaware Bay between Egg Island Point and Cape May Point. The oyster-planting territory was also extended, reaching farther south, and off shore. The inshore grounds, within the first-named limits, were practically abandoned, being considered to be worn out or exhausted, and new areas of bottom lying in deeper water were appropriated. At the present time the region which includes the oyster-planting grounds may be approximately bounded as follows: Beginning at Egg Island lighthouse and running direct toward Cross Ledge light-house about 2½ miles, thence SSE. ½ E. about 9½ miles, thence easterly by an irregular course (excluding Dead Man's Shoal) to the cape shore near the north end of Fishing Creek Shoal, thence following the line of the shore at a distance therefrom varying from ½ to 1½ miles and sweeping several miles seaward off the mouth of Maurice River to the place of beginning, and containing about 68 square nautical miles, or 57,654 acres. Of this area probably not more than one-fifth is under cultivation. The depth of water on the cultivated beds varies from about 5 to 24 feet and the extreme distance from land is about 10 miles.

The beds are located in various portions of the above-described territory wherever the conditions are thought to be most favorable for oyster-cultivation. If a ground proves unsuccessful it is abandoned and a new one is selected. In this way the greater part of the entire space has been planted at one time or another. It not unfrequently happens that a ground which has yielded unsatisfactory results and has therefore been vacated by one planter, is taken up the next year by another and the oysters do well. Experiences of this kind have given prevalence to the idea among the oystermen that the constant use of the same ground either exhausts the food supply or superinduces an unfavorable condition of bottom, which requires a period of rest to correct. The general character of the bottom in the lower part of the cove toward Cape May is mud, while that of the upper part, in the vicinity of Egg Island, is sand. In many localities the sand is shifting and renders the bottom unsuitable for oyster-planting, and in some instances entirely useless.

Before any grounds can be planted it is required by law that they shall be marked by buoys or stakes, to which a number, painted in black figures 18 inches long and 4 inches wide, shall be securely fastened. It is also required that the vessel operating these grounds shall have a corresponding number of the same color and dimensions painted in the middle of her mainsail one-third from the head, on the starboard side, and in the middle of the jib one-third from the head on the port side. The grounds are divided into lots of such form and size as are most convenient for dredging. They are usually made as nearly square as possible and are approximately 5 acres in area.

A line running direct from Egg Island light-house to Cross Ledge light-house forms the legal boundary line between the cultivated grounds on the south and the territory which includes the natural oyster beds on the north of said line. The natural grounds extend from this line for a distance of about 20 miles up the river to Stony Point and embrace all the territory between these points lying in the waters of New Jersey, or from the shore to the main ship channel, and contain an area of about 87½ square nautical miles, or 74,187 acres. It is not entirely covered with oyster beds, although there are, probably, few places where oysters can not be found. Beds of various sizes lie scattered all over this part of the bay. Some of them are large and afford ample space for dredging, while others are so small that a vessel can not dredge continuously upon them; but when she reaches the end of the bed the dredges are hauled in and she returns to the other end to begin again. These are called by the oystermen "one-haul places," and are frequented by small vessels, large ones requiring more room to operate profitably. From this vast field of natural oyster-grounds is obtained the greater part of the native seed oysters used for planting on the cultivated beds in Maurice River Cove and Delaware Bay.

The planting and cultivating industry of the cove as it now exists is practically the result of the progress achieved in oyster-culture in these waters in the past thirty years. During that period the oyster interests, chiefly of three counties of the State, viz, Camden, Cumberland, and Cape May—those of Cumberland greatly predominating in importance—have centralized at Maurice River Cove. Other counties are represented to a limited extent, the privileges of the waters being free to residents of all parts of the State choosing to avail themselves of them.

The oyster centers.—The oyster industry of Delaware Bay has its headquarters at Bivalve and Maurice River, two small villages situated on the west and east banks, respectively, of the Maurice River near its mouth. These places are the chief receiving and shipping points for the entire region and have become the greatest oyster centers of the State.

As an oyster-shipping center Bivalve takes precedence of all others in the State. During the busiest part of the season the quantities shipped daily reach at times as high as 40 carloads. The name

Bivalve has been recently given to this locality; it was formerly called Long Reach. Extending along the bank of the river for nearly a quarter of a mile is a row of oyster houses, some 25 in number (exclusive of stores and other buildings), provided with wharves and railroad platform.

A spur of the Central Railroad of New Jersey connects Bridgeton and a number of other localities interested in the oyster industry with Port Norris and Bivalve, furnishing convenient means of travel to the oystermen and shippers living in the various towns and villages along the line, and also speedy facility for transporting the oysters to market. The resident population of Bivalve is very small, there being only a few families. The large number of men who may be seen there pursuing their vocation come not only from all parts of Cumberland County, but from each of the other counties to which allusion has been made.

Bivalve is interesting in many respects. In all its appointments it is extremely characteristic of the industry to which it owes its existence. Formerly the nearest post-office, telegraph office, and not many years ago, railroad station also, were located at Port Norris, 1 mile distant. Now this unique business center has all of these conveniences, as well as many others. There are stores at which the oystermen may be furnished with clothing, supplies, outfittings, implements, etc., necessary to their occupation; blacksmith shops, where oyster dredges, chains, and various other appliances are made and repaired, and where a great deal of work in the line of ship smithing is done; and marine railways and dry dock conveniently located. The requirements of the large fleet of vessels centering here engaged in the oyster industry furnish employment to a considerable number of men in the various auxiliary trades incidental to it, especially through the winter and early spring, and to some extent during the entire year. But the work of repairing and painting vessels is not all done at Bivalve. So much of it requires attention at the same time that it would be impracticable to accommodate the whole fleet at this place. Consequently a number of other localities on Maurice River, and also at Cohansey and Dividing creeks, where many of the vessel-owners and captains live, are provided with marine railways and other facilities adapted to the needs of the oystermen.

Maurice River, which empties into Maurice River Cove, is a comparatively small stream, furnishing navigable communication to a number of towns and villages along its banks, as far inland as Millville, about 15 miles from its mouth. These localities are usually interested in the oyster business in one respect or another, either as places of residence of the oystermen and oyster-shippers, or as the hailing ports of vessels. The more important of those on the east side of the river, after leaving Millville, are Mauricetown, Dorchester, Leesburg, Heislerville, and the oyster-shipping center called Maurice River. From Bivalve the river pursues a winding course through the marshland to the cove. Looking toward the cove the view is at times rendered picturesque by the white sails of hundreds of oyster sloops sailing up and down through the marshes to and from the oyster-grounds, their dark hulls hidden by the tall reeds or intervening upland, and only the snowy sheets of canvas and the tall, tapering spars showing above the river bank. A large number of vessels owned at Port Norris and the various towns on either side of the river make their home port at Bivalve, while many others, owned in localities more remote, land their catch there, and for that reason, and also on account of the safe and convenient harbor facilities which it affords, seek it as a place of rendezvous.

Second in importance to Bivalve as an oyster-shipping center is Maurice River. It is the terminus of a branch of the West Jersey Railroad, which connects with the main line at Manumuskin. The shipping business at Maurice River is not so extensive as at Bivalve, but is constantly increasing.

About 20 miles farther up the Delaware River is Greenwich Pier, where within the past few years quite a large oyster-shipping trade has been established.

Regulations and methods.—In order to arrive at anything approximating a clear understanding of the methods now employed in the oyster industry of Maurice River Cove, it will be necessary to consider briefly the origin, growth, and some of the principal characteristic features of the system under which this fishery is conducted. At an early period the value of the oyster industry, not only as a means of support to a large number of the inhabitants, but as a source of wealth capable of extensive development, was recognized. In all the coast waters of the State oysters were abundant, but the larger areas of sea bottom in Delaware Bay that were richly populated with these mollusks were considered especially valuable and important. The improvement of these natural resources, therefore, became at an early date a question of much interest, and such steps as were deemed wise and proper by the people of those times for the care of the oyster beds were promptly taken. It is an interesting fact also that every effort put forth looking to the advancement of the industry in any particular locality, or throughout the entire State, was characterized by two great fundamental ideas or principles. These are, first, the preservation and care of the natural oyster beds in order to insure the continuance of an abundant supply; second, the protection of the interests of resident citizens of the State in their exclusive right to engage in the industry on terms of equality, unmolested by citizens of other States, and to the enjoyment of all benefits and emoluments arising therefrom. These two principles were embodied in the first act passed by the legislature of the State (then a province) relative to the oyster fisheries, and have been apparent in the intention of all subsequent legislation bearing on the subject covering a period of one hundred and seventy-five years. The act alluded to was passed in 1719 with the following preamble:

Whereas it is found by daily experience that the oyster beds within this province are wasted and destroyed by strangers and others at unseasonable times of the year, the preservation of which will tend to the great benefit of the poor people and others inhabiting this province.

The first section of the act following this preamble provided for a close-time season from May 10 to September 1 of each year, and the second section was directed against non-residents, making it unlawful for them, either directly or indirectly, to take any oysters or shells from the beds and put them on board any boat or vessel not wholly owned by residents of the province, under penalty of seizure and confiscation of the boat or vessel with all apparatus, together with the oysters that had been illegally taken. These provisions were broad enough to allow the use of proper methods necessary to the successful prosecution of the natural oyster fisheries, or the introduction of any good system of oyster-culture, and are at the same time sufficiently conservative, if strictly applied, to protect the rights of the citizens from infringement by citizens of other States or abridgment by unjust legislation.

Prior to 1856 operations in the Delaware River and Bay were confined almost exclusively to the natural beds. Considerable difficulty was experienced in protecting the beds from depredations committed by citizens of the neighboring States. In 1825 an incorporated stock company, known as the "New Jersey-Delaware Oyster Company," was formed, with a view to rendering the protection of the beds more effectual and improving the industry. This was the first organized effort that had been made in connection with the oyster industry in these waters. It failed, however, to accomplish the object desired, and its management was so unsatisfactory to the stockholders that the company soon became involved in litigation.

In 1856, by an act of the legislature, the planting of oysters in Maurice River Cove was authorized under regulations similar to those now in operation in Shark River. It is evident from the preamble of this act that during the long period of one hundred and thirty-seven years since the passage of the law of 1719, which was general in its application, little progress had been made in developing the great natural resources of this region, and no satisfactory system for regulating and conducting the industry on the broad lines above indicated had been crystallized. The disadvantages under which persons engaged in the business were then laboring were set forth by the preamble of this act as follows:

Whereas, it has been represented to the legislature of the State of New Jersey that Maurice River Cove, on the southern shore of the township of Downe, in the county of Cumberland, is particularly adapted to the growth of oysters, but that by reason of the interference of citizens of other States, and the want of more adequate protection to persons planting oysters therein, the same has become almost valueless as oyster-ground; now for the purpose of encouraging the planting and growth of oysters in said cove, and thus creating and confining at home a source of wealth which is now either undeveloped or enjoyed by citizens of other States.

The act was approved March 14, 1856, and one year, or until April 1, 1857, was allowed for making the preparations and arrangements necessary to render its provisions available to the oystermen. It provided that the board of chosen freeholders of the county of Cumberland should be authorized and empowered to occupy Maurice River Cove for oyster-planting purposes during a term of twenty years from the date of the passage of the act, within the following boundaries:

Beginning at low-water mark directly opposite East Point in the township of Maurice River, Cumberland County, and running thence a south course to the main ship channel; thence by a straight line to low-water mark directly opposite to Egg Island Point, in the township of Downe, in said county, and thence by low-water mark the several courses and distances of the shore bordering on said cove, and crossing the mouths of the several streams that empty into said cove, to the place of beginning.

The board of freeholders were further authorized to appoint one or more persons as commissioners, who should hold office for one year or until their successors were appointed, and whose duty it should be to make a survey of the grounds within the limits above prescribed (all natural oyster beds to be excepted), and file a plan of the same in the office of the county clerk; to lay off and mark by stakes such subdivisions of said grounds, not exceeding 10 acres each, as in their discretion would seem best designed to promote the planting and growth of oysters, provided, however, that navigation should not be obstructed and that no person should own more than 10 acres and no company more than 30 acres.

It was further provided that, after staking off the grounds in the manner aforesaid, the commissioners should lease or rent the same at public vendue to the highest bidder for a period of not less than one year or exceeding five years; but no person was eligible to bid on or lease grounds who had not been a resident of the State for six months.

The commissioners were also authorized to collect the rents due from the leases of oyster-grounds annually, and, after paying all necessary costs and expenses of discharging their duties and receiving such further compensation as the board of freeholders should agree they ought to have for their personal services from the proceeds arising from said rents, to pay the residue of the money, if any, to the board of freeholders, to be apportioned among the several townships of the county in the ratio of the county tax paid by each township, to be used in the support of the public schools. The commissioners were also required to make an annual report of their proceedings, submitting therewith a sworn statement of receipts and expenditures.

It was further provided that any person who should enter within the boundaries of grounds so leased without having first obtained the consent of the lessee in writing, or who should commit any trespass upon said grounds, should be liable to the party injured in treble damages for the first offense, to be recovered in an action of trespass; and for the second offense should be deemed guilty of a misdemeanor, and upon conviction should be punished by a fine not exceeding $100, or imprisonment not exceeding sixty days, or both. It was also the duty of the commissioners to enforce the law in preventing persons who were not residents of the State from obtaining grounds, and in protecting the rights of the lessees.

The oyster industry was apparently conducted under these regulations for a period of about fourteen-years, but the need of more adequate protection against depredations upon the planted grounds, which annually entailed considerable loss to the oystermen, was keenly felt. The laws then in existence for that purpose were embodied chiefly in an act passed April 14, 1846, entitled "An act for the preservation of clams and oysters," and the supplements thereto. These were general laws, and while they were sufficiently comprehensive in their provisions, they were, in some measure, rendered ineffectual, owing to the difficulty experienced in enforcing them. The fact was finally realized that legislation based upon abstract principles would not meet the requirements of the business and insure the growth and development of the industry; and that a more thorough organization of the interests of the oystermen was the only means by which existing laws could be enforced and the necessary degree of protection secured.

With this end in view, therefore, an act was passed by the legislature, March 21, 1871, entitled "An act for the better enforcement, in Maurice River Cove and Delaware Bay, of the act entitled 'An act for the preservation of clams and oysters,' approved April 14, 1846, and of the supplements thereto." By this act was created an organization known as the "Maurice River Cove and Delaware Bay Oyster Association," having for its object the protection of the oyster-grounds, natural and cultivated, in Delaware River and Bay and of the rights of resident citizens of the State in the lawful use of said grounds for the purpose of catching, planting, and growing oysters. Citizens of other States are excluded from sharing in the use of the oyster-grounds so far as may be considered practicable and desirable. In this regard, however, concessions have been made to citizens of Pennsylvania, who are permitted under certain restrictions to obtain licenses from the association and engage in the oyster business on equal terms with the residents of New Jersey.

The association operates in accordance with a system of State laws and is virtually the machinery of the State for regulating and controlling the oyster industry in these waters. During the twenty-three years of its existence its regulations have been changed and added to from time to time, as would best promote the interests of the oystermen. The captains and owners of all vessels having a license from the association to engage in the catching and planting of oysters constitute its membership. The members are authorized by law to meet on the third Monday in March of each year, at Port Morris, Cumberland County, and there organize by the election, by ballot, of three of their number as judges of election, and one as secretary, who shall keep a record of the meeting. They are further authorized to elect, by ballot, five of their number to be designated as the "Executive Committee of the Maurice River Cove and Delaware Bay Oyster Association," who shall hold office for one year, or until their successors are elected. At this annual meeting, also, is elected a "collector of the oyster fund," whose term of office is one year. The executive committee is invested with power to elect by ballot a "special officer," whose term of office continues or expires at the pleasure of the committee.

Originally the association had only two officers. These were the "special officer" and "collector." In 1875 an auditing committee was added to the official staff. In 1890 the name of this committee was changed, and it has since been called the "executive committee." The duties of the executive committee, in addition to appointing a "special officer," are substantially to superintend the affairs of the association, financial or otherwise, and present at the annual meeting an itemized report of the receipts and expenditures of all officers of the association. They are also empowered to fix the salary or compensation of the "special officer" and "collector"; to fill vacancies caused by death or resignation in either of those offices, and to fix the rate of the tax per ton to be assessed upon all vessels licensed by the association. It is the duty of the executive committee to investigate charges that may be made against captains or owners of boats or vessels found illegally dredging or tonging upon the staked-up grounds of oystermen regularly licensed to plant and catch oysters, and to revoke the license of boats or vessels found guilty of such offenses. The committee may also cause said boats or vessels to be seized by the special officer and prosecute the owners thereof before the courts. If the boat or vessel is condemned, it may be sold, together with all the dredges, tongs, furniture, and apparel, by order of the justice before whom the case is tried, who, after deducting the costs of the trial, is required to pay one-half of the remaining proceeds of the sale to the public-school fund of the State, and the other half to the collector of the oyster fund, for the use of the association. The captain or owner may also be tried and, upon conviction, subjected to a fine of $1,000, or imprisonment for two years at hard labor, or both, in the discretion of the court, one-half of the fine to be paid to the State school fund and the other half to the oyster association.

The duty of the special officer is to patrol the oyster-grounds and arrest all persons found violating the laws of the State relative to the oyster industry, whether the offenders are members of the association or not. The expenses incurred by the special officer in the performance of his duties are paid out of the oyster fund. He receives a salary of $500 per annum.

The duties of the collector of the oyster fund are, to issue a license to each and every captain or commander of a boat or vessel lawfully engaged in the business of catching, planting, and growing oysters in Maurice River Cove and Delaware Bay, and to collect the amount of tax assessed on the vessels by the association. He is also required to keep a book in which shall be recorded all licenses granted by him, together with the name and net tonnage of each vessel so licensed, and the names and places of residence of the owners. He is further authorized to pay all the expenses of the association, including the salaries or other compensation of its officers, and to make a report of the condition of the finances at each annual meeting, and to furnish to all the captains and owners of licensed vessels a printed list each year of the vessels licensed by the association, showing the name of each vessel, the name of her captain, and the number of her oyster-ground. For his services the collector receives 5 per cent of all moneys by him received and collected, and a fee of 25 cents for each license recorded. He is required to give bonds to the county clerk of Cumberland County in the sum of $2,000 for the faithful performance of his duties.

The financial requirements of the association are provided for by the assessment of a tax on the net tonnage of each vessel. This rate is fixed annually, and varies considerably from year to year. In 1892 the rate per ton was $1. In 1893 it was 75 cents, and in 1894, $1.50. Boats and vessels not exceeding 5 tons, U. S. custom-house measurement, are assessed $5. In this way a large sum of money is collected each year, but the law provides that, whenever at the end of any year the sum arising from the oyster fund, after all expenses have been paid, shall exceed $2,000, the collector shall pay the amount in excess of that sum to the treasurer of the State, to be applied to the school fund.* This provision went into effect in 1874, and is still in force. Prior to 1874 the annual amount of the oyster fund in excess of $1,000 was paid to the county clerk of Cumberland County, to be applied to the support of the schools of that county.

Every captain or commander of any boat or vessel engaged in the oyster business is required to take out a license, authorizing such captain and the boat or vessel of which he is in charge to catch, plant, and grow oysters on the flats and grounds of Delaware Bay and Maurice River Cove. This license is granted by the collector of the oyster fund upon the application of the captain, and is good for one year from the date of issue. On making such application, the captain must produce the enrollment papers of the vessel before the collector, and make oath that the vessel is to be regularly engaged in the oyster business and has not been purchased, hired, chartered, or in any way employed for the purpose of temporarily taking oysters from the natural oyster beds in Delaware Bay or Maurice River Cove. He is also required to make oath to the names of the owners, their places of residence, and their respective interest in such boat or vessel; also that he will at all times diligently aid in the enforcement of the laws of the State for the preservation of clams and oysters, and will promptly report to the special officer any knowledge he may obtain of the violation of said laws. If no doubt then exists in the mind of the collector relative to the good faith of the application, he reduces the statement to writing and places

* No funds from this source have been covered into the State treasury up to the date of this report.

it on file in his office. Then, upon payment by the captain of the amount assessed on the tonnage of his vessel, the license is issued. If, however, the collector entertains doubt as to the truthfulness of the statement, the license is refused and the application, with the oath and other papers accompanying it, are referred to the executive committee, who investigate the case and instruct the collector to issue or refuse to issue the license, as they may determine.

The oyster license entitles its holder to plant oysters in Maurice River Cove, and also to take oysters from the natural grounds of Delaware Bay for planting purposes. While licenses may be issued at any time of the year, they are generally taken out by the captains during the month of April. The fact that every man who holds a license is sworn, not only to obey the law, but also to render every assistance in his power for its enforcement, makes the protective character of the association very strong. Every licensed vessel has an oyster-planting ground in the cove. This ground bears a number, which is painted in black figures 18 inches long on white canvas, and attached to a buoy or stake. The number of the ground is entered on the license, and is painted in black figures, 18 inches long, in the middle of the vessel's mainsail on the starboard side and in the middle of the jib on the port side. The penalty imposed upon captains holding license for neglecting or refusing to thus number their grounds or vessels, after having been notified to do so by the special officer, is, for each offense, a fine not exceeding $200, or imprisonment in the county jail not exceeding six months, or both. The law also makes it imperative that every vessel or boat engaged in the business shall have a license. Any captain or owner found guilty of taking or planting oysters without a license may be punished by a fine not exceeding $200, or by imprisonment not exceeding one year, or both; and any vessel employed in the commission of such an offense may be seized and sold, with all her apparatus, and the proceeds of the sale, after deducting costs of the court, shall be paid to the collector of the oyster fund. The penalties for engaging in the business without a license and for illegal dredging are so severe, and the means for enforcing the law so efficient, that these offenses are seldom committed. Vessels propelled by steam, whether wholly or in part, are not permitted to be licensed, nor in any way to engage in the business.

It is also unlawful for any person who has not been a resident of the State for six months next preceding to plant and grow oysters in any of the rivers or bays of the State, and any oysters or shells planted by non-residents become public property and may be taken by the resident citizens. Persons so offending are also subject to a fine not exceeding $500, or imprisonment not exceeding one year, or both. This provision makes it necessary for the captains of all licensed vessels to be residents of the State, but does not preclude the hiring of non-residents as crews on vessels. A considerable number of the licensed vessels are owned in Philadelphia and other places outside the State, but in such cases the captains are residents of New Jersey and are the nominal owners and proprietors of the oyster-grounds occupied by them. In this way the law is evaded. The law further provides that oysters shall not be taken from the natural oyster beds of New Jersey and planted in the waters of any other State. It is, however, well known that vessels owned in Philadelphia procure large quantities of seed oysters annually from the natural beds in New Jersey and plant them in the waters of the State of Delaware. The penalty for violating this provision is a fine not exceeding $200, or imprisonment not exceeding one year, or both; but the law on this point has never been enforced against members of the association, for the reason, apparently, that no one desires to enforce it.

The season for taking oysters from the planted areas and for marketing them begins September 1 and continues until June 15, following; that for taking oysters from the natural beds for planting purposes begins April 1 and continues until June 15. During the months of June, July, and August it is unlawful to take oysters for any purpose whatever from certain natural beds in Maurice River Cove and in the creeks along the shores of Cumberland County, known severally as the East Point beds, Andrews Ditch beds, the beds at the mouth of Dividing Creek and Oranoke Creek, and in creeks where there is a natural growth of oysters which become exposed at low tide. These beds are also exempted from dredging.

During the latter part of March all necessary preparations for beginning the work of catching natural oysters from the public beds and planting them on the cultivated areas in Maurice River Cove are completed. The vessels usually leave port on the 31st of March, providing that day does not fall on Sunday, in order to be on the grounds and ready to begin work at sunrise on the morning of the 1st of April. The law prescribes that oysters shall not be taken before sunrise nor after sunset, nor on Sunday. The business of dredging seed oysters is prosecuted vigorously until the 15th of June, when the season ends. The oysters and shells are dredged up from the beds or natural reefs together, and are loaded on the decks of the vessels. No "culling" or separating of the loose shells from the oysters is done. The culling law, which prohibited all persons from taking away any old shells which could be separated from the oysters without injuring them, or any other materials which might be useful to the beds for the young oysters or "spat" to adhere to, was unfortunately repealed in 1877. This law made it compulsory for the oystermen to cull out, or separate from the oysters, all the old shells and throw them back upon the beds. Since that law was repealed the oysters and shells have been taken together and planted in the cove.

Naturally, the proportion of oysters to the entire quantity of oysters and shells in each deck load becomes smaller as the season advances. According to the estimates of the oystermen, the number of bushels of shells annually taken from the beds during the planting season considerably exceeds that of the oysters. These shells are not altogether useless for planting. Many of them are covered with small or "blister" oysters, which are sometimes not larger than a finger nail. These, if they live, will in time grow to marketable size. Shells that do not have oysters on them are also valuable, especially when planted on soft bottom, for rendering the beds sufficiently hard to bear oysters.

The size of the deck loads are estimated to vary from 100 to 500 bushels, according to the capacity of the vessel and the abundance or scarcity of the oysters. When a vessel is loaded she carries her freight to the cultivating grounds in Maurice River Cove, where the oysters are "thrown off" (overboard) on the oyster lots with shovels in such a manner as to scatter them over the grounds. This process is called "planting" oysters. It is customary during the planting season for the vessels to leave port on Monday morning and remain at work until Friday or Saturday afternoon, unless compelled to seek shelter from storms. The number of deck loads taken by each vessel ordinarily varies from 20 to 40.

Table showing the estimated quantity and value of shells planted in Maurice River Cove in 1889–1892 taken by dredging vessels, belonging in the counties named, in connection with the collection of seed oysters during the planting season.

Counties.	1889.		1890.		1891.		1892.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Atlantic	3,000	$120	4,500	$180	1,500	$60	4,000	$160
Cape May	3,000	120	4,000	160	4,000	160	4,000	160
Cumberland	612,850	24,514	851,875	34,065	943,520	37,740	1,393,450	55,665
Gloucester	2,000	80	2,000	80	....	....	2,900	116
Camden	81,200	3,048	94,170	3,567	116,900	4,476	187,100	7,484
Total	702,050	27,882	956,545	38,052	1,065,920	42,436	1,591,450	63,585

After the oysters are planted they are allowed to remain undisturbed on the beds from two to four years to give them time to grow large enough for market. They are sometimes shifted, before being taken up for market, from the grounds where they were first planted to other grounds, in order to facilitate their growth and fattening.

The season for marketing oysters is a busy period. Large numbers of vessels may be seen in favorable weather dredging oysters from the cultivated areas. The oysters are hauled up by the dredges and placed on the vessel's deck, where they are culled, or separated, chiefly into two grades, the large ones and the small ones. The large oysters are called "primes" and the small ones "cullens," or "cullings." These are placed in separate heaps on the deck, and the shells, together with such oysters as are unsuitable for market, are shoveled overboard upon the beds again. When the day's work is finished the oysters are carried to Bivalve or Maurice River, where they are put into large floats, which are so arranged as to admit the water. They are left in the floats for a period sufficiently long to allow them to "drink" the brackish water of the river, which makes their meat white and adds to their appearance of fatness.

The oysters are removed from the floats by men whose especial duty it is to prepare them for shipment. These are termed "scowmen," or "scow gangs." The scowmen count out the oysters into baskets and put them in sacks and barrels. The baskets hold 200 "cullens" or 100 "primes," or, approximately, one-half bushel. It is generally considered that 400 "cullens" or 200 "primes" make one bushel. A sack will usually hold from 600 to 700 "primes," or about twice that number of "cullens." The barrels are said to hold about the same number as the sacks. When this work is done the oysters are handed over to the shippers, who purchase them from the oystermen or catchers. The shippers furnish the sacks and barrels, and the owners of the oysters pay the scowmen for their work at a rate per thousand for the number of oysters handled. The prices which the oystermen receive from the shippers have gradually increased during the past few years. In 1888 the price per 1,000 oysters was $5 for "primes" and $2 for "cullens." In 1892 it was from $6.50 to $7 for "primes" and $2.50 for "cullens. They are all sold by the thousand. About one-third of the entire quantity in number are "primes" and two-thirds are "cullens," which would make an equal number of bushels of each grade. The catch of almost the entire fleet of vessels is landed at Bivalve and Maurice River for shipment by rail. At the two places combined there were, in 1892, 36 firms, large and small, engaged in the shipping business. A few of the vessels carry their oysters to Philadelphia, or elsewhere, to market. The following table illustrates the extent of the oyster trade in the years 1889, 1890, 1891, and 1892:

Wholesale oyster trade of Maurice River Cove, New Jersey.

Items.	1889.	1890.	1891.	1892.
Number of firms	23	26	31	36
Persons engaged:				
Proprietors	34	38	46	51
Employés	91	104	117	125
Wages paid	$26,942	$30,375	$32,573	$35,080
Value of property	$28,825	$31,990	$37,095	$41,159
Cash capital	$178,500	$191,500	$211,500	$232,500
Oysters handled:				
Primes ... number	64,718,804	71,850,388	70,025,373	77,744,362
Cost	$340,353	$402,258	$418,724	$466,786
Cullens ... number	158,298,228	169,140,907	182,817,770	192,171,762
Cost	$327,556	$385,371	$453,718	$480,342
Total oysters ... number	223,017,032	240,991,295	252,843,143	269,916,124
Cost	$667,909	$788,129	$872,442	$947,128
Selling price	$760,030	$840,228	$962,929	$1,050,830

The shipments of oysters from Bivalve in the years 1889–1893 are shown by months in the following table. For these valuable and accurate data the Commission is indebted to Mr. W. E. Minor, auditor of freight traffic of the Central Railroad Company of New Jersey. The same gentleman has also furnished the accompanying statement of oyster shipments from Greenwich Pier, in Cumberland County, which come largely from grounds in Delaware Bay belonging to the State of Delaware.

Table showing by months the number of sacks and barrels of oysters shipped from Bivalve, New Jersey, in 1889–1893, via the Central Railroad of New Jersey.

Months.	1889.		1890.		1891.		1892.		1893.	
	Sacks.	Barrels.	Sacks.	Barrels.	Sacks.	Barrels.	Sacks.	Barrels.	Sacks.	Barrels.
January	2,194	1,594	7,917	3,468	5,032	3,954	6,255	2,889	1,065	460
February	1,168	1,151	3,424	2,149	4,441	2,837	5,602	2,643	1,425	741
March	1,726	1,040	2,782	2,187	5,428	2,651	3,936	1,741	5,919	2,705
April	1,726	403	2,768	1,088	3,856	1,048	5,859	1,233	8,359	2,007
May	5,407	689	7,201	994	9,087	548	8,871	677	10,216	872
June	3,071	261	3,113	278	5,039	189	2,696	211	4,257	254
July	73	6	464	2	519	18	1,239	79	142	3
August	....	....	347	23	461	8	1,358	47	263	7
September	25,730	3,513	32,761	4,576	20,572	3,918	30,675	3,728	25,329	3,553
October	32,598	5,821	40,274	7,942	32,447	8,722	38,261	5,521	30,428	4,984
November	27,766	6,415	36,599	8,346	32,816	5,751	31,154	5,978	25,611	4,008
December	17,322	5,351	16,856	7,113	18,735	5,526	21,062	5,905	10,356	2,697
Total	118,781	26,244	154,506	38,166	138,433	35,170	156,971	30,652	123,370	22,291

Table showing by months the number of sacks and barrels of oysters shipped from Greenwich Pier, New Jersey, in 1889–1893, via the Central Railroad of New Jersey.

Months.	1889.		1890.		1891.		1892.		1893.	
	Sacks.	Barrels.	Sacks.	Barrels.	Sacks.	Barrels.	Sacks.	Barrels.	Sacks.	Barrels.
January	....	....	117	125	20	....	2,083	....	641	23
February	....	....	89	124	103	....	1,319	33	1,183	22
March	....	....	37	59	129	....	265	....	2,887	46
April	....	....	278	31	281	3	365	2	1,058	73
May	....	....	51	....	421	....	270	6	1,048	21
June	....	....	....	....	55	....	....	....	144	....
July	....	....	....	....	....	....	....	....	....	....
August	....	....	....	....	....	....	....	....	....	....
September	578	47	2,589	35	5,037	9	9,708	69	6,904	261
October	1,886	98	2,623	97	5,918	26	10,094	336	8.544	123
November	1,391	217	1,179	6	3,196	41	8,134	146	7,779	147
December	752	125	272	1	2.873	11	5,820	64	2,845	7
Total	4,607	487	7,235	478	18,043	90	38,058	656	33,033	723

While the shipment of oysters continues throughout the entire year, except July and August, the quantities are less in May and June and during the extreme cold weather in the winter, and greatest in September, October, and November. If the winter chances to be severely cold, as it was in 1892–93, so that the river is frozen over, the business of harvesting the oyster crop is, to some extent, interfered with and operations temporarily suspended. The vessels then lay anchored in the stream to await more favorable conditions. There is also a lull in the shipping business during the month of March, when the vessels undergo such repairs as may be necessary, and are fitted preparatory to entering upon the work of the seed-gathering season on the natural beds, which begins on the 1st day of April. At such times of the year the greater part of the fleet is moored in the river. The vessels lie in rows close beside each other on both sides of the stream, leaving only a narrow passage open along the main channel, so that a person might walk a long distance across their decks by stepping from one to another. The sails are furled. topsails clewed at the topmast head, and the scene presented is that of a veritable forest of spars. But as spring draws near, each day brings increasing signs of activity and fewer vessels are to be seen at their moorings. There is much labor to be done on the cultivated grounds before the planting season begins. The storms of winter, and the ice floes which frequently occur with the approaching spring, carry away many of the stakes and buoys that mark the oyster lots. These have all to be replaced, and 4 o'clock in the morning is not an unusual hour for the oystermen to be astir.

The oyster vessels.—The oyster industry of Maurice River Cove may be said to be exclusively a vessel fishery. Certain natural beds along the shores of Cumberland and Cape May counties are reserved for the use of persons operating in small boats and are not allowed to be planted or dredged upon, but the business done in this way is very limited. The planting business in the cove is conducted almost wholly by vessels ranging in size from 5 to 40 tons; a few small craft under 5 tons are also employed.

The number of vessels shown on the license list of the oyster association for 1892, which may be considered a representative year, is 456, of which 434 were registered at the custom-house and 22 were under 5 tons and therefore not required to register. The aggregate tonnage, exclusive of vessels under 5 tons, was 7,608.47. Of the total number of vessels, large and small, shown on the license list of the association for the year above named, 222 were sloops and 234 were schooners.

The home ports of these vessels—that is, where their permanent documents are obtained—are chiefly Bridgeton, Camden, Somers Point, and Philadelphia. Of the total number of tonnaged craft, 343 belong at Bridgeton, 42 at Camden, 31 at Philadelphia, 8 at Somers Point and at other ports in New Jersey, Delaware, and Maryland.

The typical oyster vessels are of light-draft and have a centerboard. They have a wide beam, with raking stem, projecting cutwater or "long head," wide square or elliptical overhanging stern, flaring sides, and designed to give as much deck room as possible for their size. They are strongly built and possess good sailing qualities, combined with large initial stability. They differ from the Chesapeake oyster schooner in having bulwarks. They have a flush deck, and a low but rather large cabin trunk, the latter being situated on the after part of the deck, as is usual in vessels of this size. The winders, with which the dredges are drawn up, stand near amidships. The sloops carry three sails—mainsail, jib, and gaff-topsail. The mast is tall and the topmast of medium length. The schooners carry a single jib instead of a double-head rig. They also have tall masts and one topmast of moderate length. The light sail ordinarily carried is a main gaff-topsail. Many of the vessels now in use were built expressly for the business. They are provided with sufficient cabin room to accommodate a crew of 3 to 7 men. An estimate of their adaptability for the occupation in which they are employed was summed up by an intelligent oyster captain of the locality in the following expression: "There is no better vessel in the United States for a man to get his living in." They vary in cost, when new, from about $1,000 to $5,000 each.

The following list comprises the vessels licensed to engage in the oyster business by the Maurice River Cove and Delaware Bay Oyster Association in 1892. The names, rigs, tonnage, and home ports of the vessels are given. The number of vessels here shown will be found to be in excess of that reported in the general statistics appended, for the reason that the latter include only the vessels owned in the State, while the list contains some vessels belonging in Philadelphia and also a number of craft of less than 5 tons burden, which are properly classed as boats in the statistical tables:

List of oyster vessels of Maurice River Cove.

[Vessels designated with asterisk (*) are under 5 tons burden and not documented at custom-house.]

Name of vessel.	Net tonnage.	Rig.	Where documented.
Anna B	(*)	Sch	
Anna M	9.92	Slp	Bridgeton.
Anna Maria	21.89	Sch	Do.
Anna Worrel	27.83	Sch	Camden.
Anna M. Harris	26.30	Sch	Bridgeton.
Anna M. Robbins	24.43	Sch	Do.
Anna R. Ludlam	14.58	Sch	Do.
Anna W. Neal	15.72	Sch	Camden.
Annie Cooney	23.32	Sch	Philadelphia.
Annie Douglass	11.82	Slp	Bridgeton.
Annie Neary	8.89	Slp	Do.
Annie C. Moore	25.91	Sch	Do.
Annie H. Carey	7.83	Slp	Do.
Archie Mason	7.51	Slp	Camden.
Aurora	15.29	Slp	Bridgeton.
A. Hulings	7.90	Slp	Do.
A. M. Parris	7.75	Slp	Do.
A. S. Mulford	23.57	Sch	Do.
Abram S. Bird	14.10	Slp	Camden.
Acasta	13.27	Slp	Bridgeton.
Accommodator	(*)	Sch	
Ada C. Shull	32.90	Sch	Bridgeton.
Addie V	7.93	Slp	Do.
Addy Lee	6.29	Slp	Do.
Admiral	39.27	Sch	Camden.
Agnes	23.17	Sch	Bridgeton.
Albatross	9.22	Slp	Do.
Albert G. Mulford	14.75	Sch	Do.
Albert S. Crockett	13.58	Sch	Do.
Alice M	13.92	Sch	Do.
Alice C. Ogden	32.68	Sch	Do.
Almedia	20.43	Sch	Do.
Almira Cox	17.58	Sch	Do.
Alphonso	23.27	Sch	Camden.
Amanda B	9.04	Slp	Bridgeton.
Amanda B. Lore	20.24	Sch	Do.
Amanda and David	13.29	Slp	Do.
Ann Virginia	11.59	Slp	Do.
Baltimore	21.27	Sch	Camden.
Bay Queen	18.51	Sch	Bridgeton.
Belle	15.73	Sch	Do.
Belle Sage	9.60	Slp	Do.
Bertha S	(*)	Slp	
Bertha and Stella	23.59	Sch	Bridgeton.
Bessie and Lizzie	7.54	Slp	Do.
Beulah and Mary	11.19	Slp	Do.
Bicycle	15.41	Slp	Do.
Black Bird	7.61	Slp	Do.
Boyd H. Sheppard	30.62	Sch	Do.
Breeze	6.34	Slp	Do.
C. B. Mason	6.77	Sch	Do.
C. M. Howell	13.62	Slp	Do.
C. and H. Elmer	10.82	Slp	Do.
C. W. and S. Peace	20.82	Sch	Do.
Callena	11.99	Slp	Do.
Calvin Dilks	24.34	Sch	Do.
Caroline	16.92	Sch	Do.
Caroline H. Mears	30.46	Sch	Do.
Carrie Cawman	(*)	Slp	
Carrie Egner	7.67	Slp	Somers Point.

List of oyster vessels of Maurice River Cove—Continued.

Name of vessel.	Net tonnage.	Rig.	Where documented.
Carrie Haley	13.21	Sch	Bridgeton.
Carrie M. Edwards	6.22	Slp	Do.
Cashier	23.27	Sch	Do.
Cecilia B. Sheppard	28.49	Sch	Do.
Charlie Smith	18.92	Sch	Do.
Christian Lloyd	9.97	Slp	Camden.
Clara H	(*)	Slp	
Claud Clunn	(*)	Slp	
Claude	10.72	Sch	Camden.
Clipper	25.72	Sch	Do.
Clipper	23.04	Sch	Do.
Colfax	10.50	Sch	Bridgeton.
Columbia	14.53	Sch	Tuckerton.
Cora Belle	5.51	Slp	Bridgeton.
Cornelius Britton	23.83	Slp	Do.
Cygnet	13.98	Sch	Do.
D. Corson, jr	18.72	Sch	Do.
D. C. Adams	28.12	Sch	Do.
D. P. Mulford	25.65	Sch	Do.
D. W. McLean	17.27	Slp	Do.
Daniel F	14.07	Slp	Do.
Daniel Sharp	19.80	Sch	Camden.
Daniel A. Davis	21.82	Sch	Philadelphia.
Daniel B. Harris	14.21	Sch	Bridgeton.
Dart	10.49	Slp	Do.
David R. Lake	22.80	Sch	Do.
David and Ellen	(*)	Slp	
Dawning Light	22.62	Sch	Bridgeton.
Detector	16.23	Sch	Do.
Dolphin	12.36	Slp	Perth Amboy.
Dove	21.09	Sch	Bridgeton.
Dove	8.96	Slp	Do.
Dowitcher	7.32	Slp	Do.
Druzilla B. Lee	13.36	Sch	Do.
E. Fowler	32.16	Sch	Bridgeton.
E. B. Fithian	24.23	Sch	Do.
Echo	5.82	Slp	Do.
Eden	38.87	Sch	Philadelphia.
Edison	13.54	Slp	Bridgeton.
Edmund S. Conner	19.51	Sch	Camden.
Edmund S. C. Guyant	30.53	Sch	Do.
Edna M. Lore	32.03	Sch	Bridgeton.
Edna and Zadok	9.62	Slp	Do.
Edward C. Burton	14.32	Slp	Philadelphia.
Edward C. Vannaman, jr	15.10	Sch	Bridgeton.
Elanora	31.57	Sch	Do.
Eliza Carlisle	6.40	Slp	Do.
Eliza Ann Ballard	22.42	Sch	Camden.
Elizabeth B. Buckaloo	33.84	Sch	Bridgeton.
Ella D	13.35	Slp	Do.
Ella M	14.72	Slp	Do.
Ellen Weissinger	26.47	Sch	Philadelphia
Ellen A. Richardson	28.41	Sch	Camden.
Ellsworth	25.05	Sch	Bridgeton.
Elmira H. Lake	9.45	Slp	Do.
Eloise Moore	29.98	Sch	Camden.
Elsie	9.11	Sch	Bridgeton.
Elvina English	26.43	Sch	Do.
Elvina E. Schoch	23.49	Sch	Philadelphia.
Emily B	8.26	Slp	Bridgeton.
Emily Jane	16.47	Sch	Camden.
Emily Smith	12.44	Slp	Bridgeton.
Emily J. Mulford	(*)	Slp	
Emily R. Green	13.34	Slp	Bridgeton.
Emily and Rebecca	10.25	Slp	Do.
Emlen Hewes Green	8.98	Slp	Do.
Emma Collins	19.88	Sch	Do.
Emma Rebecca	8.18	Slp	Do.
Emma A. Walsh	23.88	Sch	Camden.
Emma C. Lore	17.60	Sch	Do.
Ephraim Mulford	32.02	Sch	Do.
Equal Rights	23.99	Sch	Do.
Equator	7.97	Slp	Do.
Ethel Jerrell	23.20	Sch	Bridgeton.
Etta	10.16	Slp	Do.
Etta B	24.63	Sch	Do.
Eva	7.98	Slp	Do.
Eva M. Carlaw	8.33	Slp	Do.
Eva M. Robbins	7.22	Slp	Do.
Excel	8.48	Slp	Do.
Falcon	20.22	Sch	Do.
Fayette N. Bradford	31.25	Sch	Do.
Fearless	9.87	Slp	Do.

List of oyster vessels of Maurice River Cove—Continued.

Name of vessel.	Net tonnage.	Rig.	Where documented.
Flying Fish	25.24	Sch	Camden.
Forest G. Howell	22.16	Sch	Bridgeton.
Frances S. Du Bois	21.99	Sch	Do.
Francis Dow	15.59	Slp	Do.
Francis R. Lake	11.86	Slp	Do.
Freddie Liber	5.79	Slp	Do.
Freeman	13.25	Sch	Somers Point.
Friendship	9.29	Slp	Bridgeton.
G. Gandy	27.66	Sch	Camden.
G. W. Crist	20.72	Sch	Bridgeton.
Galileo	7.64	Slp	Do.
Gem	9.28	Slp	Do.
Gem	(*)	Slp	
Gen. McClellan	22.62	Sch	Philadelphia.
George Green	20.56	Sch	Camden.
George M. Ackerly	14.27	Slp	Bridgeton.
George W. Childs	36.04	Sch	Do.
George and Morton	15.84	Slp	Do.
Georgia A. Maxson	12.22	Slp	Do.
Geranium	12.26	Slp	Do.
Gertrude	7.70	Slp	Do.
Glide	9.15	Slp	Do.
Glide	11.44	Slp	Do.
Globe	10.51	Slp	Do.
Golden Light	15.20	Slp	Somers Point.
Gratitude	22.27	Sch	Bridgeton.
Grover Cleveland	33.99	Sch	Camden.
Gussie	(*)	Slp	
Gypsy	16.11	Slp	Bridgeton.
H. H. Meekins	18.20	Sch	Philadelphia.
H. K. Mulford	15.97	Slp	Bridgeton.
H. L. Steelman	18.27	Sch	Do.
Hannah Mulford	17.32	Sch	Do.
Hannah M. Bell	5.99	Sch	Do.
Hannah and Ida	38.65	Sch	Do.
Harriet Elmer	11.43	Slp	Do.
Harriet E. Loundes	12.02	Slp	Do.
Harry C	7.57	Slp	Do.
Hattie B	10.69	Slp	Camden.
Hattie B	5.28	Slp	Bridgeton.
Hattie Jenks	10.15	Slp	Do.
Hattie B. Robbins	17.30	Sch	Do.
Hattie R. Johnson	27.67	Sch	Do.
Hattie W. Mills	13.42	Slp	Do.
Helen Hurd	11.59	Slp	Do.
Helen and Sallie	15.52	Sch	Do.
Henrietta C	24.39	Sch	Do.
Henry Kreinco	7.92	Slp	Do.
Henry S. Lutts	9.58	Slp	Do.
Henry and Howard	13.60	Slp	Do.
Horace S. Peed	13.51	Slp	Do.
Howard T. Leach	9.81	Slp	Do.
Hunter	13.32	Slp	Somers Point.
I. T. Nichols	7.96	Slp	Bridgeton.
Ida	7.38	Slp	Do.
Ida Belle	5.34	Slp	Do.
Ida Florence	9.13	Slp	Do.
Ida Marts	23.78	Sch	Do.
Ida May	11.04	Slp	Do.
Idelia	9.59	Slp	Do.
Industrious M	8.91	Slp	Do.
Irene	6.96	Slp	Camden.
Isaac W. Norris	21.13	Sch	Bridgeton.
John B. Hegeman	22.63	Slp	Do.
John C. Hand	6.90	Slp	Do.
John P. Prifold	18.61	Sch	Do.
John S. Johnson	12.41	Slp	Do.
John S. Myers	24.09	Sch	Philadelphia.
John W. Paul, jr	8.66	Slp	Bridgeton.
John W. Willing	22.42	Sch	Philadelphia.
Jordan	24.62	Slp	Somers Point.
Josiah S. Newcomb	30.97	Sch	Bridgeton.
Julia B	24.67	Sch	Do.
Julia A. Cooke	9.88	Slp	Do.
Julia A. Jones	40.15	Sch	Baltimore.
Julia A. Newcomb	31.89	Sch	Bridgeton.
Julia A. Reid	10.84	Slp	Do.
J. Deever	22.20	Sch	Do.
J. Gordon	10.32	Slp	Do.
J. F. Armstrong	8.27	Slp	Somers Point.
J. F. Penny	13.80	Slp	Bridgeton.
J. L. Thomas	7.88	Slp. y	Do.
J. O. Smith	17.15	Slp	Do.

List of oyster vessels of Maurice River Cove—Continued.

Name of vessel.	Net tonnage.	Rig.	Where documented.
J. R. Chambers	30.40	Sch	Bridgeton.
J. W. Fennimore	15.07	Sch	Do.
J. and P. Bradford	14.07	Sch	Do.
Jacob Rivell	33.83	Sch	Do.
James Howard	10.93	Slp	Do.
James Mulvey	17.14	Slp	Do.
James D. Godfrey	15.15	Sch	Do.
James H. Nixon	30.66	Sch	Do.
James P. Nieukirk	24.66	Sch	Camden.
Jane A. Smith	15.36	Sch	Bridgeton.
Jennie Reeves	15.05	Sch	Do.
John Bierly	26.05	Sch	Philadelphia.
John Buzby	12.20	Slp	Bridgeton.
John Guyant	34.30	Sch	Philadelphia.
John A. English	24.25	Sch	Do.
Kate and Melissa	13.05	Slp	Bridgeton.
Kate and Sarah	14.53	Sch	Do.
Katie C	24.67	Sch	Do.
Katie Burton	25.92	Sch	Philadelphia.
Kensington	15.48	Slp	Camden.
Knight	(*)	Slp	
L. Drew	8.36	Slp	Bridgeton.
L. McMurray	33.04	Sch	Baltimore.
La Fayette	25.13	Sch	Philadelphia.
Lady of the Lake	20.61	Sch	Do.
Laura G	12.47	Slp	Bridgeton.
Laura May	5.69	Slp	Do.
Laura Parsons	22.36	Sch	Do.
Laurel	14.88	Slp	Do.
Lavinia	29.57	Sch	Camden.
Lavinia V. Tall	31.46	Sch	Philadelphia.
Lela Boyle	22.52	Sch	Bridgeton.
Leira	6.50	Slp	Camden.
Lena G. Bateman	13.94	Slp	Bridgeton.
Lena and Lina Cosier	7.98	Slp	Do.
Lewis Hess	28.94	Sch	Philadelphia.
Liffey	9.21	Slp	Bridgeton.
Lillie B	11.54	Slp	Perth Amboy.
Lillie D	15.32	Sch	Bridgeton.
Lillie Anderson	17.74	Slp	Do.
Lillie Smith	6.04	Slp	Do.
Linnet	5.53	Slp	Do.
Little Giant	8.58	Slp	Do.
Lizzie	6.92	Slp	Do.
Lizzie	10.42	Slp	Do.
Lizzie Burt	26.16	Sch	Do.
Lizzie May	10.16	Slp	Do.
Lizzie J. Robbins	15.73	Sch	Do.
Lizzie M. Weaver	31.75	Sch	Do.
Lorell H. Sharp	7.46	Slp	Do.
Lottie V	11.61	Slp	Do.
Lucius and Bessie	26.03	Slp	Do.
Lucy	13.75	Sch	Do.
Lucy P	10.41	Sch	Do.
Lucy Hopkins	9.03	Slp	Do.
Lucy Turner	15.46	Slp	Do.
Lucy and Willie	16.70	Sch	Do.
Luther Bateman	32.60	Sch	Do.
Lydia B	14.10	Sch	Do.
Lydia Compton	(*)	Slp	
Lydia and Sylvia	14.66	Sch	Bridgeton.
M. P. Ogden	9.98	Slp	Do.
M. and W. Robinson	13.04	Slp	Do.
M. D. and Bella Mulford	28.63	Sch	Do.
Mabel E. Lore	15.64	Slp	Do.
Madalene	7.82	Slp	Do.
Madora and Emma	8.53	Slp	Do.
Maggie D	9.36	Sch	Do.
Maggie Daniels	20.79	Sch	Do.
Maggie L. Tolen	23.58	Sch	Do.
Maggie and Ida	10.76	Slp	Do.
Magnolia	11.74	Slp	Do.
Magnolia	16.12	Sch	Do.
Mail	12.70	Slp	Do.
Marcus L. Godfrey	22.96	Sch	Do.
Maria and Frances	15.84	Sch	Do.
Marion Mayne	15.59	Sch	Do.
Martha Ann	17.89	Slp	Do.
Martha C. Campbell	14.49	Sch	Do.
Martin Anderson	30.74	Sch	Do.

List of oyster vessels of Maurice River Cove—Continued.

Name of vessel.	Net tonnage.	Rig.	Where documented.
Mary B	26.01	Sch	Bridgeton.
Mary Agnes	5.79	Slp	Do.
Mary Alice	12.73	Slp	Do.
Mary Carman	11.37	Slp	Do.
Mary Elizabeth	16.45	Sch	Philadelphia.
Mary Emma	9.52	Slp	Bridgeton.
Mary Meerwald	16.38	Slp	Do.
Mary A. Bickley	12.57	Slp	Do.
Mary A. Hand	31.87	Sch	Do.
Mary A. Rogers	22.83	Sch	Do.
Mary C. Sharp	14.80	Slp	Do.
Mary E. Davis	7.02	Slp	Do.
Mary F. Sheppard	30.46	Sch	Do.
Mary H. Lake	30.24	Sch	Do.
Mary L. Byrd	21.75	Sch	Do.
Mary L. Cooper	9.98	Sch	Wilmington.
Mary L. Robbins	15.07	Slp	Bridgeton.
Mary W. Mears	32.42	Sch	Do.
Mary Ann Brown	19.98	Slp	Do.
Mary and Eliza	9.68	Slp	Do.
Mary and Margaret	20.27	Sch	Do.
Mary and Violet	(*)	Slp	
May Bateman	15.62	Slp	Bridgeton.
Mattie B	10.37	Slp	Do.
Mattie Holly	7.64	Slp	Do.
Mattie B. Sheppard	14.01	Slp	Do.
Mattie L. Ford	30.59	Sch	Do.
Mattie P. Flavell	32.23	Sch	Philadelphia.
Maud S	6.66	Slp	Somers Point.
Maud M. Robbins	13.30	Slp	Bridgeton.
May Flower	5.84	Slp	Do.
Melvina	33.18	Sch	Do.
Melvina Condiff	22.88	Sch	Philadelphia.
Messenger	22.17	Sch	Bridgeton.
Michael Martin	29.35	Sch	Camden.
Morris R. Lee	6.06	Slp	Bridgeton.
N. B. Smith	(*)	Slp	
N. R. Godfrey	24.46	Sch	Philadelphia.
Nancy L. Cosier	14.12	Slp	Bridgeton.
Nellie and Mary	20.79	Sch	Do.
Nellie and Mattie	22.21	Sch	Do.
Nettie and Lena	30.30	Sch	Camden.
New Jersey	26.65	Sch	Philadelphia.
North Star	19.10	Sch	Bridgeton.
O. P. Smith	18.26	Slp	Crisfield.
Ocean Queen	18.55	Sch	Philadelphia.
Octavis	(*)	Slp	
Oregon	12.33	Slp	Bridgeton.
Ospray	8.65	Slp	Newark.
P. Sheridan	(*)	Slp	
Paris C	6.06	Slp	Bridgeton.
Passport	10.81	Slp	Do.
Pathway	17.53	Sch	Do.
Pearl	15.10	Slp	Do.
Pearlla and Lelia	9.98	Slp	Do.
Percy B	(*)	Slp	
Philip Ford	31.20	Sch	Camden.
Phœbe B. Townsend	25.03	Sch	Bridgeton.
Pilot	8.01	Slp	Do.
Polka	15.74	Sch	Do.
Prize	27.18	Sch	Do.
Protector	29.96	Sch	Philadelphia.
Quickstep	8.94	Slp	Bridgeton.
R. Blackman	28.48	Sch	Do.
R. B. Walling	14.74	Slp	Do.
R. D. Bateman	28.03	Sch	Do.
R. E. English	12.91	Slp	Do.
R. K. Ward	31.54	Sch	Do.
R. S. Burney	23.72	Sch	Do.
Ray	10.28	Slp	Do.
Ray R. Newkirk	32.25	Sch	Camden.
Rebecca	15.32	Slp	Bridgeton.
Rebecca N	8.59	Slp	Do.
Rebecca C. Schoch	26.17	Sch	Philadelphia
Rebecca F. Brunyate	20.07	Sch	Bridgeton.
Rebie and Ella	14.00	Sch	Do.
Rescue	26.30	Sch	Philadelphia.
Rhoda B	12.33	Slp	Bridgeton.
Richard Vaux	23.40	Sch	Do.
Richard B. Jones	22.77	Sch	Do.
Robert Walter	32.72	Sch	Baltimore.
Robert F. Brattan	12.50	Slp	Bridgeton.
Robert T. Lore	31.56	Sch	Do.

List of oyster vessels of Maurice River Cove—Continued.

Name of vessel.	Net tonnage.	Rig.	Where documented.
Rollin S	11.43	Slp	Bridgeton.
Rosa B	9.25	Slp	Do.
Roxanna Hand	15.64	Sch	Do.
Ruby S	(*)	Slp	
S. C. Kemble	23.89	Sch	Bridgeton.
S. J. Delan	34.49	Sch	Philadelphia.
S. N. Howman	(*)	Slp	
Sabrina	13.75	Slp	Camden.
Sallie R. A	13.69	Slp	Bridgeton.
Sallie M. Burton	25.77	Sch	Do.
Samuel Hanners	9.93	Slp	Do.
Samuel Lake	25.00	Sch	Do.
Samuel C. Jacoby	32.16	Sch	Do.
Sarah Cox	10.86	Slp	Do.
Sarah A. Beckett	6.98	Slp	Camden.
Sarah A. Melson	25.42	Sch	Philadelphia.
Sarah C. Lee	12.85	Slp	Bridgeton.
Sarah M. Mulford	19.19	Sch	Do.
Sarah and Hannah	17.33	Slp	Do.
Sea Bird	7.96	Slp	Do.
Seaman's Bride	27.49	Sch	Camden.
Skipjack	(*)	Slp	
Star	31.20	Sch	Camden.
Starlight	17.68	Slp	Bridgeton.
Starlight	9.04	Slp	Wilmington.
Stella	11.54	Slp	Somers Point.
Stella C	(*)	Slp	
Sue	9.14	Slp	Bridgeton.
Sun	9.36	Slp	Do.
Sunlight	25.24	Sch	Do.
Susie B	(*)	Slp	
Susie C. Raynor	28.07	Sch	Philadelphia.
Sylvan Dell	14.21	Slp	Bridgeton.
T. B. Husted	25.73	Sch	Do.
T. C. Sheppard	(*)	Sch	
T. C. Ladow	23.62	Sch	Bridgeton.
Thomas A. Rogers	26.53	Sch	Camden.
Thomas R. Berry	9.48	Slp	Bridgeton.
Thomas S. Lee	12.14	Slp	Do.
Three Sisters	22.66	Sch	Do.
Tidal Wave	29.13	Sch	Do.
Trader	11.93	Slp	Do.
Trade Wind	6.00	Slp	Do.
Trio	17.78	Sch	Do.
Two Davids	10.27	Slp	Do.
Two Friends	9.42	Slp	Do.
Walter H. Hinson	14.78	Slp	Do.
Walter M. Johnson	24.66	Sch	Do.
Wanderer	25.59	Sch	Baltimore.
Water Lilly	11.94	Slp	Bridgeton.
Waters E. Fisher	13.05	Sch	Do.
Welcome	(*)	Slp	
White Wing	21.63	Sch	Bridgeton.
William Dennis	17.18	Slp	Do.
William Edwards	23.18	Sch	Camden.
William Pollock	11.52	Slp	Bridgeton.
William Shriver	15.48	Sch	Do.
William A. Brooks	12.93	Sch	Do.
William B. Stites	18.55	Slp	Do.
William C. Lore	30.26	Sch	Do.
William F. Cullen	31.38	Sch	Philadelphia.
William H. Berry	26.01	Sch	Bridgeton.
William H. Gatzmer	24.22	Sch	Philadelphia.
William H. Vanneman	9.80	Slp	Bridgeton.
William B. and William J. Carlisle	19.87	Sch	Do.
Willie Russell	12.38	Slp	Do.
Wood Duck	17.42	Sch	Camden.
Valentine Cosier	25.00	Sch	Bridgeton.
Vandalia	10.75	Sch	Do.
Vandalia	18.83	Sch	Camden.
Victory	10.16	Slp	Bridgeton.
Village Belle	26.85	Sch	Do.
Volant	24.97	Sch	Do.
Zeph. S. Conover	16.35	Slp	Do.

Recapitulation of Maurice River Cove oyster fleet by home ports and rigs.

Ports.	Number of vessels.			Tonnage.		
	Schooners.	Sloops.	Total.	Schooners.	Sloops.	Total.
Baltimore, Md	4		4	131.50		131.50
Bridgeton, N. J	159	187	346	3,547.90	2,064.46	5,612.36
Camden, N. J	33	9	42	825.87	91.94	917.81
Crisfield, Md		1	1		18.26	18.26
Newark, N. J		1	1		8.65	8.65
Perth Amboy, N. J		2	2		23.90	23.90
Philadelphia, Pa	31	1	32	805.19	14.32	819.51
Somers Point, N. J	1	7	8	13.25	87.28	100.53
Tuckerton, N. J	1		1	14.53		14.53
Wilmington, Del	1	1	2	9.98	9.04	19.02
Unclassified	3	21	24			
Total	233	230	463	5,348.22	2,317.85	7,666.07

Personnel, wages, etc.—The men who compose the crews of the vessels are usually native-born citizens of the State. They range from 16 to 50 years of age, the majority being from 25 to 40 years old. Those who live in the towns and villages throughout the counties of Cumberland and Cape May are generally experienced oystermen; but in the spring, when the demand for help is greatest, large numbers come from the northern part of the State and are frequently inexperienced in the business. The oyster captains term them "brickyard men."

Shipping agents sometimes come from Baltimore to engage berths for men from that city and offer to supply crews at reduced wages. The rate quoted for this class of help in the spring of 1893 was $17 per month. The regular oystermen have an unconcealed dislike for this kind of competition. The rate of wages customarily paid to experienced men is $35 per month for common hands and $50 per month, and upward, for captains. When the vessels are engaged in taking up oysters from the planted grounds for market, they do not ordinarily require more than from 4 to 6 men in a crew, including the captain, but this number is generally increased to from 5 to 7 men during the planting season in the spring.

The captains do not all work for wages; many of them own vessels; but in practically all of the localities directly interested in the oyster business there is a class of men who do not own vessels and who rely upon earning a living at "oystering" for wages by the month, either in the capacity of captains or as members of crews. They are, in oystermen's vernacular, termed "monthlies" or "monthly men." These men have acquired by long experience and training a thorough knowledge of all the details of the work, which gives them a decided advantage over others less experienced and enables them to command higher wages.

Dredging apparatus.—The apparatus used by each vessel consists chiefly of 2 winders, usually of iron, 2 dredge chains, and 2 dredges. As a matter of fact, nearly every vessel is supplied with 4 dredges, but only 2 are used at a time. The whole equipment for a vessel of the larger class costs, when new, about $100. The winders have 2 iron cranks and are operated by hand. The size of the dredges is limited by law to a tooth bar not exceeding 40 inches in length. The dredge chains, when in use, pass over an iron roller attached to the rail of the vessel.

Questions affecting the oyster industry of Delaware Bay.—One of the most serious questions affecting the oyster industry of Maurice River Cove and Delaware Bay at the present time is the depleted condition of the natural oyster-grounds. With the exception of possibly from 75,000 to 100,000 bushels of oysters obtained annually from the Chesapeake Bay for planting purposes, these grounds are the source from which the large quantities of seed oysters necessary to supply the great demand of the business, which has already reached proportions of no inconsiderable magnitude and is still quite rapidly increasing, are obtained. An idea of the rate of increase may be gained from the fact that in 1888 the number of vessels licensed by the oyster association was 385, in 1892 it was 460, and in 1893 it was 480, which is an average increase of nearly 16 vessels per year. While this rate of growth does not seem large, it nevertheless indicates the probability that in ten years, if the conditions continue to be equally favorable, about 160 vessels will be added to the fleet, and the demand for seed oysters correspondingly increased.

Of course there is a limit to the capacity of the resources now being utilized which would preclude the possibility of the indefinite continuance of any rate of growth, however small, in the business. The problem seems to be to preserve the proper relations between the supply and demand for seed oysters to an extent that will not only enable the maximum of prosperity to be reached, but also to be thereafter maintained.

For the past seventeen years, during the planting season, both the oysters and shells have been dredged from the natural beds in immense quantities. This process has resulted in lessening their productiveness and diminishing the abundance of seed oysters. While many of the oystermen claim that the crop of natural oysters is as large as it was twenty years ago, the fact that some means should be employed to increase the yield of the natural beds has been gradually forcing itself into recognition. Recently the two following propositions have been suggested: First, that the State assume control over Delaware Bay and close it for oystering purposes (so far as the natural beds are concerned) for a period of from three to five years, or less; second, that a rough-culling law be enacted, compelling all dredgers to throw the shells taken with the oysters back upon the beds.

Regarding the first proposition, there are a number of strong objections on the part of many of the oystermen. One of these objections is that to close the bay would throw about 2,000 men out of employment. It might also be urged that it would do no permanent good if the same destructive and wasteful methods were, at the expiration of the period, to be resumed.

The second proposition, that of enacting a culling law, would seem to be worthy of favorable consideration. If such a law were rigidly enforced and the shells not only thrown back into the water but returned to the beds in such a manner that they would be properly distributed, and not so as to accumulate in heaps, it is probable that in a very few years the present conditions would be vastly improved and the yield of oysters greatly increased. Such a law would also be in harmony with the system under which the oyster industry in this region is now being conducted. Were it practicable to apply both of these propositions, the benefit derived would no doubt be much greater than could be secured by either applied separately.

Another question which has recently assumed considerable importance is in relation to the granting or leasing by the State of riparian claims in lands under water lying along the shores of Delaware Bay, in the vicinity of Fortesque Cove, in the region which is reserved as natural oyster-grounds. It is claimed by the oystermen that natural oyster beds are embraced in the riparian claims, and that under the laws of the State relating to the oyster industry the oysters upon these natural beds can not become private property. The culminating struggle relative to the question was precipitated in the spring of 1893, when notice was given to the riparian owners of the intended action and a vessel was sent upon the disputed grounds to dredge oysters. In 1894, by a joint resolution of the legislature, a commission was appointed to investigate and report upon the differences existing between the oystermen and the riparian owners.

The following review of the present situation and the questions at issue is from the Philadelphia Press of May 21, 1894, and emanates from the Trenton, N. J., correspondent of that paper:

There is now the liveliest kind of a war on in south Jersey among the 3,000 oystermen. In consequence, from Camden to Cape May there is a general disturbance of commercial and social relations because of the row.

The courts were appealed to and are listening to the various attitudes of the case, but the legal process was too slow and the oystermen wanted the legislature to come to their rescue, which it did. Assemblyman Austin, of Bridgeton, who has several thousand oystermen as his constituents, introduced a joint resolution which created a special investigating committee to go to the oyster war and get the facts for the legislature.

This investigation is regarded as important because it gives official information that has been needed for years. Every session of the New Jersey legislature the oyster matter comes in in some form. There are 100 or more laws now on the statute books. Nothing has given so much trouble to lawmakers as the clam and oyster laws, because so few know the actual status of the industry. The report of this commission has become the most valuable contribution to the legislature of this session.

The most salient features of the report of the legislature are contained in the following statement:

"The extent and value of the oyster industry in Delaware Bay are not generally appreciated by the citizens of the State. The territory within the bay where oysters will naturally grow or can be profitably cultivated is, roughly speaking, about 200 square miles. Between 500 and 600 vessels, carrying crews of from 3 to 10 men each, are engaged in the business, and, as appears by the last census, the annual value of the oyster crop, including that of the western shore, is about $2,000,000. Fifty years ago, when the population was sparse and the means of communication limited, the business was restricted in extent. In early times it consisted in picking up oysters from the natural beds left exposed by the falling tide and catching them with tongs. About forty years ago the business was commenced of taking the young natural oysters and planting them upon the grounds in the deep waters of the bay, where they were left to grow until of marketable size.

"The places where the oysters were planted were marked off by stakes, and the lands thus selected were situated under the waters of the bay in Maurice River Cove. The title to the lands thus appropriated to the cultivation of oysters was in the State, and they were taken without any legislative permission. By a common consent of the persons engaged in this business, the staking out of unoccupied lands in Maurice River Cove and the planting of oysters thereon gave the holder exclusive right to the possession of the lands so appropriated, and the invasion of this right has always been vigorously resented. The territory thus set apart by common consent for the cultivation of oysters is in the vicinity of 50 square miles, or about 32,000 acres, in extent. These lands are held without compensation to the State, and no taxes are levied upon them, or upon the oysters cultivated thereon."

From the time the planting and cultivation of oysters commenced the territory thus used for the purpose has been confined to that part of Delaware Bay included in and adjacent to Maurice River Cove, a locality where, generally speaking, oysters do not naturally propagate. The great body of the bay north of the cove, extending for a distance of some 35 miles in length and of an average width of between 4 and 5 miles, constitutes the natural oyster beds and grounds where the oysters spawn and grow without cultivation. It has been the custom to dredge upon this latter territory for the seed oysters used for planting in Maurice River Cove.

By the twelfth section of the act approved March 8, 1882, it becomes unlawful to take oysters from any of the natural oyster beds or grounds in Delaware Bay north of a line running direct from Egg Island light-house to Cross Ledge light-house from June 15 to April 1 in the succeeding year. This legislative action confirmed the long-recognized custom of dividing the bay into two parts, all south of the line thus established being appropriated for the cultivation of oysters and the territory north of it being retained to secure natural seed oysters for planting purposes. This line was, by the act approved April 3, 1893, moved farther north to the mouth of Straight Creek, and is generally called the "southwest line."

A few miles north of the "southwest line" is what is known as Fortesque Cove, and in that vicinity grants or leases of lands under water have been made from time to time by the riparian commissioners of the State under the act approved March 31, 1869, and the supplement thereto. These grants or leases are 15 in number, 1 being made in 1879, 3 in 1886, 9 in 1892, and 1 in 1893. They embrace a frontage on the exterior line of 13,334$\frac{22}{100}$ feet, extend out from the shore an average length of 2,876 feet, and include about 973 acres of land under water, and the total amount of consideration paid the State therefor was $12,143.96. They were all made to owners of the upland adjoining high-water mark, who under the provisions of the eighth section of the riparian act are entitled to a grant or lease upon paying to the State such reasonable compensation or rental as the riparian commissioners may fix.

The occupation by private parties of these lands has been a matter of irritation and dissatisfaction to the men engaged in the oyster business as represented by the Oyster Association. They look upon the privilege of taking oysters from the bay north of the "southwest line" as a natural right. On the other hand, the riparian owners claim that, having purchased or leased these lands from the State in good faith and for a valuable consideration, they are entitled to the exclusive possession of them. The controversy culminated in the spring of 1893, when, under the advice of the counsel of the Oyster Association, and on notice to the riparian owners, a boat was sent upon these disputed grounds and a few oysters taken, the object being to raise an issue to be decided by the courts. The counsel of the association were desirous that the questions involved should be raised, through the advice of counsel elected to proceed by criminal process, and Capt. Chew, in command of the alleged trespassing vessel, was arrested under the tenth section of the act approved March 8, 1892, which makes it a misdemeanor to dredge or catch oysters upon an oyster bed duly staked out or belonging to any other person. The case was presented to the grand jury of Cumberland County at the October term, 1893, but no indictment was then found. At the January term, 1894, Capt. Chew was indicted, but the trial was postponed until the present May term.

The excitement has been increased because of the delay of the trial of Capt. Chew. Counsel of the Oyster Association, on March 19, advised the executive committee that the best way to settle the matter was for the men to peaceably take the oysters from the natural bed, and for those who claim them under riparian grants to resist and bring action at law. At the last annual meeting of the Oyster Association it voted to increase the tax on vessels to $1.50 per ton, so as to provide a fund to defend such members as should be prosecuted for dredging upon riparian grants. This will provide a fund of $6,000. It is, however, denied that the raids were authorized by the association, but the captains acted individually. The riparian owners gave notice that everybody would be prosecuted that raided the riparian lands. The sheriff was notified to summon a posse comitatus to protect property or the county would be held for damages. The sheriff secured a steam vessel and with posse proceeded to the disputed grounds. Several boats were warned off. The sheriff, after watching several days, discharged his posse and returned to Bridgeton. Soon after his departure many vessels appeared and began dredging. One of the riparian owners shot at the invaders for the purpose of frightening them off. Over thirty persons were subsequently arrested and held for court. A bill was then filed in chancery and a temporary order was obtained restraining the officers of the association from using the moneys raised by the tonnage tax in the defense of persons.

The riparian owners claim that in the recent raids they lost $50,000 worth of oysters.

The questions at issue between the parties are nearly all of a legal character which it is not within the province of this commission to decide, and for the solution of which the courts and the ordinary proceedings therein afford adequate means. While not assuming to decide the legal questions involved, or to pass upon the merits of the claims of the respective parties, the commission deem it their duty, for the information of the legislature, to call attention to these points:

"That the disputed area consists of about 976 acres, being but a very small proportion of the territory which, under existing laws, is open to the public and which is approximately 35 miles long by 4 miles wide; the dispute on the part of the Oyster Association being one of principle rather than one of actual damage.

"That the title of the State to the lands under tide water is, under the decision of our courts, absolute, and that it has been the policy of former legislatures to reserve to the State the right to grant the same to private parties, whether such lands be staked up and occupied for the cultivation of oysters or not. The act passed April 28, 1890, confirmed the right to possession to all the citizens of this State to lands under water occupied by them since January 1, 1880, for the cultivation of oysters, and made oysters grown thereon their private property, provided the lands so occupied do not include natural oyster beds. This act, however, contains this limitation: 'That nothing in this act contained shall give any person or persons the right or title to any of the said lands as against the State, and the State may at any time alter or repeal this law, or the riparian commissioners may make grants the same as if this act had not been passed.'

"That so far as this commission is aware no legislative limitation was placed upon the power of the riparian commissioners to make grants including oyster lands or beds, whether natural or otherwise, prior to the act approved March 6, 1888, which provides: 'That no grant or lease of lands under tide water, whereon there are natural oyster beds, shall hereafter be made by the riparian commissioners of this State, except for the purpose of building wharves, bulkheads, or piers.' Four of the thirteen grants or leases on the disputed grounds were made and the rights of the parties thereto vested prior to the passage of this act. As to the remaining nine grants made subsequent to 1888, the question of whether they include within their lines any natural oyster beds, and are thus limited in their operation to the building of wharves, bulkheads, and piers, is a question of fact. The ascertainment of the fact is dependent upon the correct definition of the term 'natural bed.'

"On the part of many members of the Oyster Association it is strongly asserted and vigorously maintained that all the bottom of Delaware Bay north of the 'south-west line,' including these riparian lands, constitutes a natural oyster bed. On the other hand, while it appears that scattered natural oysters may be found over nearly all this territory, there are well defined and easily located places where, by reason of the nature of the bottom, oysters will naturally grow in large numbers. These locations are where the bottom is hard, so that the young oysters will not sink into the mud, and usually consist of a mound or elevation above the general level of the bottom, composed of oyster shells, accumulated through years, and to which the spawn attach.

"In view of the testimony presented before the commission, the commission are of the opinion that nearly the entire bottom of Delaware Bay for about 35 miles north of Maurice River Cove constitutes a 'natural oyster ground,' but they are not of the opinion that it is all a 'natural oyster bed,' as the term is generally understood and as it is used in the statutes. The 'natural oyster beds' are distinct and separate from the general bottom of the bay.

"From the testimony of witnesses, and from a personal inspection of the disputed lands, the commission find, as a matter of fact, that within the limits of the foregoing definition the riparian grants in question do not all, nor do the larger part of them, embrace 'natural oyster beds,' but the commission is of the opinion that a large part of some of the grants may, and probably do, include within their bounds what now is, or heretofore has been, such beds.

"In the course of these investigations the commission were impressed with the great depression existing in the oyster industry. Although the planting season is not yet half over, many boats are laid off, others have gone to other States, many men are out of employment, and a feeling of discouragement is general. The commission have endeavored to ascertain the cause for this deplorable situation. The consensus of opinion is, that no adequate measures have been adopted to protect the natural productiveness of the bay. The large number of vessels employed, the improved dredges in use, and lack of proper regulations as to size of the oysters taken, have all combined to practically clean the bay of all natural growth, and, in addition, owing to the absence of any law requiring the separation of the oysters from the shells in dredging, the beds themselves have, in many cases, been either destroyed or seriously injured. This removal and destruction of the beds results in the loss of the oyster spawn, as no material remains to which it can become attached. Last season at least one-half the oysters planted were purchased outside the State, and this season the result will be much worse.

"From the testimony received and the investigations made, the commission find that a majority of the persons in the business agree as to the following points:

"First. That unless some radical change is made in the laws the industry will be extinguished.

"Second. That State control of the oyster lands, under proper regulations as to their use, is desirable.

"Third. That the dredging for natural oysters in the bay should be prohibited, either in whole or in part, for a period of a year.

"Fourth. That a 'rough-cull' law should be enacted; that is, a law requiring the dredger to separate the oysters from the shells of the bed, and prevent the carrying away of the beds themselves.

"This commission strongly recommends that the oyster lands in Maurice River Cove and Delaware Bay be placed under State control, as necessary to their preservation. Connecticut, Delaware, Maryland, and Virginia, all States having large oyster interests, have adopted this policy to the benefit and satisfaction of their citizens.

"A law should be enacted providing for the leasing by the State to private persons of lands to be used for the cultivation of oysters, and for which a small annual rent per acre should be charged. In thus taking control of lands for the cultivation of oysters the State should respect the rights of persons who now occupy staked-up grounds, and they should have the first right to leases for the same and have the title to all oysters now placed thereon. All vessels engaged in the business should pay a tonnage tax to the State and receive licenses; only vessels owned by citizens of this State should be so licensed. Proper legislation for the use of the bay and for the protection of the natural oysters should be made and should include the power to prohibit dredging on the natural oyster-grounds for a time; the introduction of a 'rough-cull' rule; provision for replenishing the oyster beds with shells at State expense. Adequate means should be provided, by guard boats, to enforce the law and protect the bay. Severe penalties should be provided for violations of the law, and in the case of offending vessels the licenses should be revoked. A reasonable rental and license fee will provide sufficient funds to properly protect the industry and enforce the law.

"In case the oyster lands are placed under State control the commission advise that the State acquire title, by condemnation or otherwise, to the lands covered by these riparian grants, to the end that all oyster territory may be held by the State and the use regulated for the benefit of all its citizens."

The outcome of this investigation will be some important legislation next September, when the legislature reconvenes after the summer recess. The attorney-general has taken the report and evidence and read it over carefully, and will prepare a bill which will give the State power to condemn these lands and award to the riparian owners such damages as may be properly assessed. Then these oyster beds will be made public property, subject to the general oyster laws of the State.

IV.—STATISTICS OF THE INDUSTRY.

The following statistics relate to the four years, 1889, 1890, 1891, and 1892, and exhibit in detail the condition and extent of the oyster industry of New Jersey. The figures are specified by counties, twelve of which have oyster interests. These are Hudson, Essex, Union, Middlesex, Monmouth, Ocean, Burlington, Atlantic, Cape May, Cumberland, Gloucester, and Camden. The three first-named counties abut on New York Bay, Newark Bay, and the northern part of Staten Island Sound. The taking of seed oysters is the only branch of the industry carried on there. Middlesex County includes the lower part of Staten Island Sound and the most of Raritan Bay, with Perth Amboy as its principal oyster center. The western part of Raritan Bay, Sandy Hook Bay, the Navesink and Shrewsbury rivers, and the ocean shore of the State as far south as the Manasquan River, are embraced within the limits of Monmouth County. Ocean County contains Barnegat Bay and part of Little Egg Harbor. Most of the latter, however, is in Burlington County, in which is also a large part of Great Bay. Atlantic County embraces the southern and western parts of Great Bay, and has within its limits Little, Reed, Absecon, and Lakes bays, as well as the northern side of Great Egg Harbor Bay. Cape May County constitutes the projecting tongue of land at the southern end of the State, intervening between Atlantic County on the ocean side and Cumberland County on the Delaware Bay side. Most of Delaware Bay, including Maurice River Cove proper, is off the shores of Cumberland County. The oyster interests of Camden and Gloucester counties consist of a fleet of vessels engaged in oystering in Cumberland County.

Table showing by counties the number of persons employed in the oyster industry of New Jersey in 1889–1892.

Counties.	On vessels.							
	Dredging and tonging.				Transporting.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Hudson	4	6	4	4		2	4	4
Essex								
Union								
Middlesex	4				19	16	16	16
Monmouth	57	40	40	36	15	22	30	24
Ocean				5	14	16	10	30
Burlington	2	2	2		8	16	18	2
Atlantic	45	44	26	39	38	39	40	38
Cape May	55	52	58	72	11	14	16	17
Cumberland	1,211	1,269	1,357	1,481	3			
Gloucester	5	5		5				
Camden	152	146	166	164	3	3		
Total	1,535	1,564	1,647	1,806	111	128	134	131

Counties.	On tonging boats.				On shore.				Total.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Hudson	100	105	108	110					104	113	116	118
Essex					26	26	26	26	26	26	26	26
Union	125	110	90	100	4	6	6	4	129	116	96	104
Middlesex	257	257	249	249					280	273	265	265
Monmouth	294	298	294	279	22	21	21	21	388	381	385	360
Ocean	288	281	285	568					302	297	295	603
Burlington	304	318	328	76					314	336	348	78
Atlantic	364	360	383	431	12	12	12	12	459	455	461	520
Cape May	128	136	143	149					194	202	217	238
Cumberland	54	54	62	106	222	241	264	283	1,490	1,564	1,683	1,870
Gloucester									5	5		5
Camden									155	149	160	164
Total	1,914	1,919	1,942	2,068	286	306	329	346	3,846	3,917	4,052	4,351

Table showing by counties the number, tonnage, and value of vessels employed in the oyster industry of New Jersey in 1889–1892.

Counties.	Number.				Tonnage.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Vessels fishing.								
Hudson	2	3	2	2	25.30	45.26	32.93	32.93
Middlesex	2				15.18			
Monmouth	26	17	15	13	275.76	149.85	136.14	121.60
Ocean				2				16.32
Burlington	1	1	1		9.05	9.05	9.05	
Atlantic	16	16	10	14	192.38	181.12	112.47	157.65
Cape May	18	18	20	24	201.37	206.28	228.83	288.83
Cumberland	288	303	323	336	4,817.79	5,045.05	5,332.53	5,596.90
Gloucester	1	1		1	24.97	24.97		24.97
Camden	31	29	31	30	650.42	614.13	688.17	689.33
Total	385	388	402	422	6,212.22	6,275.71	6,540.12	6,928.53

Table showing by counties the number, tonnage, and value of vessels employed in the oyster industry of New Jersey in 1889–1892—Continued.

Counties.	Number.				Tonnage.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Vessels transporting.								
Hudson	....	1	2	2	....	5.59	17.92	17.92
Middlesex	7	6	6	6	98.37	82.89	86.04	86.04
Monmouth	7	10	14	12	80.52	116.75	178.28	160.92
Ocean	7	8	5	13	71.74	90.44	53.50	189.18
Burlington	3	6	7	1	54.30	104.76	129.13	12.96
Atlantic	15	15	15	15	392.78	418.25	420.53	372.37
Cape May	4	5	6	6	98.17	131.29	147.45	146.66
Cumberland	1	....	....	....	32.90	....	....	....
Camden	1	1	....	....	22.64	22.64	....	....
Total	45	52	55	55	851.42	972.61	1,032.85	986.05
Total.								
Hudson	2	4	4	4	25.30	50.85	50.85	50.85
Middlesex	9	6	6	6	113.55	82.89	86.04	86.04
Monmouth	33	27	29	25	356.28	266.60	314.42	282.52
Ocean	7	8	5	15	71.74	90.44	53.50	205.50
Burlington	4	7	8	1	63.35	113.81	138.18	12.96
Atlantic	31	31	25	29	585.16	599.37	533.00	530.02
Cape May	22	23	26	30	299.54	337.57	376.28	435.49
Cumberland	289	303	323	336	4,850.69	5,045.05	5,332.53	5,596.90
Gloucester	1	1	....	1	24.97	24.97	....	24.97
Camden	32	30	31	30	673.06	636.77	688.17	689.33
Total	430	440	457	477	7,063.64	7,248.32	7,572.97	7,914.58

Counties.	Value.				Value of outfit.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Vessels fishing.								
Hudson	$2,650	$5,700	$4,500	$4,500	$110	$260	$120	$120
Middlesex	1,000	....	....	....	80	....	....	....
Monmouth	21,300	13,450	21,050	19,800	2,090	1,875	2,417	2,055
Ocean	....	....	....	800	....	....	....	210
Burlington	500	500	500	....	115	115	115	....
Atlantic	13,600	13,150	7,250	9,950	3,063	2,721	1,626	2,449
Cape May	15,450	16,000	16,250	20,850	2,395	2,470	2,440	3,360
Cumberland	296,215	315,415	334,145	368,240	68,697	74,747	78,607	86,123
Gloucester	1,000	1,000	....	1,000	210	260	....	135
Camden	45,600	41,900	47,300	49,150	9,215	9,250	9,845	10,325
Total	397,315	407,115	430,995	474,290	85,975	91,698	95,170	104,777
Vessels transporting.								
Hudson	....	700	1,900	1,900	....	50	200	200
Middlesex	9,900	8,700	8,000	8,000	1,010	930	930	930
Monmouth	5,100	7,400	13,000	13,200	400	917	1,881	1,453
Ocean	6,200	7,200	4,700	14,300	330	520	395	1,735
Burlington	3,850	7,150	8,650	350	595	970	895	20
Atlantic	23,800	24,200	25,400	21,150	2,235	2,645	2,815	2,783
Cape May	5,500	6,800	8,600	8,800	360	380	520	540
Cumberland	1,800	....	....	....	25	....	....	....
Camden	1,700	1,700	....	....	115	115	....	....
Total	57,850	63,850	70,250	67,700	5,070	6,527	7,636	7,661
Total.								
Hudson	2,650	6,400	6,400	6,400	110	310	320	320
Middlesex	10,900	8,700	8,000	8,000	1,090	930	930	930
Monmouth	26,400	20,850	34,050	33,000	2,490	2,792	4,298	3,508
Ocean	6,200	7,200	4,700	15,100	330	520	395	1,945
Burlington	4,350	7,650	9,150	350	710	1,085	1,010	20
Atlantic	37,400	37,350	32,650	31,100	5,298	5,366	4,441	5,232
Cape May	20,950	22,800	24,850	29,650	2,755	2,850	2,960	3,900
Cumberland	298,015	315,415	334,145	368,240	68,722	74,747	78,607	86,123
Gloucester	1,000	1,000	....	1,000	210	260	....	135
Camden	47,300	43,600	47,300	49,150	9,330	9,365	9,845	10,325
Total	455,165	470,965	501,245	541,990	91,045	98,225	102,806	112,438

Table showing by counties the number and value of boats employed in the oyster industry of New Jersey in 1889–1892.

Counties.	Number.				Value.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Hudson	42	45	48	50	$1,050	$1,125	$1,200	$1,250
Union	75	65	55	60	3,750	3,250	2,750	3,000
Middlesex	251	255	251	251	17,125	17,535	17,065	17,175
Monmouth	282	281	276	274	11,765	11,690	11,420	11,315
Ocean	325	327	330	676	52,009	53,140	52,250	78,984
Burlington	380	397	409	108	20,815	23,060	23,635	6,750
Atlantic	490	488	532	584	24,875	25,510	28,689	30,248
Cape May	163	172	180	186	4,410	4,645	4,860	4,950
Cumberland	37	37	42	70	3,375	3,375	3,730	6,525
Total	2,045	2,067	2,123	2,259	139,174	143,330	145,599	160,197

Table showing by counties the quantity and value of apparatus employed in the oyster industry of New Jersey in 1889–1892.

Counties.	Dredges carried on vessels.							
	Number.				Value.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Hudson	4	6	4	4	$80	$130	$90	$90
Middlesex	5	......	......	......	75	......	......	......
Monmouth	48	43	46	35	750	1,340	2,264	2,109
Ocean	......	......	......	......	......	......	......	......
Burlington	......	......	......	......	......	......	......	......
Atlantic	36	30	22	26	920	730	520	610
Cape May	61	60	68	84	1,640	1,575	1,725	2,125
Cumberland	1,128	1,175	1,257	1,304	28,050	29,146	31,281	33,291
Gloucester	4	4	......	4	100	100	......	100
Camden	120	114	123	117	2,975	2,800	3,050	2,925
Total	1,406	1,432	1,520	1,574	34,590	35,821	38,930	41,250

Counties.	Tongs carried on vessels.							
	Number.				Value.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Hudson	4	2	2	2	$16	$10	$10	$10
Middlesex	......	......	......	......	......	......	......	......
Monmouth	8	......	......	4	48	......	......	28
Ocean	......	......	......	5	......	......	......	18
Burlington	3	3	3	......	12	12	12	......
Atlantic	10	16	8	18	46	74	38	92
Cape May	......	......	......	......	......	......	......	......
Cumberland	......	......	......	......	......	......	......	......
Gloucester	......	......	......	......	......	......	......	......
Camden	......	......	......	......	......	......	......	......
Total	25	21	13	29	122	96	60	148

Counties.	Tongs, rakes, dredges, etc., carried on boats.							
	Number.				Value.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Hudson	60	65	68	70	$300	$325	$340	$350
Union	150	130	110	120	1,050	910	770	840
Middlesex	507	513	496	502	3,042	3,078	2,976	3,012
Monmouth	600	595	581	565	3,102	3,072	2,982	2,882
Ocean	328	321	325	621	1,341	1,312	1,325	2,467
Burlington	304	318	328	76	1,103	1,141	1,177	228
Atlantic	364	360	383	431	1,533	1,517	1,620	1,865
Cape May	128	136	143	149	240	247	262	271
Cumberland	54	54	64	108	790	790	855	1,555
Total	2,495	2,492	2,498	2,642	12,501	12,392	12,307	13,470

Table showing by counties the value of shore property and the amount of cash or working capital employed in the oyster industry of New Jersey in 1889–1892.

Counties.	Value of shore and accessory property.				Amount of cash capital.			
	1889.	1890.	1891.	1892.	1889.	1890.	1891.	1892.
Hudson	$1,000	$1,000	$1,000	$1,000	....	....	....	....
Essex	17,400	17,400	17,500	17,500	$15,200	$16,000	$15,000	$13,500
Union	1,000	2,400	2,400	1,000	2,500	3,000	2,500	1,500
Middlesex	19,675	19,825	19,675	13,525	23,900	25,800	25,300	20,800
Monmouth	37,995	37,985	37,960	37,890	110,950	111,150	107,650	111,100
Ocean	5,300	5,415	5,445	7,320	8,500	8,500	9,500	18,000
Burlington	1,137	1,300	1,600	....	6,000	6,000	6,000	....
Atlantic	13,353	14,460	14,460	13,960	44,400	44,900	43,400	48,400
Cape May	4,325	4,335	4,245	4,245	10,500	11,600	12,000	13,500
Cumberland	111,825	114,990	122,095	128,659	203,500	216,500	246,500	272,500
Total	213,010	219,110	226,380	225,099	425,450	443,450	467,850	499,300

Table showing by counties the quantity and value of market oysters taken in the oyster industry of New Jersey in 1889–1892.

Counties.	1889.		1890.		1891.		1892.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Taken by vessels.								
Hudson	2,300	$2,450	9,300	$9,300	5,500	$5,500	6,000	$6,000
Middlesex	1,000	1,000	....	....	....	....	....	....
Monmouth *	38,908	37,642	73,250	70,906	80,620	82,195	67,415	67,600
Ocean	....	....	....	....	....	....	100	80
Atlantic	8,500	8,570	7,952	9,417	5,566	6,657	11,100	10,075
Cape May	14,813	12,186	23,900	25,694	11,650	14,650	18,280	20,680
Cumberland	539,164	470,524	565,359	573,718	527,528	577,661	597,940	649,650
Gloucester	1,000	750	1,200	900	....	....	....	....
Camden	51,058	47,294	51,914	52,990	56,534	61,670	67,050	73,625
Total	656,743	580,416	732,875	742,925	687,398	748,333	767,885	827,710
Taken by boats.								
Hudson	8,500	10,200	7,500	9,000	7,000	8,400	6,000	7,200
Middlesex	33,500	39,865	40,200	47,838	34,200	40,698	36,700	43,673
Monmouth	151,431	206,429	142,180	197,288	150,291	202,710	115,122	158,164
Ocean	47,300	40,215	45,280	39,212	41,325	35,726	64,286	52,499
Burlington	38,695	27,868	39,185	28,502	39,932	29,288	10,150	6,598
Atlantic	99,200	122,143	96,550	117,833	97,350	116,908	105,150	124,903
Cape May	28,050	31,241	30,850	34,329	38,525	43,981	40,775	46,456
Cumberland	1,925	1,805	2,025	1,865	2,025	1,865	3,525	3,365
Total	408,601	479,766	403,770	475,867	410,648	479,576	381,708	442,858
Total.								
Hudson	10,800	12,650	16,800	18,300	12,500	13,900	12,000	13,200
Middlesex	34,500	40,865	40,200	47,838	34,200	40,698	36,700	43,673
Monmouth	190,339	244,071	215,430	268,194	230,911	284,905	182,537	225,764
Ocean	47,300	40,215	45,280	39,212	41,325	35,726	64,386	52,579
Burlington	38,695	27,868	39,185	28,502	39,932	29,288	10,150	6,598
Atlantic	107,700	130,713	104,502	127,250	102,916	123,565	116,250	134,978
Cape May	42,863	43,427	54,750	60,023	50,175	58,631	59,055	67,136
Cumberland	541,089	472,329	567,384	575,583	529,553	579,526	601,465	653,015
Gloucester	1,000	750	1,200	900	....	....	....	....
Camden	51,058	47,294	51,914	52,990	56,534	61,670	67,050	73,625
Total	1,065,344	1,060,182	1,136,645	1,218,792	1,098,046	1,227,909	1,149,593	1,270,568

* The quantity of oysters credited to the vessels of this county includes the product of certain grounds in New York adjacent to New Jersey, on which some of the oyster fleet of Perth Amboy operated. The yield thus obtained consisted of 19,993 bushels in 1889, valued at $15,133; 55,320 bushels in 1890, valued at $49,569; 59,407 bushels in 1891, valued at $56,952, and 52,365 bushels in 1892, valued at $49,690.

Table showing by counties the quantity and value of seed oysters taken in New Jersey in 1889–1892.

Counties.	1889.		1890.		1891.		1892.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Taken by vessels.								
Middlesex	375	$310	....	....	....	....	....	....
Monmouth	41,950	30,955	12,000	$6,000	600	$300	....	....
Ocean	....	....	....	....	....	....	3,400	$1,000
Burlington	2,500	750	2,500	750	2,500	750	....	....
Atlantic	9,119	2,706	19,280	5,836	18,850	4,905	19,975	5,116
Cape May	25,100	7,455	18,100	6,325	20,650	7,358	33,500	12,005
Cumberland	569,732	147,517	621,325	198,958	688,261	228,606	841,015	291,965
Gloucester	2,000	500	2,500	875	....	....	2,500	875
Camden	62,400	17,470	69,800	22,130	81,500	28,050	94,100	32,970
Total	713,176	207,663	745,505	240,874	812,361	269,969	994,490	343,931
Taken by boats.								
Hudson	36,000	18,000	35,400	17,700	35,000	17,500	30,000	15,000
Union	120,000	60,000	85,000	42,500	75,000	45,000	60,000	36,000
Middlesex	48,500	24,250	40,500	20,250	43,000	21,500	40,800	20,400
Monmouth	3,000	1,500	2,400	1,200	2,500	1,250	2,200	1,100
Ocean	57,000	14,425	61,530	15,533	65,825	16,606	138,395	34,812
Burlington	29,870	6,867	49,506	10,876	48,900	10,224	18,000	3,600
Atlantic	50,700	12,000	54,800	13,350	67,000	15,190	88,510	19,822
Cape May	5,800	2,070	6,700	2,480	6,000	2,225	7,500	2,620
Cumberland	36,949	9,735	40,949	10,625	48,449	12,275	71,325	18,775
Total	387,819	148,847	376,785	134,514	391,674	141,770	456,530	152,129
Total.								
Hudson	36,000	18,000	35,400	17,700	35,000	17,500	30,000	15,000
Union	120,000	60,000	85,000	42,500	75,000	45,000	60,000	36,000
Middlesex	48,875	24,560	40,500	20,250	43,000	21,500	40,800	20,400
Monmouth	44,950	32,455	14,400	7,200	3,100	1,550	2,200	1,100
Ocean	57,000	14,425	61,530	15,533	65,825	16,606	141,795	35,812
Burlington	32,370	7,617	52,006	11,626	51,400	10,974	18,000	3,600
Atlantic	59,819	14,706	74,080	19,186	85,850	20,095	108,485	24,938
Cape May	30,900	9,525	24,800	8,805	26,650	9,583	40,800	14,625
Cumberland	606,681	157,252	662,274	209,583	736,710	240,881	912,340	310,740
Gloucester	2,000	500	2,500	875	....	....	2,500	875
Camden	62,400	17,470	69,800	22,130	81,500	28,050	94,100	32,970
Total	1,100,995	356,510	1,122,290	375,388	1,204,035	411,739	1,451,020	496,060

Table showing by counties the quantity and value of the oysters planted in New Jersey in 1889–1892.

Counties.	1889.		1890.		1891.		1892.	
	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.	Bushels.	Value.
Middlesex	20,400	$10,250	19,600	$9,800	22,300	$11,150	17,700	$8,850
Monmouth	200,975	105,905	163,940	87,705	140,881	74,732	169,934	91,174
Ocean	47,715	12,103	49,365	12,491	61,050	15,412	115,450	29,086
Burlington	39,630	9,407	50,560	11,549	48,885	10,720	15,800	3,160
Atlantic	108,300	58,815	118,300	61,885	123,450	59,248	139,600	65,085
Cape May	34,500	9,284	38,200	9,984	40,000	10,385	46,400	12,016
Cumberland	671,081	175,222	734,674	232,588	818,210	268,931	1,008,940	344,585
Total	1,122,601	380,986	1,174,639	426,002	1,254,776	450,578	1,513,824	553,956

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