Shelve: Annual Report of the Commissioners of Inland Fisheries.

State of Rhode Island and Providence Plantations.

~~TWENTY~~ Thirty-THIRD ANNUAL REPORT

OF THE

COMMISSIONERS OF INLAND FISHERIES,

Compliments of the

Commissioners of Inland Fisheries.

PROVIDENCE:
E. L. FREEMAN & SONS, STATE PRINTERS.
1903.

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COMMISSIONERS OF INLAND FISHERIES,

MADE TO THE

GENERAL ASSEMBLY

AT ITS

JANUARY SESSION, 1903.

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COMMISSIONERS OF INLAND FISHERIES OF RHODE ISLAND.

J. M. K. SOUTHWICK, *President*.....Newport, R. I.
HENRY T. ROOT, *Treasurer*.....Providence, R. I.
CHAS. W. WILLARD.....Westerly, R. I.
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ADELBERT D. ROBERTS.....P. O. Box 264, Woonsocket, R. I.
WM. H. BOARDMAN.....Central Falls, R. I.
WM. P. MORTON, *Secretary*.....P. O. Box 966, Providence, R. I.

5671

REPORT.

To the Honorable the General Assembly of the State of Rhode Island and Providence Plantations, at its January Session, 1903.

The Commissioners of Inland Fisheries herewith present their annual report for the year 1902:

The work undertaken by the commissioners during the past year may be tabulated as follows:

First. The stocking of our ponds and streams with suitable fresh-water fish, through the distribution of eggs and fry.

Second. The collection of definite data respecting the times of arrival and departure of various food-fishes, and the preparation of statistics of exportation.

Third. The location of fish-traps within the waters of Narragansett Bay, and the collection of statistical data bearing upon their ownership.

Fourth. Further investigation of the red-water plague.

Fifth. The continued examination of the physical and biological conditions of the waters of the Bay, begun in 1898.

Sixth. A continuance of the survey of the shores of the Bay, for the purpose of determining those portions which are most productive of young seed-clams.

Seventh. A continued investigation of the life-history of the clam. Methods of artificial propagation and cultivation.

Eighth. The investigation of the quahaug.

Ninth. Experiments in lobster-culture.

Tenth. The efforts of the commission to prevent the illegal taking of short lobsters.

In pursuing the line of work indicated by the topics given above, your commission have continued their policy; (1) of directly improving the fisheries of the State by the introduction and protection of fish whenever experience has shown it to be advisable; (2) of investigating by observation and experiments the fisheries problems which are always presenting themselves for solution; and (3) of endeavoring to create an intelligent interest in the subject of fisheries, in order that the people of the State who benefit directly or indirectly by the fisheries may co-operate with the commission for their own good.

There is no longer any question as to the advisability of restocking lakes, streams, and ponds with bass, trout, etc., and the results of the work of the commission in this direction in previous years are gratifying and have amply repaid the labor and expense involved. It is to be regretted that, notwithstanding the fact that the law states explicitly that fishes less than a certain number of inches in length shall be returned to the waters from whence taken, large numbers of small fish are annually destroyed, by thoughtless or indifferent fishermen, which, if allowed to mature, would not only afford better fishing, but would materially aid nature in her efforts toward restocking. Your commission would encourage the formation of local fish and game associations, and it should be the duty of every sportsman who is in sympathy with the commission in its desire to perpetuate the fishing in our waters to discourage among all classes the taking and killing of all immature fish. Experiments in restocking waters with new fish, and data and statistics respecting the physical and biological conditions of bodies of fresh water and of the Bay, are collected and recorded with the view, not only to their immediate interests, but to their future value, and for the purpose of comparison with similar statistics from other States. Were we in possession of such statistics for the last fifty years, we should have invaluable information regarding many unsolved problems of practical importance; for example, on the effect of trap fishing on the abundance of fishes, of the effect of our methods of scallop fishing,

lobster fishing, and clam digging on the total product of these fisheries.

It is an undoubted fact, which has too often been demonstrated, that many species of fish and shell-fish cannot withstand for an indefinite period of time the onslaught of indiscriminate fishing. The favorite species must be propagated, fed, and protected. The determination of the best methods of propagation, of providing for food, of protection from natural enemies and man, necessitates a special knowledge of the natural conditions under which those species live. But more than this, the time has come when these food and game animals must be produced in abnormal quantities to meet the increased demand, and it is more than ever necessary to know natural conditions. A good case in point is that of the oyster fishery. Within the memory of the older generation the natural oyster beds of our Bay furnished an ample supply; but as time went on, the demand upon these beds became so great that even with protective laws the beds could not begin to supply it. The present great oyster industry has been developed at the expense of long experience and a great many costly experiments upon methods of propagation, spat collecting and protection. (The expense of fighting star-fish alone has been many hundred thousands of dollars. The damage done by stars to oyster beds in Connecticut alone for the year 1888 was estimated by Collins, "*Notes on Oyster Industry of Connecticut*," at $631,500.) The clam fishery, the scallop fishery, the lobster fishery, are now going the way of the natural oyster fishery, while the price is constantly increasing. It is possible to some extent to check the further diminution of these fisheries by the enactment and enforcement of restrictive laws, but the framing of effective and reasonable laws obviously depends upon accurate knowledge of conditions of life of the animals in question; for example, upon the breeding habits, age at sexual maturity, rate of growth, powers of migration, etc. While it is very doubtful if restriction in the catching of scup and other migratory fishes would have any beneficial effect, there is no doubt that restrictive measures regulating the clam

and lobster and scallop would be effective, if they could reasonably be enforced.

Especial investigations which the commission have undertaken have been directed to the star-fish, clam, scallop, quahaug, lobster, flat-fish, tile-fish, "red-water," and to diatoms and other microscopic forms which furnish food for most of the shell-fish. The star-fish became the object of investigation because of its terrible destructiveness to the oyster. Attention was therefore directed to its breeding season and habits; to the dispersal of the swimming young by the tides; to the great destruction of the star-fish at this stage by the menhaden; to the possibility of destroying young stars by the removal of grass and seaweed; to the rate of growth and the age at which they reach sexual maturity; to the age at which they become destructive to oysters; to their destructiveness to other animals, like clams, mussels, etc.; to the method employed by the star-fish in opening oysters; to the enemies of the star-fish and to the methods of destroying star-fish, including the effect of the old method of tearing them to pieces, and their power of regeneration.

The work of the commission on the clam problem has resulted in definite information on the season and manner of breeding, the rate of growth, the dependence of the rate of growth upon various conditions of location, etc., the distribution of clams in the Bay, the age at which clams begin to breed, the age at which they attain edible size, the effect of excessive digging, the effect of natural enemies and of "churning," also the effect of setting aside areas of shore which shall not be dug, and the impossibility of absolute extermination. Among the most important results of this work are the methods devised of catching the spat, of assisting nature to restock the shores by sowing young clams, and the progress in artificial clam culture.

The investigations have now reached the practical stage. There is no doubt that the shores of our Bay could be made to produce, not double the present output, but hundreds of times the present output. There are many problems which remain partly or wholly

unsolved, but the commission believe that at the present stage of research the main difficulties in the way of developing a clam industry of great value, and of credit to the State, lie in the attitude of the people who frequent the shores. Ideal legislation which, in the opinion of the commission, would give immediate and highly beneficial results is perhaps at the present time impracticable because of the great difficulty in enforcing its provisions. The difficulty which has been experienced by this and other States in enforcing laws regulating the oyster, scallop, and lobster fisheries, where the apparatus used is comparatively expensive and conspicuous and used in a limited territory, would become very much greater in case of the clam legislation. The territory is very much greater, and is scattered over a hundred miles of the shore line of our Bay; the apparatus used is practically of no value and easily concealed, and it would obviously be extremely difficult and expensive, even if it were possible, to patrol the shores and prevent poaching. The proposition of leasing the shores to private parties, to the exclusion of others, presents a grave question of constitutional right and of general advisability. While there seems to be no doubt that the clam output could be greatly increased by prohibiting digging for a limited time, together with the planting of the shores with seed clams, or, on the other hand, by leasing the shore to private parties, it is doubtful if either of these extreme measures would be advisable at the present time.

The work of the commission upon the life-history of the scallop has emphasized the necessity for the strict enforcement of the scallop law, and has furnished positive and much needed means of determining the age of the scallop. A new method of hatching flat-fish has been devised by the commission, which has the advantage of the one commonly used, in being simpler and capable of installment in any protected harbor or estuary. The occurrence of "red-water" in such abundance as to constitute a plague, which has caused the death of great quantities of fish and shellfish, has been investigated and found to be caused by the presence

of the microscopic plant (or animal) Peridinium. Further investigations of the life-history of this form, and the causes of its sudden appearance and disappearance, are being conducted.

The increasing importance of the quahaug fishery, the appeal for regulation regarding the catching of little-necks, the disputes between oystermen and quahaugers, and the lack of definite knowledge of its breeding habits, rate of growth, etc., has led the commission to begin a systematic investigation of this shellfish.

In attacking the problems of lobster fishery, the commission have directed their efforts to a thorough investigation of the general habits and movements of the adult lobster, the hatching of eggs, the rearing of the newly-hatched fry through the critical period of their free-swimming life to a stage where they are comparatively well able to take care of themselves; to ascertaining the conditions necessary to the later growth of the young lobsters; to ascertaining whether the physical conditions of Narragansett Bay would permit the rearing of lobsters to the adult stage; and to the enforcement of laws regulating the capture of short lobsters and lobsters bearing eggs. The success of the attempts at lobster culture have been most satisfactory, and especially so during the last two years. The apparatus invented by the commission, and put into use at Wickford in 1901, which proved far more successful than any hitherto used, was supplanted last summer by an improved apparatus constructed on the same general principle, but much more economical and efficient. The experiments of the last three years in rearing lobsters to ascertain how long it requires them to reach the marketable size, and to ascertain if it is possible to rear them through the cold of the winter and the changes in the density of the water in the spring of the year, have given positive and encouraging information in this regard, and the commission is in possession of live lobsters which were hatched in 1900. The deputies appointed to enforce the provision of the short lobster law, report favorable progress, and there is no doubt that, through the efforts of the

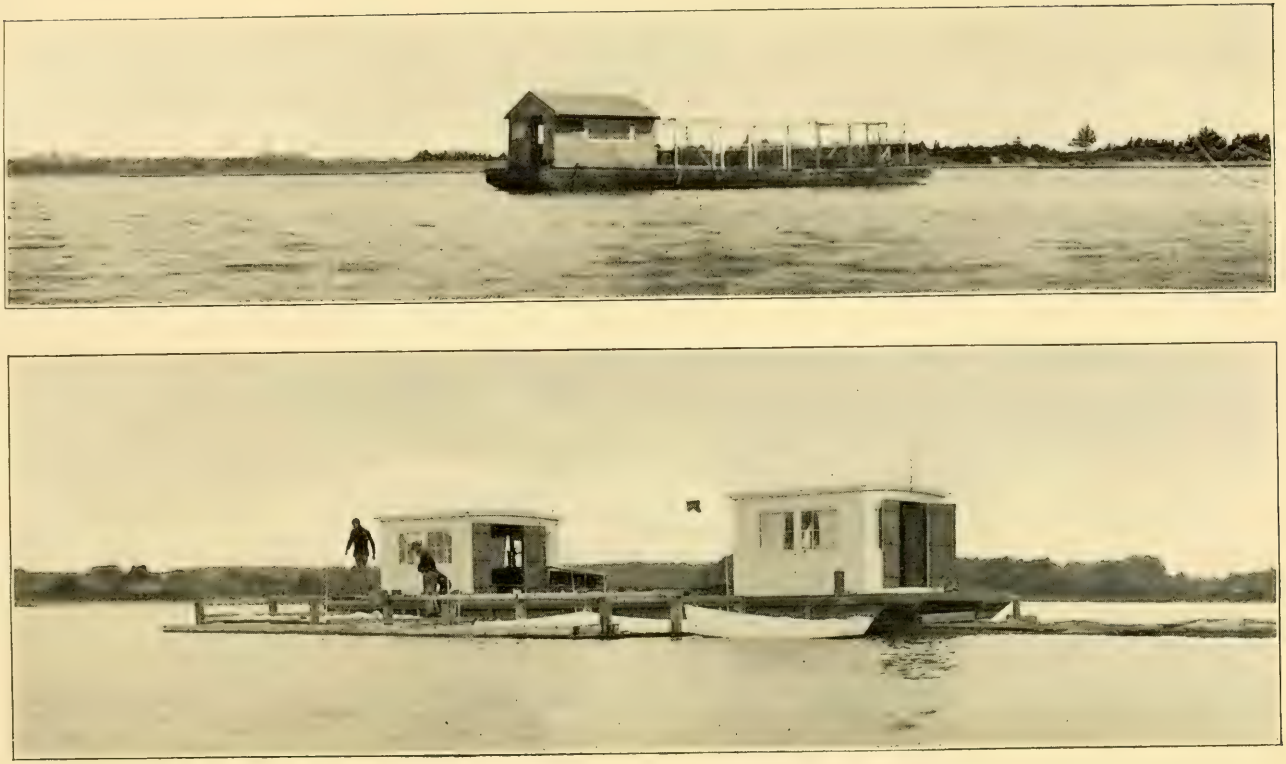

FIG. 1.—The old and new floating laboratories (house-boats) of the Commission of Inland Fisheries at Wickford, R. I. The upper picture represents the house-boat reconstructed from an old scow which served the Commission as a laboratory in the summer of 1899. The new house-boat is shown in the lower figure, with two of the floats attached. It has been in use since the spring of 1900.

commission, many thousands of short lobsters have been returned to the water to become breeders of future generations.

The scheme of "reversed legislation," recently urged through the Massachusetts commission and through the press, namely, that the law should protect from capture all lobsters above nine inches or so in length, and allow to be caught without restriction lobsters smaller than this, is, in the opinion of the commission, highly undesirable. The present plan, which deals with the lobster on the same principle which has proved successful in protecting fresh-water fish, game, etc., is the correct one and promises better results. The commission would deplore the introduction of such a subverting method of procedure in this or adjoining States, especially at a time when the artificial hatching and rearing of lobsters to the "lobstering" stage promises to be of practical benefit.

The commission have undertaken, as a part of their legitimate work, to interest the general public in the further investigations of the food animals of Narragansett Bay, and have prepared for exhibition several series of specimens illustrating the rate of growth of the star-fish, clam, scallop, and lobster, with a relief map, or model, of Narragansett Bay, showing the configuration of the bottom, the location of oyster beds, etc.; and have begun a collection of rare fishes and other specimens of educational importance. This collection was exhibited at the Pan-American Exposition, where it was awarded a gold medal, and last summer was loaned for exhibition at Crescent Park. It is now permanently installed at the rooms of the commission in the State Capitol.

Your commission would take this occasion to thank your honorable body for generous appropriations which have made it possible to carry on their work. The experience which has been gained by uninterrupted work, and the valuable equipment which has gradually been acquired, consisting of a first-class floating laboratory, a launch, and several small boats, make it possible for them to work to better advantage than ever before.

The receipts and disbursements of the commission have been as follows:

State of Rhode Island in Account with Commissioners of Inland Fisheries.

1901.		Dr.	
Dec.	31.	To balance due commissioners	$37 07
1902.			
Oct.	1.	To paid for 43,000 yearling trout, and distributing same	1,097 80
Dec.	31.	To expenses of laboratory on lobster, clam, quahaug, flat-fish, and scallop, and "red-water"	2,817 34
		To expenses of deputy commissioners under lobster law	2,512 15
		To planting 3,000,000 shad fry	11 00
		To planting black bass	13 13
		To printing	10 50
		To expenses of commissioners	764 04
		Total	$7,263 03

1902.		Cr.	
Jan.	3.	By cash from State Treasurer	$259 16
	6.	" " "	65 75
		" " "	75 35
		" " "	45 00
	9.	" " "	29 60
Feb.	6.	" " "	46 92
		" " "	25 35
	7.	" " "	67 75
		" " "	42 00
		" " "	64 75
		" " "	50
Mch.	7.	" " "	45 50
		" " "	56 00
		" " "	60 50
		" " "	1 82
	14.	" " "	72 00
	21.	" " "	5 65
Apr.	3.	" " "	60 60

1902.					
Apr.	3.	By cash from State Treasurer			2 50
		"	"	"	67 00
		"	"	"	31 50
		"	"	"	46 50
	18.	"	"	"	1 35
		"	"	"	1 45
	24.	"	"	"	46 50
		"	"	"	125 91
		"	"	"	26 14
May	1.	"	"	"	60 00
		"	"	"	70 25
		"	"	"	56 75
		"	"	"	76 85
	10.	"	"	"	5 00
	12.	"	"	"	2 50
		"	"	"	40 00
	29.	"	"	"	78 35
		"	"	"	58 90
June	1.	"	"	"	7 25
	6.	"	"	"	25 00
		"	"	"	56 00
	7.	"	"	"	11 00
	12.	"	"	"	10 50
	27.	"	"	"	215 69
		"	"	"	23 27
July	1.	"	"	"	68 45
		"	"	"	65 60
		"	"	"	73 00
	31.	"	"	"	2 35
Aug.	1.	"	"	"	4 60
		"	"	"	71 00
		"	"	"	81 40
		"	"	"	76 35
	12.	"	"	"	78 44
	30.	"	"	"	79 38
		"	"	"	9 62
Sept.	1.	"	"	"	82 75
		"	"	"	150 00
		"	"	"	92 80

1902.				
Sept.	1.	By cash from State Treasurer		72 50
		" " "		55 00
		" " "		92 96
		" " "		81 20
	12.	" " "		174 41
		" " "		95 00
		" " "		192 45
		" " "		148 64
Oct.	1.	" " "		40 00
		" " "		77 00
		" " "		1,000 00
		" " "		19 49
		" " "		70 00
		" " "		40 00
		" " "		452 63
		" " "		81 20
		" " "		71 15
		" " "		61 50
		" " "		3 05
		" " "		88 00
		" " "		50 00
		" " "		50 00
Nov.	7.	" " "		82 25
		" " "		73 60
		" " "		76 00
		" " "		67
		" " "		10 45
		" " "		2 00
		" " "		7 70
Dec.	1.	" " "		23 65
	2.	" " "		77 55
		" " "		69 20
	5.	" " "		60 50
	24.	" " "		75 00
		" " "		36 39
		" " "		70 00
		" " "		46 76
		" " "		210 43
	29.	" " "		22 90

1902.					
Dec.	29.	By cash from State Treasurer			69 34
	31.	"	"	"	18 90
		"	"	"	20 24
		"	"	"	12 90
		"	"	"	4 57
		"	"	"	19 75
	Total				$7,263 03

J. M. K. SOUTHWICK,
HENRY T. ROOT,
CHARLES W. WILLARD,
A. D. MEAD,
A. D. ROBERTS,
WILLIAM H. BOARDMAN,
WILLIAM P. MORTON,

Commissioners of Inland Fisheries.

PROVIDENCE, December 31, 1902.

I. The Stocking of our Ponds and Streams with Suitable Fresh-water Fish, Through the Distribution of Eggs and Fry.

Trout.

The commission have purchased, and placed in various waters of the State fifty thousand (50,000) yearling trout. The beneficial effects of stocking the streams in previous years are now becomming clearly evident, and the results are highly gratifying. There are several brooks in which the results of restocking have been shown in the most satisfactory manner. Many years ago the trout were abundant in these streams, but, through over fishing, were practically exterminated. In the year 1900 two of these were stocked with fingerling trout, and during the past summer the commissioners have examined the streams and found a surprisingly large number of trout in them. In some instances fishermen have complained of the large number of small trout, which interfere with the sport of angling for the larger ones. If the fishermen would co-operate with the commission by returning to the water trout and bass which are smaller than the legal length, the fishing in our waters could be maintained with comparative ease.

Large-Mouth Black Bass.

The efforts of the commission in restocking the lakes, ponds, and streams with large-mouth black bass, have thus far been amply rewarded. Fishing has steadily improved in the waters stocked, and is, from year to year, growing in importance. Experience has shown that the large-mouth black bass is well adapted to slow-running, muddy, and weedy rivers and ponds, while the small mouth species prefers clear waters, gravel, and rocky bottoms. The commission is again indebted to the United States Fish Commission for a liberal consignment of large-mouth black bass which have been liberated during the last year in seven or eight different ponds.

Shad.

The commission have received during the past year, through the courtesy of the United States Fish Commission, a car-load of shad fry numbering three million (3,000,000), which were placed in Runnin's and Palmer's rivers, one million two hundred thousand (1,200,000) in the former river, and one million eight hundred thousand (1,800,000) in the latter. The run of shad in both these rivers was later than that of last year, and the fish averaged larger size.

Alewives.

The commission are indebted to Mr. George A. Griffin, of Wakefield, for information regarding the catch of alewives. Since the opening of the branch in Point Judith Pond, alewives have been unusually abundant, but the shipment during the past year has been rather less than usual, owing to the fact that the market has been low. The fish, for the most part, are shipped to the West Indies, and the recent political and other disturbances in these islands have decidedly interfered with the market. Only about five or six hundred barrels were shipped this year, and the price was somewhat lower than usual. Three or four hundred barrels were sold to the local trade.

II. The Collection of Definite Data Respecting the Times of Arrival and Departure of Various Food-Fishes, and the Preparation of Statistics of Exportation.

Table of Fish and Lobsters Shipped From Newport During the Year 1902.

	Fish, Barrels.	Lobsters, Barrels.	Sword-Fish, Number.
January	874	435	...
February	448	429	...
March	177	575	...
April	377	451	...
May	14,527	983	...
June	17,371	664	...
July	7,558	302	5
August	5,490	142	1
September	3,646	124	173
October	1,649	145	...
November	935	19	...
December	934	73	...
Total	53,986	4,342	179
Deduct lobsters from Nova Scotia re-shipped	.....	1,532	...
Product of Rhode Island	53,986	2,810	179

Table of Fish, Lobsters, and Sword-Fish Shipped From Newport for the Last Seventeen Years by Regular Transportation Lines.

Year.	Barrels, Fish.	Barrels, Lobsters.	Total.	No. of Sword-Fish.	Barrels. Crabs.
1886	.....	.....	17,434	...	..
1887	16,657	834	17,491	...	..
1888	15,033	1,161	16,194	...	..
1889	19,306	2,047	21,353	...	..
1890	8,933	2,650	11,583	...	..
1891	18,032	2,204	20,236	...	..
1892	26,832	2,123	28,955	...	..
1893	24,452	1,399	25,851	...	..
1894	17,769	2,392	21,161	...	..
1895	24,622	2,119	26,741	...	..
1896	20,425	1,728	22,153	143	..
1897	25,098	2,039	27,137	45	..
1898	34,065	1,163	35,228	74	..
1899	34,917	4,143	39,060	162	..
1900	38,184	4,793	42,977	166	..
1901	50,500	4,393	54,893	21	..
1902	53,986	4,342	58,328	179	1

Lobsters Shipped From Newport to the Following Places, 1902:

Taunton, Mass.,
Boston, Mass.,
Fall River, Mass.,
Poughkeepsie, N. Y.,
Minneapolis, Minn.,
Rome, N. Y.,
Buffalo, N. Y.,
New York, N. Y.,
Newburg, N. J.,
Albany, N. Y.,
Detroit, Mich.,
Troy, N. Y.,
Binghamton, N. Y.,
Olean, N. Y.

III. The Location of Fish-Traps Within the Waters of Narragansett Bay, and the Collection of Statistical Data Bearing upon Their Ownership.

With the publication of the report for 1898, the State first came into possession of definite data respecting the location and ownership of the numerous fish-traps within the Bay and immediately outside, between Sakonnet and Point Judith. In the reports for 1899, 1900, and 1901, revised lists of these traps and their owners were published, and during the past season the traps have again been located, as will be seen in the following chart. A list of the principal owners of the fish-traps is here given, together with the localities in which the traps are set, as follows:

Inside Traps.

Almy and Sanford (000)* .....East shore, Sakonnet River.
Brownell, John (00).....West shore, Sakonnet River.
Brown, Edward .....West Rumstick Neck.
Brown, Edward.....West Rumstick Neck.
Carpenter Bros.....S. Ferry Wharf, Saunderstown.
Carpenter Bros..... .. ..S. Ferry Wharf, Saunderstown.
Carpenter, George.....Beaver Head.
Calvert, Geo..... ....Spouting Rock.
Corey, Ed. (000).....Lower west shore, Sakonnet river.
Corey, Ed. (00)..... Lower west shore, Sakonnet river.
Corey, George and Martin (00).....North High Hill Point.
Corey, George and Martin (000) Lower east shore, Sakonnet River.
Corey and Seabury..... Upper west shore, Sakonnet river.
Cottrell, S.....N. Popasquash Point.
Cottrell, S.....Popasquash Neck.
Cottrell, S..... .... .Popasquash Point.
Cottrell, S.... .....W. Mount Hope Point.
Cottrell, S..... .....East Hog Island.

* Three ciphers signify triple traps, two ciphers double traps, etc.

Cottrell, S.....East Hog Island.
Cottrell, S.....S. Mount Hope Point.
Cottrell, Wm.....North Tiverton.
Cottrell, Wm. (00).....North Tiverton.
Dennis, Wm .....Upper west shore, Sakonnet River.
Dennis, Wm.....West shore, Sakonnet River.
Doane, S. P.....Rumstick.
Easterbrooks, Comer (00).....Price's Neck.
Fish, Clinton.....North Tiverton.
Fish, Clinton.....North Tiverton.
Gladding, A. B.....Castle Hill, South.
Gladding, A. B.....Coddington Cove.
Gray, Benj.....Church's Cove.
Gray, Chas.....East shore, Sakonnet River.
Gray, George E. (00).....Lower west shore, Sakonnet River.
Gray, George E. (000).....West shore, Sakonnet River.
Gray, George E.....West shore, Sakonnet River.
Gray Bros. (000).....West Prudence Island.
Griffin & Taylor.....Watson's Pier.
Harvey, Charles.....North Carr's Point.
Helger, Henry (0000).....West shore, Sakonnet River.
Hicks, O. G.....Castle Hill, South.
James, Arnold.....N. Coddington's Cove.
Johnson, Frank.....Fox Island.
Kaye & Brayton (00).....West Prudence Island.
Kaye & Brayton (00).....Pine Hill Point, Prudence Island.
King, Chas.....Upper east shore, Sakonnet River.
King, Chas. (0000).....West shore, Sakonnet River.
Lake and Northup.....Conanicut.
Lake and Northup.....Conanicut.
Lake, Isaac (00).....Quonset Point.
Lawton, Ed.....Mackerel Cove.
Lawton, Ed.....Mackerel Cove.
Lawton, Ed.....Mackerel Cove.
Lawton, Ed.....Brenton's Point.

Lawton, J. M.....Brenton's Cove.
Lewis Bros.....Scragg Rock.
Lewis Bros.....Plum Beach.
Lewis Bros.....Wild Goose Point.
Lewis Bros.....Sauga Point.
Lewis Bros.....Dutch Island Harbor.
Lewis Bros.....Dutch Island Harbor.
Lewis Bros.....Conanicut.
Lewis Bros.....Conanicut.
Lewis, Will (000).....West shore, Sakonnet River.
Lewis, Will.....Fogland Point.
Locke, Moses.....Buttonwood.
Lorenzen, C.....Southwest Prudence Island.
Lorenzen, C.....Northeast, Hope Island.
Lorenzen, C (000).....East Hope Island.
Lorenzen, C.....West Hope Island.
Madison, Peter.....Buttonwoods.
Manchester, (00).....West shore, Sakonnet River.
Manchester, Daniel.....Quonset Point.
Manchester, Daniel.....Quonset Point.
Manchester.....West shore, Sakonnet River.
Matteson, C.....Fox Hill.
Matteson, C.....Conanicut.
Mitchell, G. D.....Dutch Island Harbor.
Negus Brothers.....East Bristol Neck.
Negus Brothers.....East Bristol Neck.
Northup, Al.....Austin's Hollow.
Rice, Herbert H.....Warwick Neck.
Rice, Herbert H.....Patience Island.
Rose, Chas.....Upper east shore, Sakonnet River.
Rose, Geo.....Mount Hope, East.
Rose, Geo.....Mount Hope, East.
Rose, Geo.....West shore, Sakonnet River.
Rose, Ed.....Upper east shore, Sakonnet River.
Rose, Ed.....East shore, Sakonnet River.

Rose, Sam.....North Sapowet Point.
Rose, Sam.....North Sapowet Point.
Simons, John.....Tiverton.
Smith, John.....Johnson's Ledge.
Smith, R.....North Point, Conanicut.
Spink, J. W.....Dutch Island Harbor.
Spink, J. W.....Fox Hill, North.
Sisson, ——.....Chippanogsett.
Sisson, ——.....Long Point, Potowomut Neck.
Taber, ——.....North Tiverton.
Tew, R.....Price's Neck.
Tourgee, P.....Austin's Hollow.
Tourgee, P.....Beaver Head.
Tourgee, P.....Saunderstown.
Tourgee, P.....South Saunderstown.
Wilcox, Ralph (000).....South, High Hill Point.
Wilcox, Ralph.....Church's Cove.
Wilcox, Ralph (00).....East shore, Sakonnet river.
Wilson and Mitchell.....Off Brush Neck Cove.
Wilson (00).....West Prudence.
Wilson, Al.....Pojac.

Sea Traps.

Brightman, W. J.....South Cormorant Rock.
Brightman, W. J.....South Cormorant Rock.
Brownell, John.....Seal Rock, South.
Brownell, John.....Seal Rock, South.
Brownell, John.....South Cormorant Rock.
Church, D. T. (00).....South Sakonnet Light.
Church, J. B.....Off Seal Rock.
Church, J. B. (00).....Off Coggeshall's Ledge.
Church, J. B.....South Cormorant Rock.
Church, J. B.....West Sakonnet Light.
Cook Bros.....North Coggeshall Point.

Cook, Chas. (00).....North Sakonnet Light.
Fisheries Co.....Off Seal Rock.
Gray, Benj.....North Sakonnet Point.
Providence Fish Co.....Schyler Ledge.
Rose, Geo.....Sakonnet Point.
Rose, Wm .....South Cormorant Rock.
Rose, Wm. R.....Off Coggeshall's Ledge.
Tallman, B. (00).....South Cormorant Rock.
Thompson, Noah.....Off Seal Rock.
Wait, Benj.....North Sakonnet Point.
Wilcox, Frank.....Off Sakonnet.
Wilcox, Frank.....Sakonnet Point.
Wilcox, Ralph.....South Cormorant Rock.
Wilcox, Grinnell & Co.....Sakonnet Point.

NARRAGANSETT BAY.

Showing the Location of Fish Traps for 1902.

PREPARED BY THE
Rhode Island Commission of Inland Fisheries
to accompany Report for 1902.

IV. Further Investigation of the Red-Water Plague.

The remarkable occurrence of red-water in the Bay, particularly in the Providence River, has been observed for many years. Sometimes it becomes exceedingly annoying on account of the bad odor which accompanies it. On some occasions, when it has occurred in very great abundance, it has seemed to be responsible for the death of vast quantities of marine animals. Shrimp, crabs, eels, menhaden, flat-fish, and many other animals have been stupefied and washed ashore in windrows. The commission, in 1898, made a preliminary investigation of the matter, and discovered that it was caused by the excessive abundance of a microscopic animal (or plant) organism—Peridinium. (See report for 1898.) The cause of its sudden appearance and disappearance, the explanation of its effect upon fish, and the general facts of its life-history are unknown. It is indeed a new species. The commission have entrusted the thorough investigation of the subject to Mr. E. W. Barnes, whose paper will appear in a future report.

V. The Continued Examination of the Physical and Biological Conditions of the Waters of the Bay, Begun in 1898.

Data concerning the temperature and density of the water, the occurrence of microscopic animals and plants which furnish food for shell-fish, and miscellaneous notes in regard to various other physical and biological conditions, which may be of use in future investigations, are being collected by the commission.

The changes in these conditions which have been brought about by the opening of the breach into Point Judith Pond are extremely interesting, and are of great importance from a practical point of view. The pond comprises a considerable body of water. It is about four miles long, and one and a half miles wide in the widest portion. The pond was formerly in more or less free communication at its lower end with the salt waters of Long Island Sound, but for many years has been closed during a considerable part of the time by the sand bars. Through the efforts of the local fishermen, the breach has from time to time been opened enough to provide a runway for alewives, which are annually caught and prepared for export to the number of from 1,000 to 4,000 barrels.

For several years, those who have recognized the possibilities of this body of water, if its communication with the sea could be maintained, have urged the permanent opening of the breach, and in the spring of 1901 the work of making such a permanent opening was begun, and is now near completion. The operations include the dredging of a canal through the bar and well into the pond, and the building of a jetty on the outside to prevent the subsequent filling of the canal with sand. The results of the opening of the breach have equalled the highest expectations. During the first summer clams and oysters set very abundantly all over the pond, the oysters lodging, not only on gravel, old shells, brush, etc., but upon the widgeon grass. In the latter part of September, 1901, the breach was closed, and was opened again on February 18th,

FIG. 2.—This figure is reproduced from a life-size photograph, and represents a sample of the newly-set oysters taken from Point Judith pond by Mr. George A. Griffin. The small specimens are seen to be very thickly scattered over the surface of the large oyster shell, and the larger specimens below and to the left represent oysters which have set on the widgeon grass. The under surface of these oysters bears a deep grove made by the growing of the shell around the spear of grass.—*(Reproduced from Report for 1901.)*

FIG. 3.—Cluster of oysters taken from Point Judith pond in October, 1902. These oysters were set in 1901 after the opening of the breach at the lower end of the pond. Compare with Fig. 2. Several thousand bushels have already been taken from the pond.

1902, remaining open about a week. About the 10th of March it was again opened, but filled once more in about ten days. Early in April another opening was made, which remained throughout the summer and fall. It is thought that, when the jetty is completed, the opening will be permanent.

Notwithstanding the fact that the communication with the sea was cut off for several months in the winter, the clams and oysters remained and have shown a good growth. The two accompanying figures of oysters, taken respectively in the fall of 1901 (reproduced from last year's report) and in the fall of 1902, speak for themselves. The value of the clam and oyster crops of the pond alone is very great, and under careful management the annual yield would undoubtedly much more than pay for the whole cost of building and maintaining the breach. Besides the clams and oysters, there have already appeared in the pond many kinds of food and game fish which have not been taken there for about thirty-five years. Among these are the blue-fish, striped bass, squiteague, and flounder.

VI. The Continuance of the Survey of the Shores of the Bay for the Purpose of Determining Those Portions Which Are Most Productive of Newly Set Clams.

During the past season the commission have again made an examination of the shores of the Bay, to determine the clam set. As stated in the previous reports, the comparison of results from year to year shows that the set of clams varies in abundance in successive years, and that, in certain localities, where the set is very abundant in one year, there may be almost no clams in the succeeding year. In the three years preceding the last summer, it was possible to obtain from certain limited areas a very large number of young clams, suitable for sowing, which measured, in the latter part of July, from an eighth of an inch to about one-half inch in length. In 1901, on the east shore of Green's Island the set was the thickest that has thus far been observed. As stated in the report for that year, nearly eight thousand (8,000) small clams were dug in one shovelful of sand, and twenty bushels of these minute specimens were taken from a comparatively small area without noticeably decreasing the whole number. In 1900 a small area on the Buttonwoods shore furnished also a very thick set of clams. In 1899 similar thick sets were found on Cornelius Island, near the entrance of Mill Cove in Wickford harbor. During the past season, however, the most diligent search in all these localities, as well as in many others, failed to discover any area in which the clams set in great abundance.

At Green's Island the clams which set the year before are still extremely abundant, and they furnish an excellent opportunity to observe the greater growth, and also to observe the rapidity with which the clam diggers denude a productive area. During the present year this area did not have one newly set clam to a thousand of the year before. The explanation of this variation in the thickness of the clam set in certain areas in successive years is still to be discovered. That there were many free-swimming

young clams in the water is not to be questioned, and indeed on the mussel beds at Nayatt Point the set was quite abundant; but, owing to the presence of the mussels and the stony condition of the ground, the young clams could not be gathered in sufficiently large numbers to render transplanting feasible.

VII. A Continued Investigation of the Life-History of the Clam. Methods of Artificial Propagation and Cultivation.

These investigations, which have been continued since 1898, have each year become more interesting and promising of practical results. The commission in 1891 felt warranted in asking that a reservation be allotted them upon which experiments could be made on a larger scale than before, and under normal conditions. Your honorable body granted to the commission such a reservation, not to exceed three acres of land between high and low tide. The commission selected such land with a view to furnishing various conditions of soil, etc., and planted upon it a large number of clams. The results of these experiments have been most satisfactory.

In this investigation the commission have appreciated the cooperation of the citizens owning land bordering the shore, who have taken an interest in the experiments. The following paper gives the results of investigations which have been carried on during the past season.

OBSERVATIONS ON THE SOFT-SHELL CLAM—(*Mya arenaria.*)

(*FOURTH PAPER.*)

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In view of the importance of the soft-shell clam as a food product, and in view of the increasing scarcity of clams, the Commission of Inland Fisheries have for several years been conducting a systematic investigation of the life-history, habits, and requirements of this species, together with experiments on clam culture. We have had constantly before us certain general questions:

What is the breeding season?

How, when, and where are the eggs laid; and what are the habits of the young fry before they set and begin to burrow?

What is the rate of growth of the clams after they have set?

At what age do they breed?

What are the natural enemies of the clam?

What is the food of the clam?

Is it feasible to transplant clams?

What is the best method of collecting spat and transplanting?

The information already gathered has thrown light on all of these questions, and during the past two seasons we have been making use of the facts relating to the natural history of the clam, and have got under way a number of experiments to test our conclusions in regard to the methods of clam propagation and the possibility of replenishing the shores. In order to make intelligible the report of the progress of this work during the past season,

it is necessary to review briefly some of the more important facts in regard to the habits of the species.

The breeding season was found to be, for the most part, in June, though it begins in May and ends in July. Clams spawn to some extent also in other months, but in comparatively small numbers. In the early spring (April) a meagre set is sometimes found, which, from the uniform size of the specimens, seems to represent a definite breeding season, probably in the late autumn. This set is so sparse that it can hardly be considered to be of any economic importance. (Report for 1899, page 23; report for 1900, pages 22 and 23.)

The sexes of the clam are separate. The eggs are of microscopic size and are laid in inconceivably great numbers wherever adult clams abound, being extruded, without any means of protection, into the sea-water where they are fertilized. The young larvæ which develop from these eggs are swimming animals of microscopic size also, and are carried by the tides and scattered in every direction until, after a period of several days (the exact duration is not known), they strike upon some object like sea-weed, stones, or the ground itself, and become attached by an apparatus exactly comparable to the anchor-threads of the common mussel. But, although the spat is everywhere present in the water, the density of the set along the shore is very unequally distributed; so that in one area the little clams may be found in great abundance, while in other areas, not far off, very few are to be found. It is also true that these areas which are most favorable for catching the spat are often not favorable for the future growth of the clams. The significance of these peculiarities of the young clam for the future of the clam industry cannot be overestimated. (Report for 1899, pages 23 to 27.)

The problem of the rate of growth of the clams after they have set has received a large amount of attention, on account of its obvious practical value, and the results, illustrated by numerous photographs, are given in the reports for 1899 and 1900. The rate of growth varies greatly according to the locality, and the varia-

tion can be referred back still further to two general conditions: 1st, the position of the individual clams as regards comfortable surroundings, and 2nd, of more importance, the position in relation to the abundance of food-supply. In certain localities, and at certain depths of water, the average food-supply is greater than at others. Moreover, the longer the water covers the clams, the longer time they can feed; for they derive all of their food from the water, and can take it only when they are submerged. Other conditions being the same, clams grow more slowly near the high-water mark. Without taking into account the extreme variation, the one-year-old specimens vary between three-quarters of an inch and two inches in length.

Contrary to the opinion ordinarily held, the clams reach sexual maturity and breed during the first year of their life.

In regard to the natural enemies of the clam, it is doubtless impossible to enumerate them all. Of the eggs laid, probably great numbers perish without being fertilized. Of the enormous number which reach the swimming stage of development, it is certain that only relatively few are successful in burrowing. During these early stages, not only are they preyed upon by innumerable small predaceous animals, but the chances of perishing by falling upon unfavorable ground where they are smothered by the silt, or where they cannot burrow on account of the rocks are equal to, if not greater, than their chances of falling upon good ground. When they begin to burrow they are subject to the attacks of the crabs, eels, star-fish, and probably many other enemies; and those which attain a somewhat greater age are continually being dug out of their burrows by man, and thus exposed to the attacks of fishes and all other enemies, even if they are not actually carried away by the clam-diggers. There is some evidence that in certain parts of the Bay the red water has worked havoc among the clams, as mentioned in the last report. It is probable, however, that the excessive and indiscriminate digging is largely responsible for the decrease in the clam product of the Bay.

The clam gets its food-supply from the sea-water, which is

drawn in through the incurrent openings of the snout or siphon. The food consists of microscopic organisms of various sorts, a large portion being diatoms. The abundance of this food varies in different localities, and in the different depths of water, and at various times of the year. The clam feeds continuously when covered with water, if it is comfortably situated.*

The work of the past season, 1902, may be conveniently classified under the following headings: Further observations on the breeding season, spat collecting apparatus, continued growth of "artificial set," continued experiments in transplanting clams upon reserved plots, and enemies of the clam.

Further Observations on the Breeding Season.—The possibility that there is a second more or less extensive breeding season for the clam, in certain years at least, is indicated by the observations made in the spring of 1900, and we quote the following paragraph from the report of that year:

"Between the regular spawning season of June, 1899, and June, 1900, there was another distinct breeding season, probably in the fall of 1899. The set resulting from this was first discovered in April, 1900, when the largest specimens were about one-quarter inch long. The evidence that this was a fall set is that every specimen had the surface of the shell next to the hinge corroded and distinctly marked off from the new growth. This condition is never seen in the summer set, but would be accounted for if the clams lay for months with almost no growth. The mark persists in these specimens until they are more than an inch long. By the tenth of June some of these had grown to 30 mm. in length and were as long as many sexually mature year-old specimens. Photographs of specimens taken May, 1900, are shown in figure 7."

In the spring of 1901 very few clams were observed which seemed to have set out of the regular season, but during the present winter such specimens have been found in greater numbers than ever before. In the latter part of January, 1903, small clams,

* Report for 1901, pp. 20 to 23.

ranging from those which were hardly visible to those nearly one-half inch in length, were taken in abundance from the spat collector at Rumstick. Figure 6 represents the clams of various sizes taken from an area 6 x 6 inches in this spat collector on January 20th, and the smaller specimens belong to this latter set. The shores in various places were immediately examined, and it was found that in many localities similar small clams were present. At the reservation bed in the Kickemuit river they were abundant, although not so thick as in the spat collector. The set of clams at the regular season seemed to be much poorer in 1902 than in the three previous years, and for the first time in four years we were unable to find any locality in which they set in great abundance. Whether the fact of this meagre set at the usual time is related to the fact of the increased winter set, we cannot say at present.

Spat-Collecting Apparatus.—The principle of this simple contrivance, to which we have several times referred, is discussed in the report of 1900, page 25. A box is set into the ground or is filled with sand, and the cover provided with a fine screen or perforated with numerous holes; the box is then placed where the tide will cover it for a considerable portion of the time. The small swimming clams find their way into the box and apparently have difficulty in getting out. At any rate, large numbers will set in the box, even when the set in the immediate vicinity outside is very sparse. Through the kindness of Mr. Charles Alexander, we have been able to place one of these collectors on the shore of Rumstick Point with the best assurance that it will not be disturbed. Figures 4 and 5 show this particular collector in operation. It is modelled after Mr. Alexander's ingenious invention for retaining and growing clams, which is described and figured in the last report.

Continued Observations on the Rate of Growth.—The conclusion in regard to the rate of growth stated in the previous reports has been confirmed by the further experiments and observations: First,

there is a wide difference in the growth of clams placed under different circumstances; second, under ordinarily favorable conditions, a respectable marketable size is attained in about one year and a half. The clams which set so thickly at Green's Island in 1901, where nearly 8,000 were taken in a single shovelful of sand, have been observed from time to time and records of their growth have been kept. A large number of these specimens were taken from the island and transplanted into the various plots of shore reserved for this purpose. The conditions under which the transplanted clams have lived differ in the several localities, and differ, also, from those at Green's Island. Besides these clams, we have had under observation a valuable collection which were set in '91 and '92 in the spat collector at Rumstick, and we have also the survivors of the "artificial set," which is described more at length under the next heading. The clams of the Green's Island set which have remained there have grown somewhat less rapidly than those which were transplanted at Wickford and the Kickemuit river. The figure 6, reprinted from the last report, represents the size of these clams at the time of transplanting, and figures 7 and 8 their size when one year and a half old. These figures show the average rate of growth in different localities. The clams set and reared in the clam-catcher at Rumstick are shown life-size in figure 17, the larger one representing the set of the summer of 1901.

Continued Growth of "Artificial Set."—This name has been applied to the clams which were caught from the water by the first spat collector in the summer 1900. Thirteen hundred specimens about the size of the Green's Island specimens in figure 6 were taken in one square foot in this apparatus, and many of them were transplanted and raised in boxes. An account of their growth has been given in previous reports. The boxes have been placed in various localities, from time to time, and the rate of growth has been correspondingly increased and diminished. On the 22nd of August, 1901, about a year after they were transplanted, the average length, computed from measurements of seventy-five speci-

mens taken at random, was slightly over two inches. On January 20th, 1902, eighteen months after transplanting, the average length was about 2½ inches. Samples of the specimens at this time are pictured life-size in the last report (figure 4). On August 5th, 1902, when they were two years old, the average length of all the specimens which remained was 2⅞ inches (74 mm.). The smallest specimen was 2½ inches long and the largest one 3⅜ inches. The following table gives the size of all the specimens on that date:

No. of specimens.	Length in inches.	Length in millemeters.
1	3⅜	85
1	3 3/16	80
16	3⅛	79
21	3 1/16	77
40	3	76
16	2 15/16	74
23	2⅞	73
11	2 13/16	71
24	2¾	69
9	2⅝	67
1	2½	64

The growth during the past year has probably been smaller than it would have been had the specimens lived under more favorable conditions. They were left on the shore in the box, and most of the time had a depth of soil insufficient for the best growth. The brief history of the growth of these specimens, from August 14th, 1900, to January, 1902, is given in figure 11.

Continued Experiments of Transplanting Clams in Reserved Plots.— The transplanting of clams by sowing the small spat, measuring from ⅛ to ½ inch in length, was tried on a small scale in the summer of 1900, and it was clear from these preliminary trials that the method had many distinct advantages over that of planting the older clams. The spat can usually be found in great abandance in certain restricted localities, or can be obtained in spat collectors. The young clams burrow more rapidly and more

surely than the larger ones, and are therefore more easily transplanted. In the summer of 1901 these experiments were extended, and between two and three acres of shore were sown with these small clams (see figure 6) taken from Green's Island, where, as before mentioned, they were exceedingly thick. They were sown on several plots, on different kinds of soil, and under various other conditions. The plots were, for the most part, staked out, advertised, and posted in accordance with the requirements of the law (see page 46). Certain strips of shore were sown and not staked out, in order to ascertain what the effect would be of sowing and not protecting. The record of the plots sown is given in tabulated form below.

TABLE No. 1.

Number.	Location.		Area.	Amount sowed.	Aver. No. per qt.	When sowed.	Condition of Tide.	Condition of wind.	Time between digging and sowing.	How kept.	Remarks.
1	S. shore, Mill Cove	a	50 x 25 ft.	36 qts.	2,135	Aug. 14, 11 a. m.	Just turning. Low about 12.	None.	24 hours.	In water.	⅓ unplanted.
		b	50 x 25 ft.	54 qts.	2,135	Aug. 17, 5:30 p. m.	Coming in. Low about 2:30.	None.	26 hours.	Dry.	Plot partly grass.
2	S. shore, Cornelius Island	a	50 x 25 ft.	36 qts.	2,135	Aug. 14, 1 p. m.	Coming in. Low about 12.	None.	24 hours.	In water.	Loamy sand.
		b	50 x 25 ft.	54 qts.	2,135	Aug. 16, 5:30 a. m.	Half in. Low about 1:40.	None.	26 hours.	In water.	Loamy sand.
3	Rumstick		150 x 50 ft.	72 qts.	9,700	Aug. 17, 3 p. m.	Coming in. Low about 2:40.	Brisk.	2 hours.	Dry.	Stony beach.
4	Fishing Cove	a	25 x 50 ft.	45 qts.	9,700	Aug. 18, 10 a. m.	High. Low about 3:30.	Light.	20 hours.	Dry.	Fine gravel.
		b	25 x 50 ft.	54 qts.	9,700	Aug. 24, 5 p. m	Half out. Low about 7:20.	Light.	4½ hours.	Dry.	Fine gravel.
5	Kickemuit River	a	60 x 150 ft.	108 qts.	9,700	Aug. 19, 2 p. m.	Going out. Low about 4:10.	Light.	4½ hours.	Dry.	Sandy loam.
		b	60 x 150 ft.	108 qts.	9,700	Sept. 7, 9:30 a. m.	Low. Low about 8.	None.	24 hours.	Dry.	Sandy loam.
6	Smith's pasture, Mill Cove		200 x 60 ft.	153 qts.	9,700	Aug. 23, 3 p. m.	Going out. Low about 6.	Light.	4 hours.	Dry.	Marl.
7	Duck Cove		100 x 50 ft.	45 qts.	9,700	Aug. 24, 6 p. m.	Going out. Low about 7.	Light.	4 hours.	Dry.	Rocky beach.
8	South shore, Mill Cove		100 x 60 ft.	108 qts.	9,700	Aug. 26, 5:30 p. m.	High tide. Low about 10.	Light.	4 hours.	Dry.	Coarse gravel & sand.
9	Old Buttonwoods		150 x 60 ft.	99 qts.	9,700	Aug. 28, 1 p. m.	Half in. Low about 10.	Light.	3 hours	Dry.	Shifting sand.
10	*Rabbit Island		100 x 50 ft.	54 qts.	9,700	Aug. 28, 4 p. m.	Almost in. Low about 11:40.	Light.	6 hours.	Dry.	Fine gravel and sand.
11	*N. shore, Cornelius Island		200 x 20 ft.	45 qts.	9,700	Aug. 29, 5 p. m.	High. Low about 12:30.	Light.	3 hours.	Dry.	Coarse gravel.
12	*Quonset		60 x 60 ft.	36 qts.	9,700	Sept. 5, 10 a. m.	Half in. In, 1:20.	Light.	20 hours.	Dry.	Sandy and shifting.
13	*Cold Spring		60 x 60 ft.	40 qts.	9,700	Sept. 5, 11 a. m.	Coming in. In, 1:20.	Light.	21 hours.	Dry.	Sandy gravel.
	Total		2½ acres.								

*Not staked.

Some of the results of this method are given in the last report in the form of life-size photographs of clams about five months after planting (see figures 2 and 3, report for 1901), and the results of the examination of the beds in January, 1903, a year and a half after transplanting, are here given, as briefly as possible, in tabulated form. The experiment numbers correspond to those of the table given on the preceding page, and to facilitate reference to that table, the data are reprinted here in italics.

TABLE No. 2.

Number.	Location.	Area.	Amount sowed.	Aver. No. per qt.	When sowed.	Condition of Tide.	Condition of wind.	Time between digging and sowing.	How kept.	Remarks.
1	*S. shore, Mill Cove*	*a* 50 x 25 ft.	36 qts.	2,135	Aug. 14, 11 a. m.	Just turning ..... Low about 12.	None.	24 hours.	In water...	1-3 unplanted.
	Very poor soil. At time of planting and for sometime before there were *no* clams in plot. Now a very few, not over 2 or 3 per square foot. None at all in the third unplanted.									
1		*b* 50 x 25 ft.	54 qts.	2,137	Aug. 17, 5:30 p. m.	Coming in..... Low about 2:30.	None.	26 hours.	Dry.....	Plot partly grass.
	Three diggings gave an average of 17 per square foot. (1) Area 15 x 15 inches produced 16 clams. (2) Area 15 x 15 inches produced 28 clams. (See figure 00.) (3) Area 1 x 1 foot produced 21 clams. (See figure 10.)									
2	*S. shore, Cornelius Island*	*a* 50 x 25 ft.	36 qts.	2,135	Aug. 14, 1 p. m.	Coming in..... Low about 12.	None.	24 hours	In water...	Loamy sand.
	Upper half of bed gave 24 per square foot. Area 15 x 15 inches produced 37 clams (See figure 00.) Lower half (miry sand) 7 to 8 per square foot.									
2		*b* 50 x 25 ft.	54 qts.	2,135	Aug. 16, 5:30 p. m.	Half in..... Low about 1:40.	None.	26 hours.	In water...	Loamy sand.
	Upper half produced 34 per square foot. (See figure 9.) Area 15 x 15 inches produced 51 clams. Lower half (miry sand) 9 to 11 per square foot.									
3	*Ramstick*	150 x 50 ft.	72 qts.	9,300	Aug. 17, 3 p. m.	Coming in..... Low about 2:40.	Brisk.	2 hours.	Dry.....	Fine gravel.
	Only occasionally a clam.									
1	*Fishing Cove*	*a* 25 x 50 ft.	45 qts.	9,700	Aug. 18, 10 a. m.	High..... ... Low about 3:30.	Light.	20 hours.	Dry.....	Fine gravel.
	Two diggings averaged 16 per square foot. (1) 15 x 15 inches produced 24 clams. (2) 15 x 15 " " 23 "									

TABLE No. 2.—(Continued).

Number	Location.	Area.	Amount sowed.	Aver. No. per qt.	When sowed.	Condition of Tide.	Condition of wind.	Time between digging and sowing.	How kept.	Remarks.
4	One digging gave 14 per square foot. 15 x 15 inches produced 21 clams.	*b* 25 x 50 ft.	54 qts.	9,700	Aug. 24, 3 p. m.	Half out..... Low about 7:20.	Light.	4 1-2 hours	Dry.....	Fine gravel
5	*Kennebec River*..... One digging in a place with average number of holes gave 31 per square foot. 15 x 15 inches produced 127 clams or 3 quarts. (See figure 00.) (Some of them of more recent set.)	*a* 60 x 150 ft.	108 qts.	9,700	Aug. 19, 2 p. m.	Going out..... Low about 4:10.	Light.	4 1-2 hours	Dry.....	Sandy loam.
5	One digging gave 90 per square foot. 15 x 15 inches produced 138 clams or 4 quarts. (See figure 8.) (Some of more recent set.)	*b* 60 x 150 ft.	108 qts.	9,700	Sept. 7, 9:30 a. m.	Low..... Low about 8.	None.	4 hours.	Dry.....	Sandy loam.
6	*Smith's pasture, Mill Cove*..... Two diggings gave average 23 clams per square foot. 18 x 18 inches produced 56 clams. 18 x 18 " " 51 " As on Cornelius (2 (a) & (b)) lower edge of bed clams very poor.	200 x 60 ft.	153 qts.	9,700	Aug. 23, 3 p. m.	Going out..... Low about 6.	Light.	4 hours.	Dry.....	Marl.
7	*Duck Cove*..... Very few present.	100 x 50 ft.	45 qts.	9,700	Aug. 24, 6 p. m.	Going out..... Low about 7.	Light.	4 hours.	Dry.....	Rocky beach.
8	*South shore, Mill Cove*..... One digging produced 32 per square foot. 15 x 15 inches produced 46 clams.	100 x 60 ft.	108 qts.	9,700	Aug. 26, 5:30 p. m.	High tide..... Low about 10.	Light.	4 hours	Dry.	Coarse gravel & sand.

TABLE No. 2.—(Concluded).

Number.	Location.	Area.	Amount sowed.	Aver. No. per qt.	When sowed.	Condition of Tide.	Condition of wind.	Time between digging and sowing.	How kept.	Remarks.
9	*Old Buttonwoods*..... Showed excellent growth in January, 1901 (See last report). Since then clams have disappeared; either many been dug or otherwise destroyed.	*150 x 60 ft.*	*99 qts.*	*9,700*	*Aug. 28, 1 p. m.*	*Half in* ..... *Low about 10.*	*Light.*	*3 hours.*	*Dry*.....	*Shifting sand.*
10	*Rabbit Island*..... Produced a great quantity of clams. Bed was dug over many times before clams were 1 year old.	*100 x 50 ft.*	*54 qts.*	*9,700*	*Aug. 28, 4 p. m.*	*Almost in*..... *Low about 11:40.*	*Light.*	*6 hours.*	*Dry*.....	*Fine gravel and sand.*
11	*N. shore, Cornelius Island*..... Poor locality; no results.	*200 x 20 ft.*	*45 qts.*	*9,700*	*Aug. 29, 5 p. m.*	*High* ..... *Low about 12:30.*	*Light.*	*3 hours.*	*Dry*.....	*Coarse gravel.*
12	*Quonset*..... Produced good quantity. Thoroughly dug up.	*60 x 30 ft.*	*36 qts*	*9,700*	*Sept. 5, 10 a. m.*	*Half in* ..... *In, 1:20.*	*Light.*	*20 hours.*	*Dry*.....	*Sandy and shifting.*
13	*Cold Spring*..... Evidence of some digging; no results.	*60 x 60 ft.*	*40 qts.*	*9,700*	*Sept. 5, 11 a. m.*	*Coming in*..... *In, 1:20.*	*Light.*	*21 hours.*	*Dry*.....	*Sandy gravel.*

These experiment indicate clearly that it is not necessary to dig up the shore frequently in order that clams may thrive. They show, on the contrary, that the shore, if properly stocked with small clams and left undisturbed, will become exceedingly productive. To obtain the best results, clams should be allowed to grow two years. Nothing could be more short-sighted than the policy, or lack of policy, now in vogue, when no effort is made to increase the product: when all shores are dug indiscriminately; when small clams are taken, which, were they allowed a few months of life, would, without expense to anyone, increase many hundred per cent. in bulk. To form an estimate of the proportion of undersized clams which are constantly being taken, it is necessary only to pay a visit to any of the popular Rhode Island clam-bakes.

There is much difference of opinion in regard to the question of the damage to small clams from covering over with soil in the process of digging, and we have made a few preliminary experiments to determine this point. The experiments are on too small a scale, perhaps, to have great weight, but they are significant so far as they go. Three hundred clams, one and one fourth inches in length, were planted in different depths and in different positions and covered over with soil (a muddy gravel in which clams thrived). After four days they were carefully uncovered, and a record was made of their change in position and of the number which died. The following table gives the result in brief form:

TABLE No. 3.

Depth as a Factor in Planting.—Results Four Days After.

Depth of Planting.	Method of Planting.	Number Planted.	Number alive.	Number dead.	Number missing.	Range in depth.	Average depth.
Just covered over..	Inverted	25	22	3	None.	1″–3″	2″
	Buried flat... ...	25	24	1	None.	1″–3″	2″
	Normal position..	25	25	0	None.	½″–1″–4″	2½″
Six inches	Inverted	25	17	8	None.	4″–6″–7″	6″
	Buried flat.....	25	19	6	None.	3″–5″–7″	5½″
	Normal position..	25	23	2	None.	1″–3″–5″–	4″
	Inverted.....	50	10	37	3	10″–5″–4″	7″
Twelve inches.....	Buried flat.....	50	21	29	None.	5″–6″–9″	8″
	Normal position..	50	33	17	None.	1″–4″–8″	6″

There may have been some other cause of death than their being buried, but the greater mortality among those which were buried deep and among those which were in an unnatural position, lying flat or with the snouts down, would seem to show that their being buried was the chief cause of death.

The Enemies of the Clam.—Passing by the arch enemy, man, there are many lesser enemies of the clam — perhaps more than are known at present. The free-swimming spat are doubtless devoured by most of the animals which, like the oyster, mussel, barnacle, and many other species, derive their food from the microscopic forms which swim in the water. After the clam has set, and while it is preparing to burrow, star-fish, mummychogs, ducks, crabs, etc., feed upon it. Even when it has burrowed, it is not secure from its natural enemies. Evidence of the destructiveness of two of these, the rock-crab, and one of the sea snails (*Neverita*), has been observed during the past summer.

The Rock-Crab.—Anyone who frequents the shore, and has ever watched the incoming tide, knows that the rock-crabs, are seen in great numbers following the encroachment of the water, eager to take possession of the new territory. This is especially noticeable on the evening tide. These crabs, as may be readily observed, are enormous feeders, and evince a shrewdness in overcoming difficulties and taking advantage of situations which is quite remarkable. To just what extent they may be detrimental to the clams is not known. In all probability they help destroy the young clams which are just setting, and a clam which is unfortunate enough to push its way out of the soil would be made short work of. In the early part of September an incident was noticed which showed the possibilities in a crab. A rather small-sized crab, about 1½ inches across, was seen to attack and eat a large scallop, measuring about 2½ inches across the shell. The crab approached the scallop and warily touched it with one claw. The scallop immediately closed up. The crab quietly waited till it opened, and then quickly thrust its claw into the opening between the shells. The scallop closed over the claw, but the crab did not appear to be concerned about it. When the scallop again opened, the crab turned its claw so that the opening would be kept as wide as possible, and then proceeded to tear out the rim and viscera and eat them at its leisure.

Because of this observation, an experiment was made to show whether the crabs could be induced to dig up large clams. A large box (1½ feet x 4 inches across the top and 1½ feet deep) was filled with sand, and fifty clams, averaging 1½ inches, were buried just below the surface. Four large rock-crabs were put in, and the top covered with wire screen. The box was then set out just above low-tide mark, and being opened, two weeks later, the surface was found to be covered with shells. Upon screening the sand, only twenty-nine clams were found alive. The bare shells, with broken edges, bore witness to the fate of the other clams. It is not to be concluded from this that under normal circumstances

the crabs ever touch clams of this size. But it does show that they would, if compelled by hunger.

As a control to the above, experiments with small snails were carried on; and the small percentage of deaths would make improbable the supposition that the clams in the former experiments had first died and had then been eaten by the crabs.

Sea Snail.—*Nevcrita.*—(Figs. 13 and 15).—Often along the shores where clams occur, shells are found with holes neatly bored through them, usually near the hinge. These holes, which are nicely countersunk, measure almost $\frac{1}{8}$-inch in diameter. Similar holes are frequently found in the quahaug shells (Fig. 13). The holes in quahaug shells are easily traced to the sea snail (*Nevcrita*), since in almost every case where a *Nevcrita* is found, if one will examine the under side, a quahaug will be found buried in the folds of flesh. It would have been natural, judging from the similarity of the perforations in the clam and in the quahaug, to assign them to the same cause; but since the clam lies buried in from 6 to 11 inches of soil, and both the snail and the quahaug are surface animals, it is difficult to say positively that the cause is the same, unless these perforated clams are some that have made their way to the surface. In the early part of September, Mr. Madison, while digging in one of our experiment beds, brought up a *Neverita* and clam together from a depth of six inches. The *Nevcrita* had not as yet finished its work, but had already penetrated the shell. The presence of great numbers of bored shells along the shore where clams are thickest gives evidence of the destructiveness of the snail, but it is likely that many of the shells are not brought to the surface and that many more are washed away.

A rather crude experiment was tried, to determine the amount of damage which the snail would do in a limited time. An orange box, with two compartments, was inverted over a part of one of the clam-beds after the surface of the ground had been cleared of debris. One *Nevcrita* was placed in each of the two compart-

ments. A fortnight later the box was taken up. In one side, neither the snail or any bored shells were found; while on the other side, the *Neverita* was found five inches below the surface of the ground near a shell of a clam which had evidently just been eaten. The bored shells of seven others bore witness to the snail's voracity.

Paddler Crabs (Blue crabs).—There is a general belief among clam diggers that the paddler crab is an enemy of the clam. Some consider them to be the controlling factor in determining whether the clams in any season will be abundant or not. Often large holes are found where the young set is abundant. These holes have an appearance similar to those which hens might scoop out in making nests, and some longshoremen have seen the "paddler" digging down and picking out the little clams. In order to ascertain exactly the amount of injury which the crabs might inflict upon clams, three large ones measuring 5 inches across the back were confined in a space (3 ft. x 3 ft.) in one of the commission beds where the clams averaged about 26 to the square foot. The box had the bottom removed, and was covered over with wire screen so the paddlers could be observed without removing the box. A little over a month later (35 days) the box was finally removed. Only one crab remained alive, and there were no signs of its having attempted to dig, although the clam holes were very thick under the box.

An Act in Amendment of Chapter 174 of the General Laws of Rhode Island, "Of the Inland Fisheries."

[Passed March 29, 1901.]

It is enacted by the General Assembly as follows:

Section 1. Section 2 of chapter 174 of the General Laws is hereby amended so as to read as follows:

"Sec. 2. The commissioners of inland fisheries shall introduce, protect, and cultivate fish in the inland waters of the state, and may make all needful regulations for the protection of such fish, and shall prosecute for

the violation of such regulations and of the laws of the state concerning inland fisheries. (*They may in their discretion, from time to time, make experiments in planting, cultivating, propagating, and developing any and all kinds of shell-fish; and for the purpose of so doing may from time to time take, hold, and occupy, to the exclusion of all others, in one or more parcels, any portions of the shores of the public waters of the state or land within the state covered by tide-water at either high or low tide, not within any harbor line and which is not at the time of such taking under lease as a private and several oyster fishery:* Provided, that the land so held and occupied at any one time shall not exceed three acres. Said commissioners upon taking such land shall forthwith give public notice thereof by advertisement in some newspaper in the county in which said land is situated, which advertisement shall contain a description of said land: they shall also forthwith notify the commissioners of shell fisheries of such taking and shall transmit to them a description of said land, and shall also stake out or otherwise mark the bounds of said land. Said commissioners may make all needful regulations for the protection of the land so taken and of all animal life and other property within the lines thereof and shall prosecute the violations thereof.) They may co-operate with the fish commissioners of other states, and they shall make an annual report to the general assembly of their doings, with such facts and suggestions in relation to the subject for which they were appointed as they may deem proper. Said commissioners, whenever complaint is made by them or either of them for a violation of any regulation made by them as aforesaid, or for violation of any of the provisions of this chapter or of chapters 171, 172, and 173, shall not be required to enter into recognizance on such complaint or become liable for costs thereon."

SEC. 2. Section 3 of chapter 174 of the General Laws is hereby amended so as to read as follows:

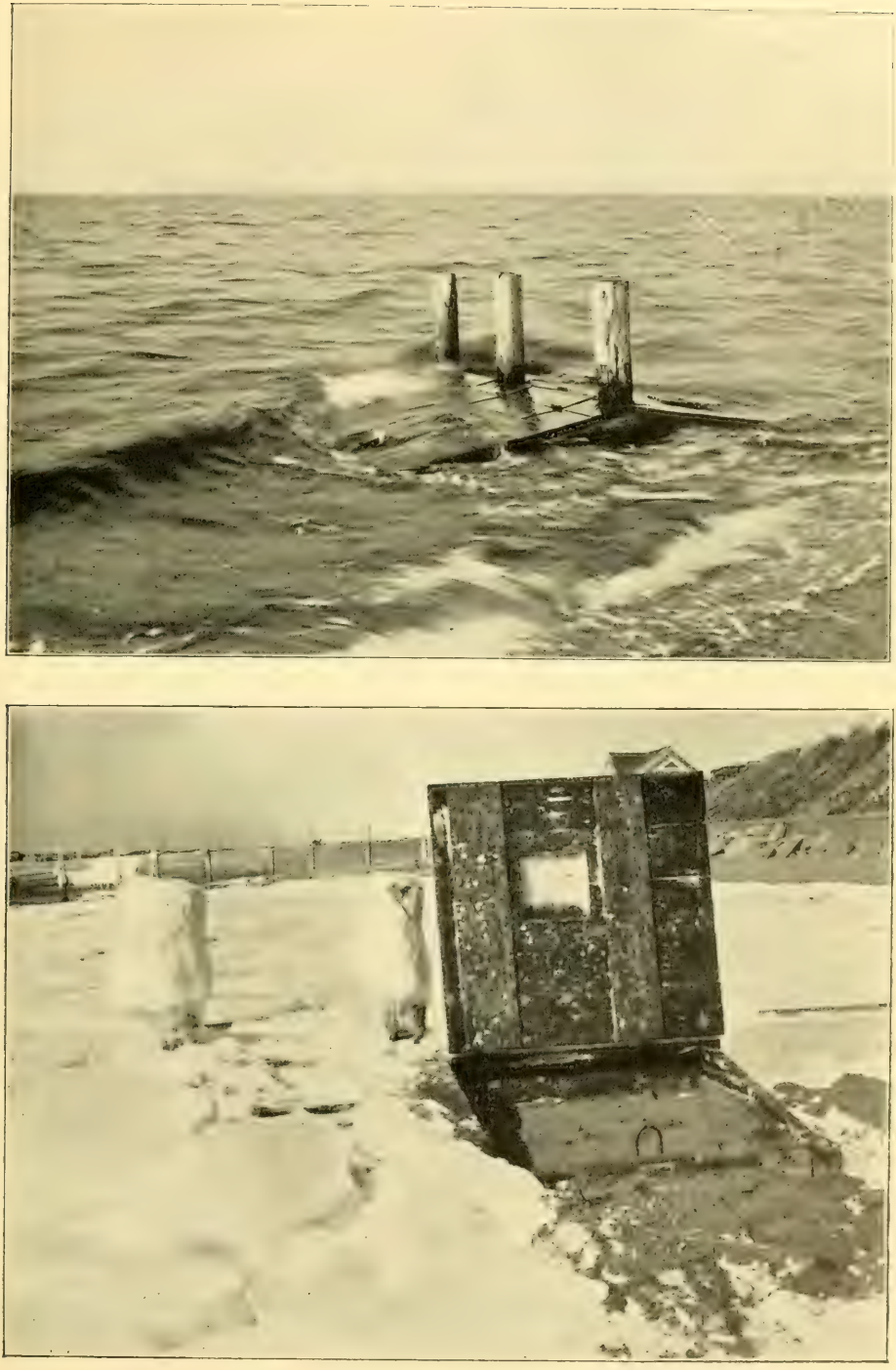
"SEC. 3. The said commissioners shall cause a copy of any regulation made under the authority of the preceding section to be filed in the office of the town clerk of any town in which any waters stocked with fish, or land occupied for experiments under the authority of the preceding section and to which such regulations may apply, may be, and shall also cause a copy of such regulations to be advertised in some newspaper published in the same county."

SEC. 3. Section 4 of chapter 174 of the General Laws is hereby amended so as to read as follows:

"SEC. 4. Every person who shall violate any of the regulations made by the commissioners of inland fisheries under the authority of the

provisions of the preceding three sections, or who shall take any fish, fish-spawn, or any apparatus used in hatching or protecting fish, from any pond, lake, river, or stream stocked with or set apart by said commissioners or by private parties for the protection and cultivation of fish with the consent of the town council of the town where such cultivation is carried on, without the consent of such commissioners or, if the cultivation of fish be carried on by a private party, without the consent of the person cultivating the same, or who shall trespass within the boundaries of any land which may be taken and occupied by said commissioners for their experiments in relation to shell-fish, authorized by section 2 of this chapter, shall be fined not exceeding three hundred dollars or be imprisoned not exceeding six months or be both fined and imprisoned, in the discretion of the court before which the offender shall be tried."

SEC. 4. This act shall take effect from and after its passage.



FIGS. 4 AND 5.—Spat collector on the shore of Mr. Alexander's estate at Rumstick Point. The upper figure shows the collector closed at about half tide, and the lower one gives a view of the conditions with which the clams contend in the water. One of the four covers is lifted and ice has been taken from the inside.

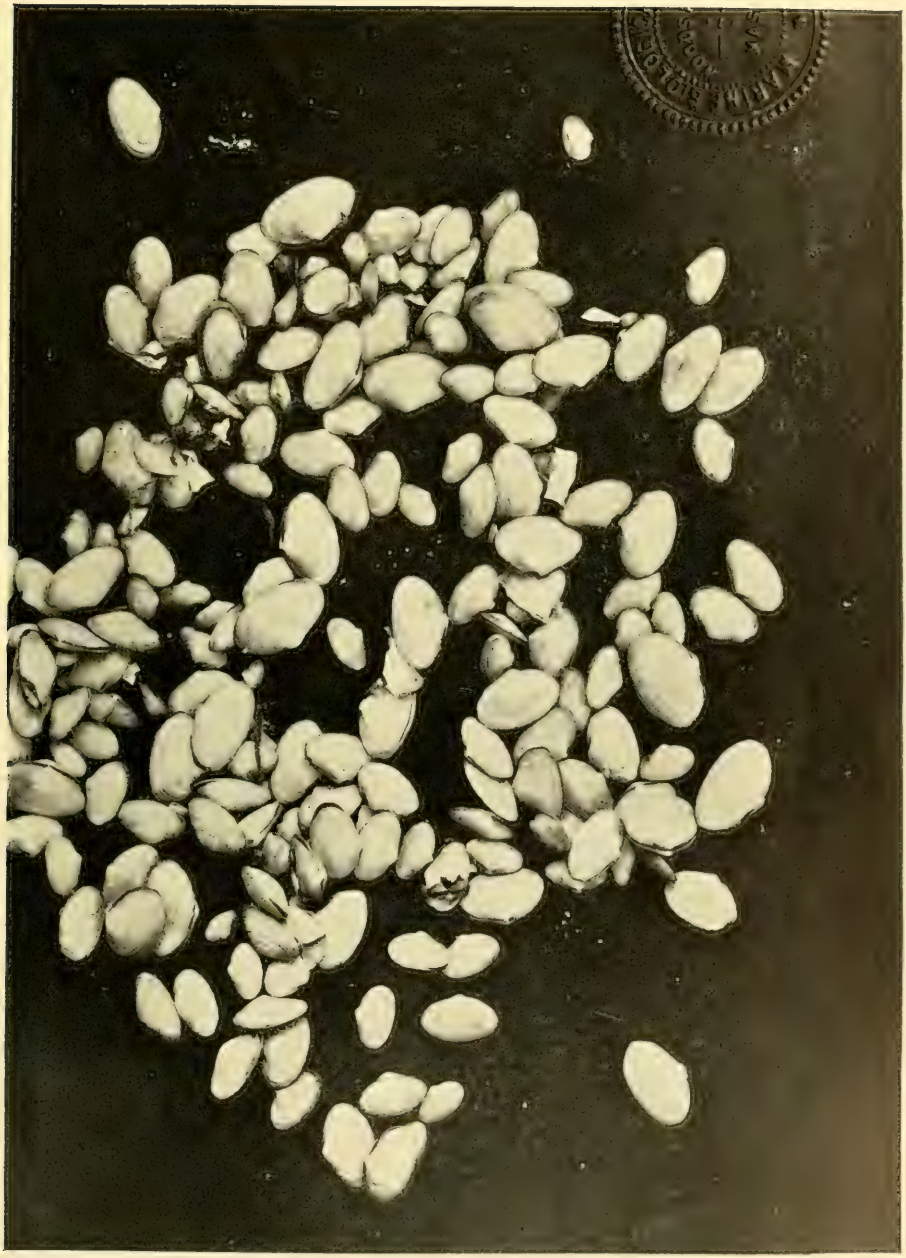


FIG. 6. - Sample of small clams taken on August 17, 1901, at Green's Island. Transplanted to beds reserved for this purpose.

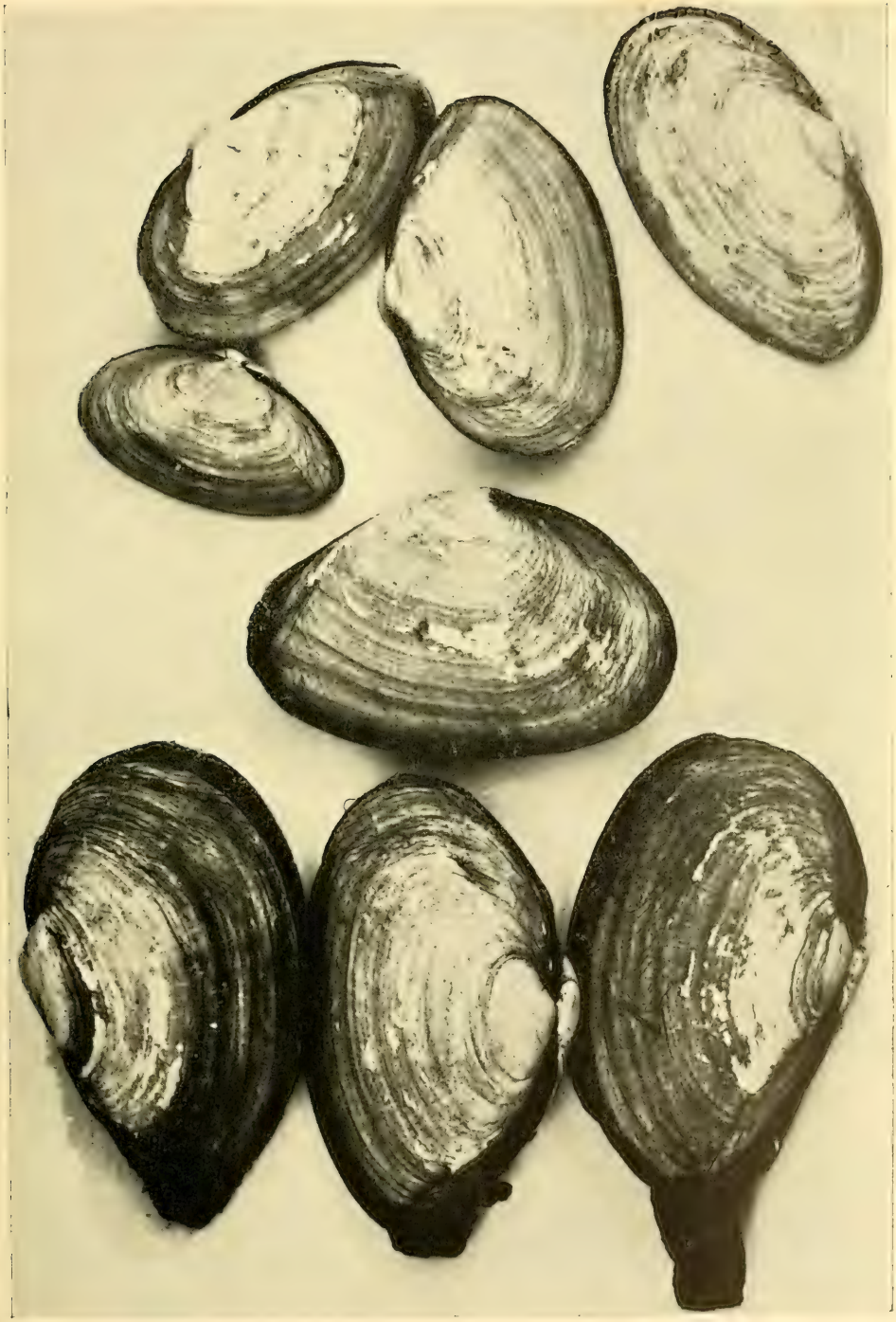


FIG. 7.—Clams set at Green's Island in the summer of 1901; taken from the same place in January, 1902. These clams were therefore about a year and a half old. Photograph natural size.

FIG. 8.—Specimens of clams set at Green's Island, 1901; transplanted to the Kickemuit river when about the size of those in Fig. 6; and finally dug in January, 1902. These clams were one year and one-half old. Photograph natural size.

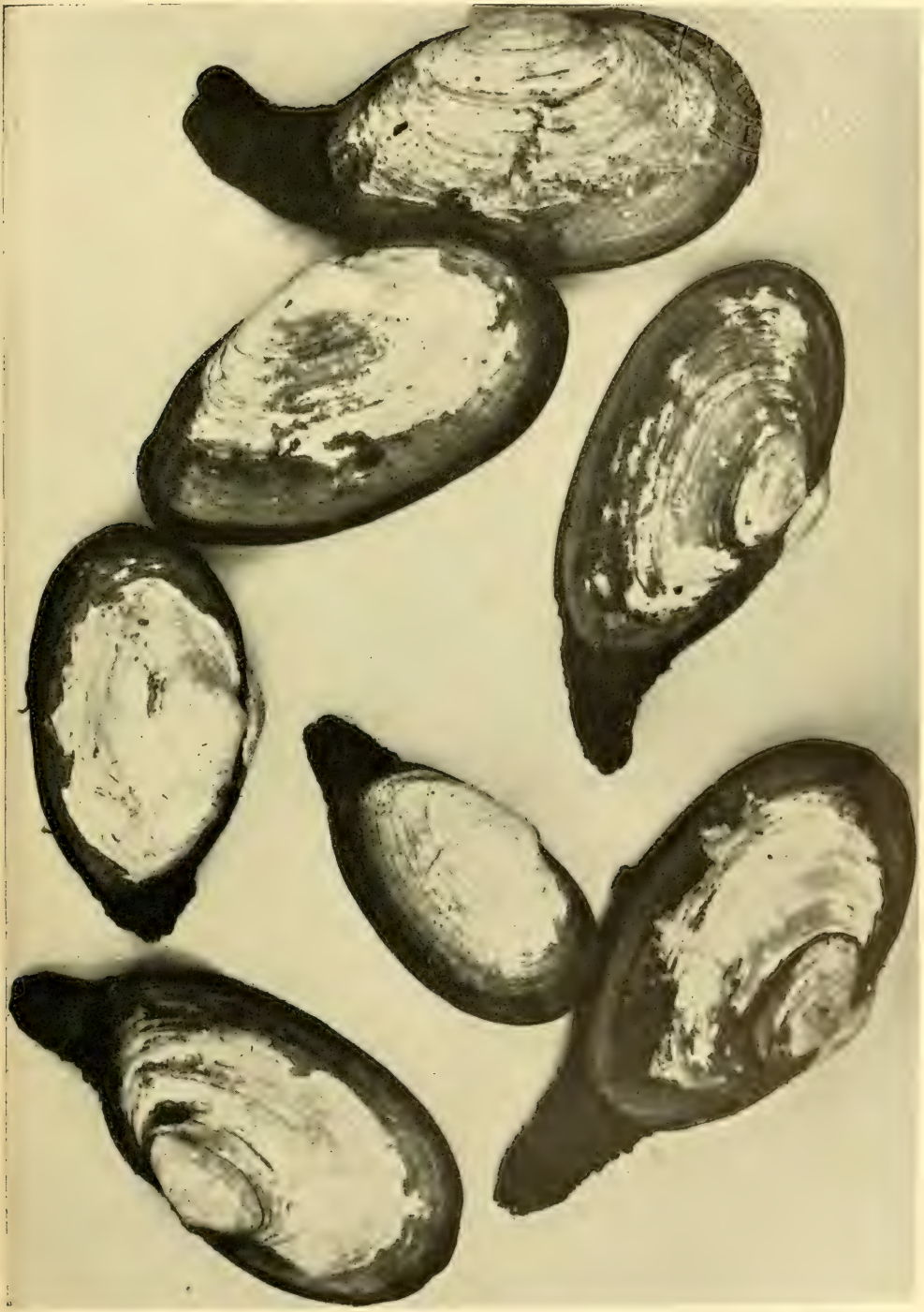


FIG. 9.—Specimens of clams set at Green's Island in 1901; transplanted on Cornelius Island, Wickford, when about the size of those in Fig. 6; and finally dug in January, 1902. These clams were one year and a-half old. Photograph life size.

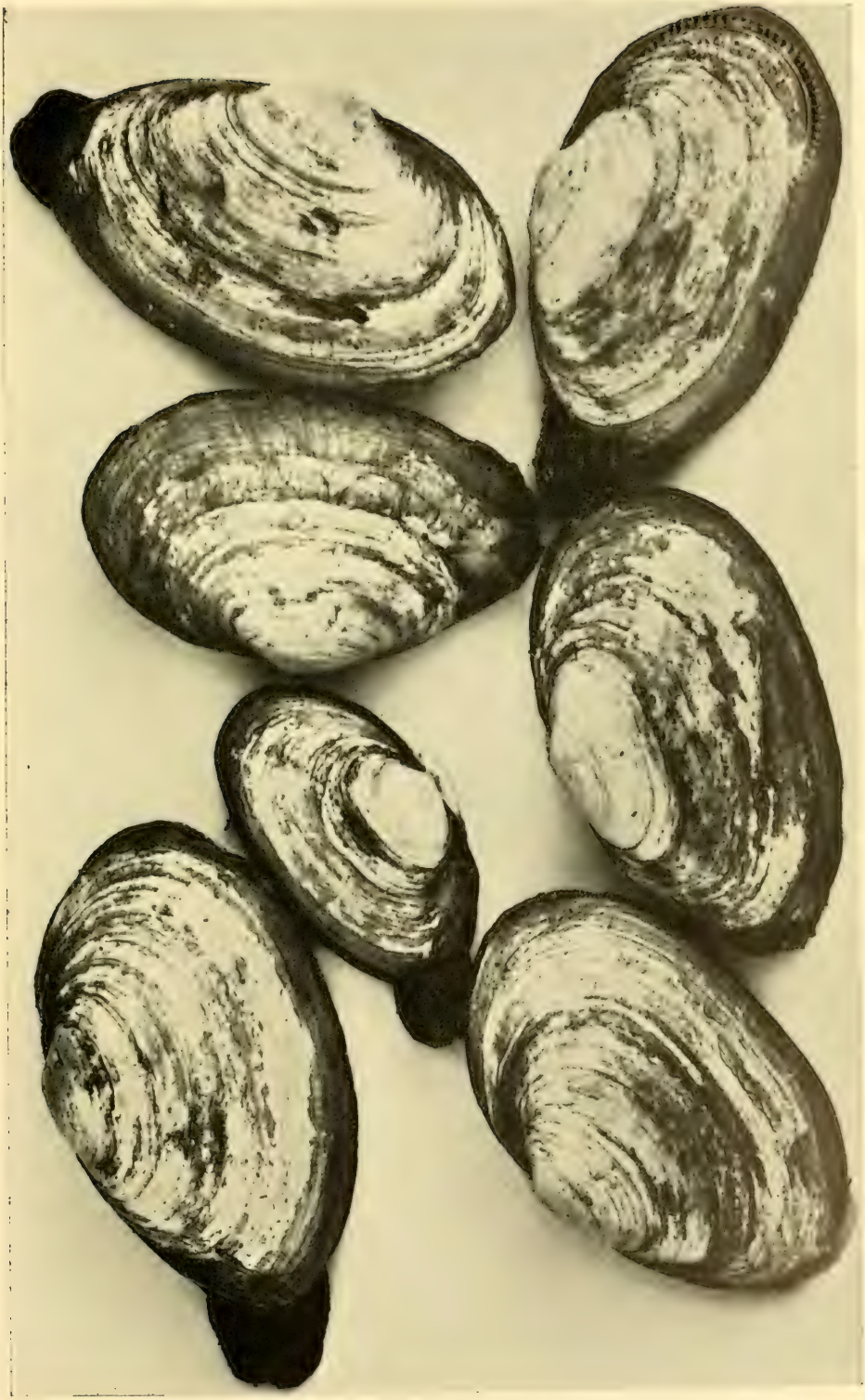
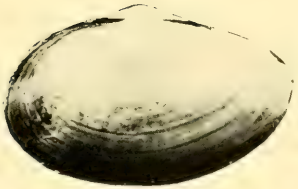


FIG. 10.—Specimens of clams set at Green's Island in 1901; transplanted to south shore of Mill Cove, Wickford, when about the size of those in Fig. 6; and finally dug in January, 1902. These clams were one year and a-half old. Photograph natural size.

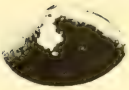
FIG. 11.—Clams set in Point Judith pond since the opening of the breach, and dug October 20, 1902. Life size.

Aug. 14, 1900.

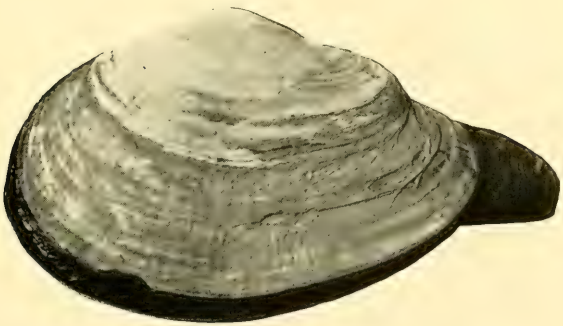
Sept. 8, 1900.



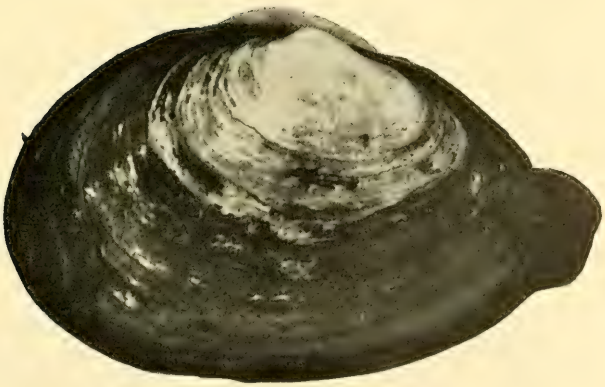
Sept. 20, 1900.



Sept. 20, 1900.



Jan. 30, 1902.



Jan. 17, 1903.

FIG. 12.—Clams set in the summer of 1900 in clam catcher, and raised in sand boxes. The various specimens, taken at intervals, represent their growth during two years and a half. (*See page 34.*) The difference in size of the two specimens on Sept. 20 1900, is due to the difference in locality.

FIG. 13.—Shells of *Neverita*, and shells of quohaugs and clams showing the holes drilled by the *Neverita*. In the smaller quohaug shell the hole is not drilled completely through the shell. Natural size. (*See page 45.*)

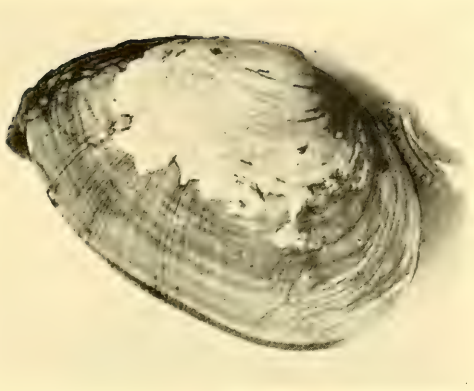


FIG. 14 represents a specimen of the clam from one of the undisturbed beds, and shows the epidermis, or skin, of the clam partly covering the shell.

FIG. 15 is from a photograph, taken through the water, of the living *Neverita* in the expanded condition. Natural size.

FIG. 16.—This represents one of the largest clams taken at the very low tides which often occur in midwinter. These clams are ordinarily beyond the reach of the clam-diggers, and consequently live to be of great size. Natural size.

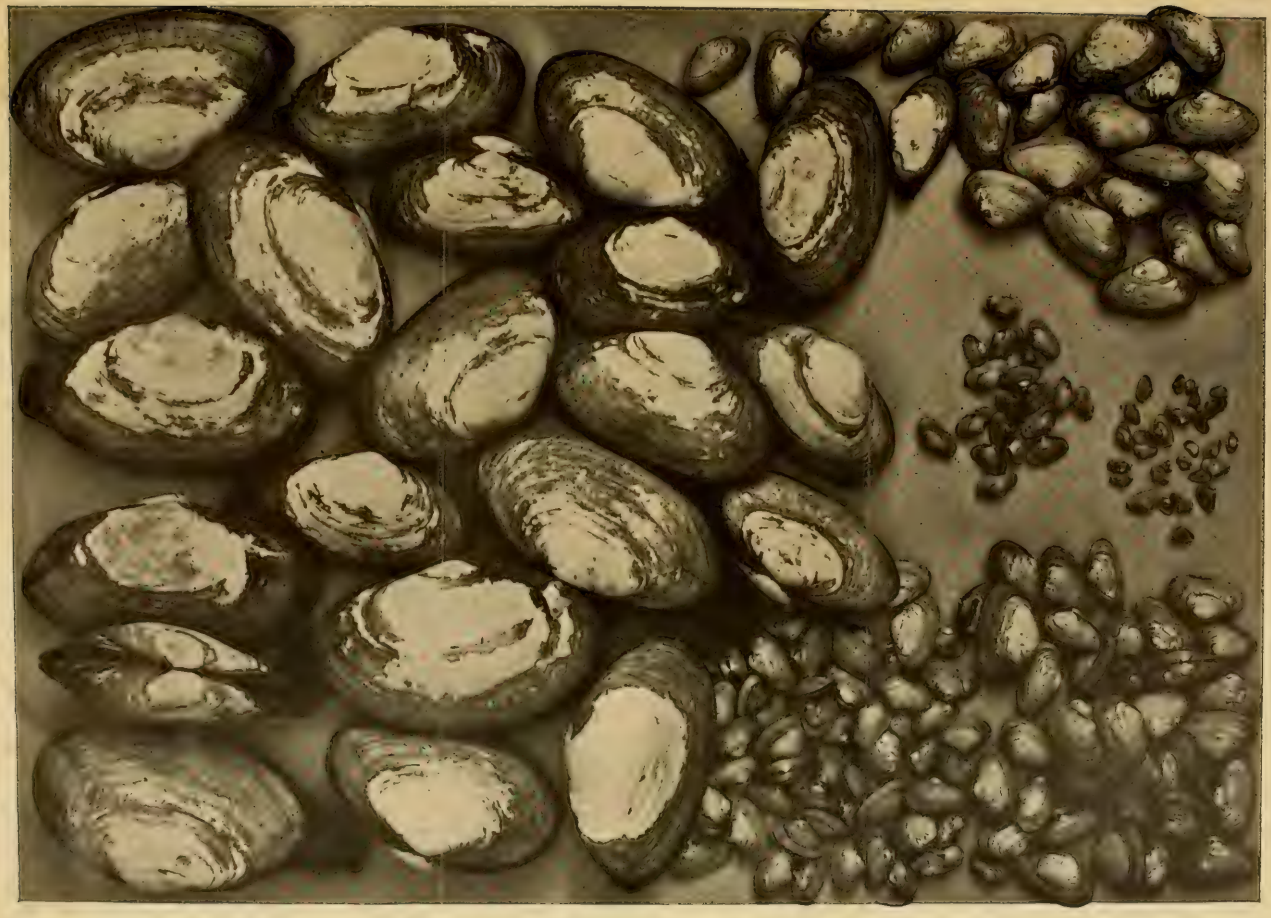


FIG. 17.—Collection of clams taken from an area 6"x6" in the clam catcher at Rumstick Point. All of these clams entered the clam catcher in free-swimming condition since the summer of 1901. These clams were dug January 17, 1903. Life size. (*See page 53.*)

FIG. 18.—A specimen of clams embedded with mussels; taken from Nayatt Point in January, 1903. Life size, from photograph.

VIII. The Investigation of the Quahaug.

This species, *Venus mercenaria*, variously called the quahaug, quohaug, cohaug, cohauk, quohog, quog, hard-shell clam, and (when of small size) little-neck clam, is one of great importance among the food animals of the Bay. Inquiries have come to the commission, from various sources, regarding the breeding habits, growth, and means of cultivating the quahaug. It is not possible, at present, to give satisfactory answers to these questions, and your commission has begun an investigation of the life-history and habits of the animal. The work is in the hands of Mr. A. K. Krause, and a preliminary statement of the investigation he has undertaken is given in the following pages.

PRELIMINARY REPORT ON THE HABITS AND LIFE-HISTORY OF THE QUAHAUG—(*Venus mercenaria.*)

A. K. KRAUSE, BROWN UNIVERSITY.

Questions which naturally present themselves at the beginning of this investigation are:

What is its geographical distribution?

What is its distribution in relation to depth of water?

What is the breeding season?

How, when, and where are the eggs laid?

What are the habits of the young fry?

Are they free swimming, like those of the soft-shell clam?

Do the fry "set," like clam and scallop, and what are their habits after setting?

What is their rate of growth?

At what age do they breed?

What are their natural enemies?

What is their food?

To what extent do they wander or migrate?

What can be done to increase the supply of quahaugs in the Bay?

The systematic investigation of these questions was begun in August, 1902. Inquiry among the fishermen who are familiar with the quahaug brings out a variety of different opinions in regard to them, and an examination of the literature fails to give satisfactory answers. Quahaugs are found in greater or less abundance in all parts of the Bay, from the shore which is exposed at low tide to considerable depths.

The smaller sizes were found to be very abundant in Mill Cove,

Wickford. In the interval of shore between high and low tide levels they might have been taken in great numbers at any time since August. When the tide is out, they rest normally under a thin layer of soil, and seem to have a peculiar affinity for anything that will serve as a support. While they do not limit themselves to this special kind of environment, it is nevertheless noticeable that in any particular area of shore they are more numerous in the immediate vicinity of stones, clumps of sea-weed and eel-grass, large shells, or any object that has become fixed in the dirt. They cluster around almost every stone of any size, imbed themselves in the spaces between the roots of the eel-grass, and, if a larger quahaug has fixed itself for a shorter or longer time, the smaller ones frequently gather around it. In warm weather they seldom move around on the portion of shore from which the tide has receded, but in cold weather many of them come to the surface.

Digging was carried on during late August and early September at Rumstick, Nayatt, Sheep Pen, and Coggshall's Coves, Portsmouth, the Bonnet, and the northern end of Conanicut, but of all places surveyed, Mill Cove showed them in greatest abundance. Here they were so numerous that on September 5, 1902, I gathered 425 within a radius of three feet. As late as January 17, 1903, I found that they had not appreciably decreased in numbers.

In order to determine the breeding season I have closely followed the methods employed for the soft-shell clam. (Described more fully in report of 1899, pp. 43 etc.). There have been three lines of experimentation: First, the examination during the year of large numbers of adult quahaugs, to see whether these contain ripe eggs and sperm at any particular time; second, the skimming of the surface of the water with a silk tow-net, which will take in any free-swimming larvæ that may be present in the water; and third, the endeavor to catch such larvæ in a car, where they may grow and develop under artificial conditions.

It will be necessary to continue these experiments through at least one year, in order to interpret them, for they have given, as yet, mainly negative results.

Another attempt to get at the breeding season of the quahaug was made by an indirect route. As soon as the collecting of quahaugs in the prolific area at Wickford began, it was noticed that, though the animals were apparently just as numerous at one time as another, their sizes varied little. There was not the increase in size that one would expect if the quahaugs have a short and definite breeding season. There were just as many small quahaugs found at the end of September as at the beginning of the month; and, in fact, the catch in January from the same place showed that there were as many small animals as in the previous September. (Fig 19). At first it would seem that this similarity in size means that the quahaugs are breeding throughout the year, a supposition that other evidence contradicts rather than substantiates.

It is possible, and even probable, that the young fry of the quahaug behave like those of the clam; that they "set" upon coming in contact with sticks, stones, eel-grass, and other hard objects along shore. Here again the data is, as yet, insufficient to warrant a conclusion. It is true that, as a general rule, more quahaugs of the smallest sizes so far obtainable are to be found in the eel-grass; but this does not necessarily mean that the quahaugs "set" here and attain a certain size before they venture beyond the confines of the eel-grass. Unlike the clam, the quahaug is an animal that possesses the power of locomotion to a comparatively high degree; and it may "set" almost anywhere on shore, and then make its way into the eel-grass. This is a point that remains to be determined.

Rate of Growth. — The measurements used in determining rate of growth in the quahaug are the following:

1.—The dimension from the hinge to the free edge of the valve, or the dorso-ventral diameter.

2.—The long diameter.

3.—The thickness of the animal, or the lateral diameter.

On August 20th six quahaugs were measured, marked, and replanted. Their dimensions on this date, on September 5th,

FIG. 19.—The above figures represent a series of quohaugs taken January 17, 1903, showing the gradation in size referred to on page 52. The clam shell and quohaug shells in the lower part of the figure illustrate the method of determining the rate of growth by notching the shell. The growth takes place at the edge, and the notches are left as distinct marks upon the shell.

and on September 26th, are here given in millimeters (1 mm. —$\frac{1}{25}$ of an inch).

TABLE No. 4.

Dorso-ventral diameter (hinge to edge of shell).

	Aug. 20.	Sept. 5.	Sept. 20.
No. 1	23.5 mm.	24.5 mm.	26.0 mm.
" 2	17.5 "	19.0 "	20.0 "
" 3	15.0 "	none taken.	18.5 "
" 4	19.0 "	19.5 mm.	21.0 "
" 5	19.0 "	20.0 "	21.0 "
" 6	21.5 "	22.0 "	24.0 "

Antero-posterior diameter (length).

No. 1	27.0 mm.	28.0 mm.	30.0 mm.
" 2	18.5 "	19.5 "	23.0 "
" 3	16.0 "	none taken.	20.0 "
" 4	20.5 "	22.0 mm.	25.0 "
" 5	21.0 "	22.5 "	24.0 "
" 6	23.0 "	24.0 "	26.5 "

Lateral diameter in thickest part.

No. 1	13.5 mm.	14.0 mm.	14.5 mm.
" 2	9.0 "	9.5 "	12.0 "
" 3	8.0 "	none taken.	10.0 "
" 4	10.0 "	11.0 mm.	12.5 "
" 5	11.0 "	11.0 "	11.0 "
" 6	11.5 "	12.0 "	13.0 "

Analysis of these figures shows that the average growth per animal in the dorso-ventral direction was 2.5 mm., and in length 3.75 mm., for the five weeks between August 20th and September 26th. This would permit an average weekly growth of 0.5 mm. in breadth and 0.75 mm. in length. These particular quahaugs were placed under favorable conditions. They were kept in a car in the house-boat float, where they were covered with water continuously, and thus assured a food supply as abundant as possible. Unfortunately they were lost about the first of October, so that no further data concerning their growth is obtainable.

On September 10th, a hundred quahaugs were planted in a box whose bottom was covered with sand. The free edges of the valves had been notched so that their subsequent growth could be determined at any time by measuring from the notch to the edge of the shell. Specimens taken from this box on October 16th, or thirty-six days after planting, showed an average growth of 2.0 mm. (from the hinge to the edge). This would mean a weekly average growth of 0.4 mm. The box was placed at about half-tide level on the south shore of Mill Cove.

On October 16th, four hundred quahaugs were planted in the soil at low tide level on the south shore of Mill Cove, and directly down from the box planted on September 10th. These quahaugs have been living under conditions that are as natural as could be given them. They are in the same soil from which they were taken, and have a limited area (about five feet square) over which they can move. Covering them, protecting them from enemies, and confining them to the space to which they were transferred is an inverted box, whose sides have been driven into the mud and whose wooden bottom (which is now the top) has been replaced by a wire screen. On January 19th, 1903, specimens taken from this colony showed a growth that in the dorso-ventral direction averaged only 1.0 mm. This indicates a slow growth as compared with that of the clams planted in the sand bar on September 10th. The latter had grown 2.5 mm. since October 16.

This marked difference in the rate of growth of quahaugs during the same period may be due to several causes, such as their position with reference to the depth of water and the character of the soil in which they were planted. Further experiments are now in progress which have particular reference to the influence of soil upon the rate of growth. If this factor is potent in determining the growth, the fact is of considerable importance from the economic point of view.

IX. Experiments in Lobster-Culture.

The question of the importance of building up the waning lobster industry of Rhode Island needs at the present time no argument. The fact that the lobsters are becoming scarce, and that the demand is very great, notwithstanding the increase in price, which makes that formerly common food distinctly a luxury, is all too obvious. One Providence dealer alone imports from outside our State more than thirty thousand dollars' worth of lobsters annually, and the Commission of Sea and Shore Fisheries of Maine estimates the value of the catch of lobsters in Maine for the year 1902 at $1,226,561. How to stop the decline of the industry is not a new problem, but is every year becoming a more serious one. Every State which has a lobster fishery has passed laws restricting, in various ways, the catching of lobsters; and the United States Fish Commission, as well as those of some of the States, has spent large sums of money in attempting to increase the supply by hatching the eggs artificially.

The new line of attack suggested and strongly urged in 1898 by Professor H. C. Bumpus, then a member of your commission, and Director of the U. S. F. C. laboratory at Woods Holl, has been developed and carried into effect by your commission during the last three years: namely, the development of a feasible method of protecting the young lobsters through the most perilous stages of growth. Your commission have devised an apparatus entirely unique in principle and application, which has made it for the first time possible to rear lobster fry through these early stages in considerable numbers.

A second significant step which has been taken toward the solution of the problem of lobster-culture is the demonstration beyond possibility of doubt that the young lobsters can live through the winter in the shallow estuaries of Narragansett Bay, where they are subjected to the extreme cold of winter and to the increased

freshness of the water in the early spring. The progress of these investigations has been recorded in the reports of the commission of the last three years, and the following pages give, besides a brief review of the early reports, the results which have been obtained during the past season.

HABITS AND GROWTH OF THE LOBSTER, AND EXPERIMENTS IN LOBSTER-CULTURE.

(THIRD PAPER.)

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The investigations recorded in this and the two previous papers on the same subject have been conducted in the endeavor to contribute new data which, combined with those obtained by Herrick,* Bumpus, and other writers, should furnish an adequate knowledge of the lobster and the conditions under which it lives. Definite information relating to the following questions is not only of general biological interest, but of direct economic importance: the geographical distribution of the lobster, and its distribution relative to the depth of the water; its breeding habits, including the time, place, and frequency of breeding, manner of depositing and caring for the eggs, number of eggs deposited and the method of their dispersement, age and size attained before breeding begins, and the numerical proportion of males and females; the habits of the young fry, their movements, their food and manner of feeding, their natural enemies, their adjustment to physical conditions such as temperature and density of water, their rate of growth, manner and frequency of moulting, the changes in structure and habits which accompany the early moults; the habits and requirements of the young lobsters which have passed through the earliest stages; the rate of growth and age of lobsters up to the marketable size; the migration of adult lobsters along the shore and to and from the waters of adjoining States; their migrations to and from deep water; the rate of growth of

*Bulletin of U. S. F. C., Vol. XV, for 1895.

large lobsters, and the extreme age to which lobsters may live and breed.

Besides these questions, additional ones confront us in any attempt to overcome the abnormal conditions which the excessive fishing for lobsters has created: for example, the problems of hatching the eggs artificially in such a manner as to increase the natural number of fry, and of depositing the newly hatched fry where the conditions are more favorable than those which surround them when deposited naturally; the possibility, feasibility, and the methods of confining, feeding, and protecting the young fry until they can take care of themselves much better than when they are first hatched; and the possibility, feasibility, and methods of rearing the lobsters from the egg to maturity in confinement. Upon the solutions of such problems will depend the future of a great fishing industry in which Rhode Island, because of her location, is particularly interested.

Of the problems enumerated above, those referring to the habits of the fry, to the rate of growth, and methods of rearing the fry from the earliest stages to the adult, have especially engaged the attention of this commission. In order to render intelligible the work of the past season, we must briefly review some of the facts already published.

Geographical Distribution, and Distribution Relative to Depth of Water.—The lobster ranges from Labrador to Delaware, and inhabits the waters from the very shore to a depth of more than 100 fathoms. "It is thus confined to a strip of the Atlantic Ocean about 1,300 miles long, and at some points (as the coast of Maine) from 30 to upwards of 50 miles wide." (Herrick.)

Breeding Habits.— The eggs are laid, for the most part, in the late summer, July and August, but the laying season varies within certain limits according to the latitude, and frequently extends into the fall and winter in the case of certain individuals. The eggs are carried, through the winter and spring, under the tail of the females, attached to the swimmerets, and the hatching begins in May and ends about the middle of July. The

number of eggs deposited varies with the size of the lobsters, and probably also with other conditions, since one lobster may bear three times as many eggs as another of the same size. The number of eggs is known to vary from 3,000 to over 90,000, as may be seen by consulting the following table:

TABLE No. 5.

Length of Lobster.	Smallest number of eggs.	Largest number of eggs.	Average number of eggs.	Number of lobsters examined.
8 inches	3,045	9,135	4,822	6
8¼ "	6,090	7,612	6,851	2
8½ "	3,045	12,180	6,935	9
8¾ "	6,090	9,135	7,105	3
9 "	3,045	18,270	7,902	143
9¼ "	6,090	12,180	9,083	35
9½ "	3,045	20,792	9,297	241
9¾ "	3,045	15,225	9,947	55
10 "	3,045	24,360	10,555	514
10¼ "	6,090	22,838	11,622	61
10½ "	3,045	36,540	12,905	532
10¾ "	6,090	24,360	14,067	45
11 "	3,045	48,720	15,410	568
11¼ "	6,090	25,882	17,102	43
11½ "	3,045	42,630	18,668	307
11¾ "	12,180	24,360	17,993	11
12 "	3,045	54,810	21,351	414
12¼ "	18,270	27,405	23,396	8
12½ "	9,135	42,630	24,812	156
12¾ "	18,270	42,630	26,390	12
13 "	6,090	48,720	28,610	321
13¼ "	24,360	48,720	33,495	5
13½ "	6,090	54,810	32,858	146
13¾ "	42,630	42,630	42,630	2
14 "	6,090	85,260	36,960	426
14½ "	21,315	60,900	42,968	90
15 "	12,180	97,440	46,524	280
15¼ "	.....	.....	54,810	1
15½ "	24,360	97,440	53,795	45
15¾ "	48,720	54,810	50,750	3
16 "	24,360	97,440	57,146	103
16¼ "	.....	.....	66,990	1
16½ "	36,540	85,260	66,053	13
17 "	12,180	85,260	63,336	36
17½ "	60,900	73,080	64,960	3
18 "	60,900	91,350	77,430	7
19 "	54,810	91,350	77,647	4
Total number examined				4,645

Table of the production of eggs compiled by F. H. Herrick from 4,645 observations upon egg lobsters brought from various localities into the U. S. F. C. lobster hatchery at Woods Holl. (See Herrick, p. 51.)

There is apparently no limitation to the localities where eggs may be deposited. The very young fry and females carrying eggs ready to hatch are found from shallow water to very deep water. In the latter part of June, 1902, Mr. Vinal N. Edwards, the veteran collector and naturalist of the Woods Holl Fish Commission station, found young fry swimming at the surface about 40 miles off No Man's Land. There are many stories of doubtful authenticity relating to the maternal care which female lobsters display for the young, but they can hardly be reconciled with what is known of the habits of the newly hatched fry. The latter are entirely free, have no means of attachment, and are readily scattered by the tides and waves.

The Size Attained by Lobsters before They Begin to Spawn. — This question is one of obvious importance in view of the almost universal short-lobster legislation. It would seem, from common observation, and from the results obtained by Herrick from the large number of measurements, that the majority of female lobsters begin to spawn when they are about 10½ inches in length. They occasionally spawn at 8 inches, or even at a smaller size; and, on the other hand, they sometimes reach 12 inches without having spawned. Whether they have ever spawned or not can be proved with reasonable certainty by dissection. Herrick found that of 61 female lobsters from 9 to 13 inches in length, taken at random, 25 had never spawned, though 9 would have done so in a few weeks. (Eleven of the 25 were 10½ inches or more in length.)

These investigations should be extended, but at present the facts seem to indicate that, if the Rhode Island law intends to protect lobsters until they have had at least one chance to spawn, it should be altered to conform with the 10½-inch law of Maine and Massachusetts.

The Numerical Proportion of Male and Female Lobsters. — In general the sexes seem to be about evenly divided, but in certain localities and at certain seasons of the year one sex or the other may predominate. For example, in May, 1894, of 1,318 lobsters caught off No Man's Land, only 84 were males; while north of

Plymouth, according to Atwood, in 1886, fully three-fourths of the catch were males. (Herrick, pp. 73–74.)

Habits of the Young Fry. — The young lobsters, after hatching, shed their skin three times during as many weeks; and following each moult there is a marked change in the structure as well as in the size of the animals. Accordingly, it is convenient to designate the young immediately after hatching as belonging to the "first stage;" after they have moulted once, as belonging to the "second stage," and so on. The surest and quickest means of distinguishing the different stages is by the appendages along the underside of the abdomen (tail). In the first stage there are none; in the second stage several pairs of swimmerets are present; in the third stage appendages appear upon the end segment of the tail. The fourth stage is so different from the preceding ones that no difficulty is ever experienced in distinguishing it.

During the first three stages the lobsters swim near the surface in an aimless, jerky way, that reminds one of a "wiggle-tail" (mosquito larva). They are entirely unfitted for a bottom life. The thorax bears five pairs of forked limbs, which ultimately become the walking limbs of the lobster. One branch of each leg — the lower — extends forward and downward, and is used solely for feeding; the other, which is fringed with long hairs, bends upward to the side of the thorax, and by vigorous downward strokes helps to keep the larva afloat. The abdomen ("tail") of these lobsters is bent downward at right angles to the body, and is the chief swimming organ, and by means of rapid, irregular, downward strokes sends the animal tumbling over and over. When the lobster has nearly reached the surface, it often rests for a little, and sinks gradually toward the bottom. Although insatiate and voracious, the young lobsters do not seem to search for food; and, although the sea is full of enemies, among which their own fellow lobsters are conspicuous, they do not try to avoid them, nor in any way show fear.

The duration of each stage is indefinite, depending upon the water temperature, the food supply, and the general health of the

lobster. The first stage lasts about three days, the second about four or five days, and the third usually about five or six days, though the length of each period varies greatly. From nine to sixteen days (sometimes longer) are required for the larvæ to pass from the first to the fourth stage.

A most marvellous change of form, and an even more astonishing change of habits, occurs at the third moult. The emerging fourth-stage lobster has the general form of the adult. The abdomen is no longer bent down at right angles to the body, but, as in the adult, extends straight behind. The downward stroke of the abdomen, which was the chief means of motion during larval life, is now used, as in the adult, only for rapid retreat. All five pairs of walking legs have lost their upper branches, and the first pair, which now are the large characteristic "nippers," are extended straight in front of the head while the lobster is swimming. The other walking legs are relatively shorter than in the larva, and are fitted for walking. These structural changes are accompanied by more radical changes in habits and instincts. The lobster, no longer helpless upon the bottom, burrows under shells or stones, and forms a home, from which it sallies forth to crawl over the bottom, or swims about in search of food, and to which it retires when satisfied or attacked. A new style of swimming, which lasts only a week or two, is now adopted. The tail being extended straight behind the body, and the large claws extended in front of the head, the lobster swims forward in a straight and perfectly definite course by the strokes of the swimmerets. No trace of its former aimless activity remains, for the lobster now actively seeks food, avoids enemies, and retreats from danger. The active, but careless and helpless, infancy has been succeeded by enterprising, independent youth. The fourth-stage lobster has passed the most critical period of its entire life and is vastly better fitted for the struggle for existence than at any earlier stage.

Habits and Requirements of Young Lobsters Which have Passed Through the Earliest Stages. — Young lobsters from 1 to 5 inches in

length are frequently found under stones along a rocky shore, and sometimes are caught in traps, on sandy, muddy, or rocky bottom; they are often found also in the stomach of the cod and dog-fish, at a long distance from the shore. They are, therefore, of wide distribution, as far as the depth of water, character of the bottom, and distance from shore is concerned. The lobsters which have been raised at the house-boat of this commission have furnished an excellent opportunity for observations upon the habits of the animal during this little-known period of life. The hiding and burrowing habits which are taken up when the fourth stage is reached continue to be characteristic of the lobster during the adolescent period, and doubtless throughout life. In the cars where they are confined, the young lobsters show a ready appreciation of anything which will serve as a hiding place, such as shells, stones, broken tile, or seaweed. There is also a marked individuality among lobsters, which is displayed in their preference for certain nooks, burrows, or other places of concealment, and in the relative timidity or boldness in the matter of feeding and of fighting. This factor can by no means be left out of account in an attempt to ascertain the rate of growth, age of maturity, etc. Some individuals soon take the lead of the rest in point of size, from the fact that they are more enterprising and get more food, and once they acquire this advantage, they do not give it up, but constantly menace the safety, and, indeed, the life, of the less courageous individuals. The result is that, in every instance where a considerable number of lobsters in the fourth stage are put into a car and kept apparently under the same conditions, a great difference in growth occurs, and after a few months certain individuals are found to be twice the length of others.

Some interesting and important questions have arisen in regard to the habits of the young lobsters during the winter season. Do they, as is commonly supposed, migrate into deep water when the cold weather comes on? If so, would these migrations take them outside our Bay? Can they withstand the cold of winter, and the freshened water of early spring? The extent of such migrations,

if they occur, is not at present known; but occasionally lobsters less than three inches long are washed ashore by heavy gales in midwinter, and this would indicate that all had not gone into deep water. Such a phenomenon is recorded by Vinal Edwards, at Woods Holl. On January 28, 1882, after a severe storm, Mr. Edwards found many of these specimens on the shore at Nobska Point, and on the point where the United States Fish Commission station now stands. Sixteen of them were preserved, and their measurements recorded in Herrick's monograph, page 164.

We have succeeded, in Wickford, in raising some of the lobsters hatched in the summer of 1900 and 1901. These were carried through the winter in cars, which were sunk in the channel at the entrance of Mill Cove, at a depth of about eight to ten feet at mean tide. The surface was often frozen over, and when the cars were raised in the spring, the lobsters were subjected to comparatively fresh water (the density of the water in the cars on May 11, 1901, was only 1.0095, while the average density is about 1.020). In these experiments the cars were sunk in November and not raised until spring, except in one instance. Some food material probably entered the cars through the wire screening, but other than this no provision was made for feeding the lobsters. They seemed not to have suffered from their long fast, and when, on the occasion referred to, one of the cars was raised in the latter part of December, they were certainly in no mood for feeding, but were so torpid with the cold that they could readily be picked up with the hand. Those taken out for samples became very lively when they were warmed.

These observations prove conclusively that the conditions of our more shallow estuaries meet the actual requirements of the young lobsters the year round; and they point also to the conclusion that perhaps the migration into deep water in the winter is limited, and that their disappearance is in part due to the torpor produced by the cold, which makes the animals at this time less in evidence than during the warmer months.

Rate of Growth of Young Lobsters Beyond the Fourth Stage.

We have attempted at Wickford to raise the young lobsters from the egg to maturity, in order to determine not only their habits and requirements at various stages and in various seasons, but to ascertain as nearly as possible the normal rate of growth. The experiments in this line were begun in 1900. A number of lobsters in the fourth stage were put into cars provided with sand, gravel, seaweed, etc., to simulate as closely as possible the natural environment. The sides of the cars were made of galvanized iron screening, which allowed a free circulation of water. During the summer the cars were suspended from the house-boat, or from floats, so that the water in them was about eighteen inches deep. In the fall they were provided with tight-fitting covers, and were sunk in the channel in from eight to ten feet of water (see p. 64), and left undisturbed until spring. The lobsters were frequently fed during the summer, but in the winter no food was given them, although they may have obtained some from the water or from the animals which grew in the car. The same methods were pursued in succeeding seasons. The question at once arises, does the rate of growth of these lobsters, kept in confinement, fairly represent the rate of growth in their natural environment? It is impossible to answer this question definitely at the present time, but the following facts have a bearing upon it. The cars seemed to furnish a natural environment, for not only were the lobsters in a healthy condition, but seaweed, oysters, clams, mussels, shrimp, tunicates, barnacles, various specimens of marine worms, and other animals grew inside of the cars as rapidly and normally as in other places. Other experiments have proved that star-fishes, raised in similar cars, maintain a normal rate of growth.

More direct evidence may sometime be derived from a comparison of the size of lobsters in the cars at a certain age with that of specimens caught at certain times of the year in lobster pots, under stones, in the stomach of codfish, etc. The hatching season of the lobster is, in our waters, apparently definite, and

extends between the latter part of May and the middle of July. When, therefore, lobsters two or more inches in length are caught from the ocean during this hatching period, it is practically certain that they are at least one year old. If a considerable proportion of these should be of the same size as the specimens which have been raised and kept in confinement for a year, it would show that the latter had kept pace with some, at least, of the lobsters in the natural habitat. In Herrick's tables of measurements, of about sixty lobsters between $1\frac{1}{4}$ and 6 inches long, he gives two specimens, which were caught in June, at Woods Holl. One of these, caught June 1, 1891, measured $69\frac{1}{2}$ millimeters (equals $2\frac{3}{4}$ inches); the other, caught on June 30, also at Woods Holl, measured $74\frac{6}{10}$ millimeters (3 inches.) The measurement of the Wickford lobsters on May 31, 1902, when they were about a year old, showed that, of the twenty-five specimens, eight were equal in length, or longer, than the June 1 specimen of Herrick's table. Three of our specimens were 74 millimeters or over (see table 9.)

The comparison of only two specimens caught from the ocean is an uncertain basis for general conclusions, but it shows, at least, that some lobsters in natural conditions do not grow more rapidly during the first year than some of those kept in the cars.

The accompanying tables explain themselves, but there are a few points which deserve especial attention. The size of the lobsters of the same age varies greatly, though they are reared in the same car and under apparently the same conditions This is greatly marked in the lobsters two or three months old (table 6) and is also evident among the oldest lobsters raised. The measurements of length hardly give a correct impression of the amount of variation, for a slight difference in the length means a great difference in bulk. Figure 23, reproduced life size, from a photograph taken October 20, 1902, of three lobsters, about 1 year and 4 months old, gives a better idea of this variation. The immediate cause of these variations is probably the difference in the amount of food taken by different individuals, and this, in turn, depends upon accidents of location, etc., which bring the food to

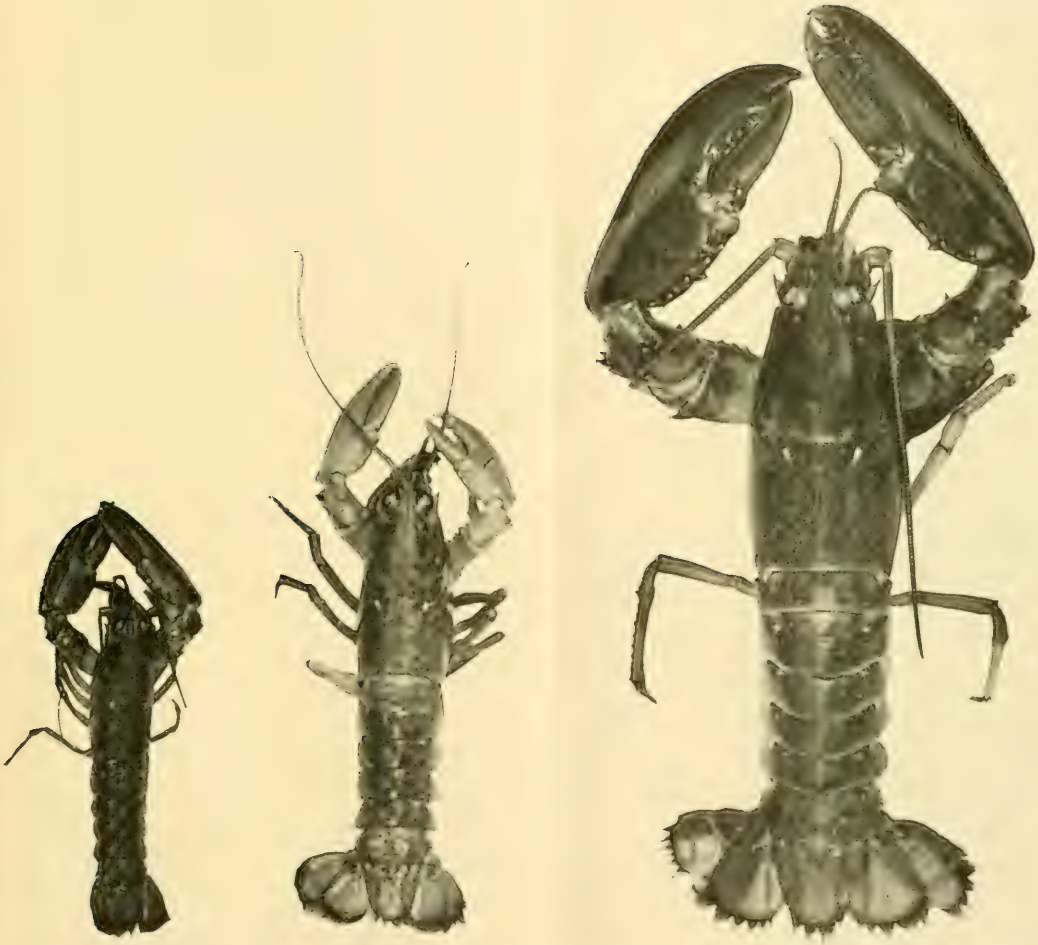

FIG. 23.—Three lobsters of the same age, illustrating the differences in the rate of growth. They were hatched in summer of 1901, and photographed alive October 23, 1902. Age about one year and four months. Life size.

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the lobsters; but it depends also upon the difference in disposition of individual lobsters, for, when food is put into the car there is enough for all, but some individuals prove themselves to be much more courageous than others in foraging for food.

The second point which we would emphasize is similar to the first, namely, the greatly increased rapidity of growth in the lobsters, which are placed only a few in a car (see table 99. Cars No. 53 and No. 54, as compared with cars No. 52 and No. 56). Fear of one another, rather than the difference in the amount of food put into the car, is the main factor in bringing about this discrepancy in the rate of growth. The general problem of the rate of growth and the factors which control it is worthy of careful investigation.

TABLE No. 6.

Measurements of Lobsters Hatched in 1900, Showing Growth During First Summer.

(Each column represents a separate car).

Hatched May 31. Measured Sept. 15. Age 3½ months		Hatched June 10. Measured Sept. 15. Age 3 months.		Hatched June 26. Measured Sept. 15. Age 2½ months.		Hatched between May 31 & June 26. Measured Sept. 15. Age ab't 3 months.		Hatched between May 31 & June 26. Measured Sept. 15. Age ab't 3 months.	
mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.
26	1 1/16	21	13/16	20	13/16	19	3/4	20	1 3/16
30	1 2/16	22	7/8	21	13/16	20	13/16	22	7/8
30	1 3/16	22	7/8	23	15/16	21	13/16	23	15/16
30	1 3/16	25	1	24	15/16	22	7/8	23	15/16
31	1 1/4	27	1 1/16	25	1	22	7/8	23	15/16
33	1 5/16	27	1 1/16	25	1	22	7/8	24	15/16
33	1 5/16	30	1 3/16	26	1 1/16	24	15/16	24	15/16
33	1 5/16	30	1 3/16	26	1 1/16	24	15/16	25	1
35	1 3/8	30	1 3/16	27	1 1/16	24	15/16	25	1
36	1 3/8	30	1 3/16	27	1 1/16	25	1	26	1 1/16
37	1 7/16	32	1 1/4	27	1 1/16	25	1	26	1 1/16
38	1 1/2	32	1 1/4	29	1 1/4	25	1	27	1 1/16
38	1 1/2	32	1 1/4	30	1 3/16	25	1	28	1 1/8
39	1 9/16	32	1 1/4	30	1 3/16	25	1	28	1 1/8
44	1 3/4	33	1 5/16	31	1 1/4	26	1 1/16	28	1 1/8
44	1 3/4	35	1 3/8	31	1 1/4	26	1 1/16	29	1 1/8
		35	1 3/8	31	1 1/4	26	1 1/16	29	1 1/8
Av. 34.7	1 5/16	37	1 7/16	32	1 1/4	26	1 1/16	30	1 3/16
Total No. 16.		38	1 1/2	32	1 1/4	26	1 1/16	30	1 3/16
		38	1 1/2	33	1 5/16	26	1 1/16	31	1 1/4
		40	1 5/8	34	1 5/16	27	1 1/16	32	1 1/4
		40	1 5/8	34	1 5/16	27	1 1/16	34	1 5/16
		40	1 5/8	35	1 3/8	27	1 1/16	34	1 5/16
		42	1 5/8	35	1 3/8	27	1 1/16	34	1 5/16
		45	1 3/4	36	1 3/8	29	1 1/8	35	1 3/8
				37	1 7/16	30	1 3/16	35	1 3/8
		Av. 32.6	1 1/4	37	1 7/16	30	1 3/16	36	1 7/16
		Total No. 25.		40	1 1/2	32	1 1/4	37	1 7/16
				41	1 5/8	32	1 1/4	37	1 7/16
				42	1 5/8	33	1 5/16	37	1 7/16
				46	1 3/4	33	1 5/16	37	1 7/16
						34	1 5/16	37	1 7/16
				Av. 29.9	1 1/8	35	1 3/8	37	1 7/16
				Total No. 31.		38	1 1/2	38	1 1/2
						40	1 5/8	38	1 1/2
						40	1 5/8	39	1 9/16
						40	1 5/8		
						40	1 5/8	Av. 31.8	1 1/4
						43	1 11/16	Total No. 38.	
						44	1 3/4		
						Av. 30.1	1 3/16		
						Total No. 39.			

Total No. of 1900 lobsters in cars on September 15, 149.
Average length, 31.8 mm. 1¼ inches.

TABLE No. 7.

Measurement of Lobsters Hatched in 1900, Between May 31 and June 26, Showing Growth to November 7, 1901.

May 10. Approximate age 10 months.		June 12. Approximate age 1 year.		Aug. 22. Approximate age 14 months.		Nov. 7. Approximate age 17 months.	
mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.
40	$1\frac{5}{16}$	41	$1\frac{5}{8}$	49	2	69	$2\frac{3}{4}$
41	$1\frac{5}{16}$	42	$1\frac{5}{8}$	55	$2\frac{1}{8}$	73	$2\frac{7}{8}$
41	$1\frac{5}{8}$	42	$1\frac{5}{8}$	57	$2\frac{1}{4}$	79	$3\frac{1}{4}$
42	$1\frac{5}{8}$	44	$1\frac{3}{4}$	57	$2\frac{1}{4}$	79	$3\frac{1}{8}$
43	$1\frac{5}{8}$	47	$1\frac{7}{8}$	60	$2\frac{3}{8}$	82	$3\frac{1}{4}$
44	$1\frac{3}{4}$	47	$1\frac{7}{8}$	62	$2\frac{1}{2}$	82	$3\frac{1}{4}$
45	$1\frac{3}{4}$	47	$1\frac{7}{8}$	65	$2\frac{1}{2}$	85	$3\frac{3}{8}$
45	$1\frac{3}{4}$	49	2	65	$2\frac{1}{2}$	85	$3\frac{3}{8}$
47	$1\frac{7}{8}$	49	2	68	$2\frac{3}{4}$	88	$3\frac{1}{2}$
47	$1\frac{7}{8}$	49	2	69	$2\frac{3}{4}$	95	$3\frac{3}{4}$
48	$1\frac{7}{8}$	50	2	70	$2\frac{3}{4}$	95	$3\frac{3}{4}$
48	$1\frac{7}{8}$	50	2	70	$2\frac{3}{4}$	98	$3\frac{7}{8}$
50	2	51	2	70	$2\frac{3}{4}$	101	4
50	2	52	2	70	$2\frac{3}{4}$	107	$4\frac{1}{4}$
52	2	52	2	75	3	111	$4\frac{3}{8}$
53	$2\frac{1}{8}$	52	2	80	$3\frac{1}{8}$	111	$4\frac{3}{8}$
53	$2\frac{1}{8}$	54	$2\frac{1}{8}$	80	$3\frac{1}{8}$	120	$4\frac{3}{4}$
53	$2\frac{1}{8}$	55	$2\frac{1}{8}$	81	$3\frac{1}{8}$		
54	$2\frac{1}{8}$	55	$2\frac{1}{8}$	82	$3\frac{1}{4}$	Av. 87	$3\frac{1}{2}$
55	$2\frac{1}{8}$	56	$2\frac{1}{4}$	82	$3\frac{1}{4}$	Total No. 17.	
56	$2\frac{1}{4}$	57	$2\frac{1}{4}$	85	$3\frac{3}{8}$		
58	$2\frac{1}{4}$	57	$2\frac{1}{4}$	86	$3\frac{3}{8}$		
58	$2\frac{1}{4}$	58	$2\frac{1}{4}$	95	$3\frac{3}{4}$		
		59	$2\frac{3}{8}$	110	$4\frac{3}{8}$		
Av. 50.5	2.0	63	$2\frac{1}{2}$				
Total No. 23.		64	$2\frac{1}{2}$	Av. 72.6	$2\frac{13}{16}$		
		66	$2\frac{5}{8}$	Total No. 24.			
		68	$2\frac{5}{8}$				
		Av. 52.7	$2\frac{1}{8}$				
		Total No. 28.					

TABLE No. 8.

Measurement of Lobsters Hatched in 1900, Between May 31 and June 26, Showing Growth to October 4, 1902.

March 27. Approximate age 1 year 9 months.		May 31. Approximate age 2 years.		Sept. 10. Approximate age 2 years 3 months.		Oct. 4. Approximate age 2 years 4 months.	
mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.
69	$2\frac{3}{4}$	85	$3\frac{3}{8}$	106	$4\frac{3}{16}$	106	$4\frac{3}{16}$
73	$2\frac{7}{8}$	88	$3\frac{1}{2}$	106	$4\frac{3}{16}$	106	$4\frac{3}{16}$
76	3	88	$3\frac{1}{2}$	108	$4\frac{1}{4}$	108	$4\frac{1}{4}$
79	$3\frac{1}{8}$	95	$3\frac{3}{4}$	108	$4\frac{1}{4}$	108	$4\frac{1}{4}$
79	$3\frac{1}{8}$	95	$3\frac{3}{4}$	108	$4\frac{1}{4}$	108	$4\frac{1}{4}$
82	$3\frac{1}{4}$	98	$3\frac{7}{8}$	117	$4\frac{3}{4}$	117	$4\frac{3}{4}$
82	$3\frac{1}{4}$	98	$3\frac{7}{8}$	123	$4\frac{7}{8}$	123	$4\frac{7}{8}$
85	$3\frac{3}{8}$	106	$4\frac{3}{16}$	123	$4\frac{7}{8}$	123	$4\frac{7}{8}$
88	$3\frac{1}{2}$	114	$4\frac{1}{2}$	128	$5\frac{1}{16}$	128	$5\frac{1}{16}$
95	$3\frac{3}{4}$	127	5	149	$5\frac{7}{8}$	149	$5\frac{7}{8}$
98	$3\frac{15}{16}$	127	5	159	$6\frac{1}{4}$	159	$6\frac{1}{4}$
107	$4\frac{1}{4}$	130	$5\frac{1}{8}$				
111	$4\frac{3}{8}$	130	$5\frac{1}{8}$	Av. 122	$4\frac{7}{8}$	Av. 122	$4\frac{7}{8}$
				Total No. 12.		Total No. 12.	
Av. 87	$3\frac{1}{2}$	Av. 0	$4\frac{1}{2}$				
Total No. 14.		Total No. 14.					

—Increase in average size in per cent.:

May 10 to June 12, 4.4 per cent.
June 12 to August 22, 38.4 per cent.
August 22 to November 7, 20.8 per cent.
May 10 to November 7, 72 per cent.

March 27 to May 31, 22.9 per cent.
May 31 to September 10, 14.0 per cent.
September 10 to October 4, 0 per cent.
March 27 to October 4, 40.2 per cent.

TABLE No. 9.

Measurement of Lobsters Hatched in 1901, Between May 31 and June 26, Showing Growth to October 4, 1902.

Car No. 52. Measurements taken				Car No. 53. Measurements taken				Car No. 54. Measurements taken				Car No. 56. Measurements taken			
May 31. Approximate age 1 year.		Oct. 4. Approximate age 1 year, 4 months.		May 31. Approximate age 1 year.		Oct. 4. Approximate age 1 year, 4 months.		May 31. Approximate age 1 year.		Oct. 4. Approximate age 1 year, 4 months.		May 31. Approximate age 1 year.		Oct. 4. Approximate age 1 year, 4 months.	
mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.	mm.	Inches.
38	1 1/2	52	2 1/16	38	1 1/2	62	2 7/16	57	2 1/4	92	3 5/8	36	1 7/16	60	2 3/8
40	1 9/16	60	2 3/8	48	1 5/16	105	4 1/8	63	2 1/2	105	4 1/8	36	1 7/16	69	2 3/4
44	1 3/4	69	2 3/4	53	2 1/8	129	5 1/16	71	2 13/16	117	4 5/8	36	1 7/16	69	2 3/4
44	1 3/4	69	2 3/4	53	2 1/8	133	5 1/4	72	2 7/8	117	4 5/8	41	1 5/8	76	3
45	1 13/16	76	3					72	2 7/8	123	4 7/8	44	1 3/4	82	3 1/4
45	1 13/16	79	3 1/8	Av. 43	1 11/16	Av. 107.5	4 9/16	72	2 7/8			52	2 1/16	82	3 1/4
47	1 7/8	79	3 1/8	Total No. 4.						Av. 110.8	4 1/2	55	2 3/16	84	3 5/16
47	1 7/8	79	3 1/8					Av. 67.8	2 11/16			57	2 1/4	86	3 3/8
48	1 15/16	79	3 1/8	Average increase in length since May 31, 154 per cent.				Total No. 6.				57	2 1/4	86	3 3/8
48	1 15/16	82	3 1/4									63	2 1/2	92	3 5/8
48	1 15/16	89	3 1/2					Average increase in length since May 31, 79 per cent.				63	2 1/2	95	3 3/4
48	1 15/16	89	3 1/2									63	2 1/2	95	3 3/4
50	2	89	3 1/2									63	2 1/2	105	4 1/8
50	2	92	3 5/8									63	2 1/2	105	4 1/8
50	2	92	3 5/8									67	2 5/8	105	4 1/8
50	2	107	4 1/4									69	2 3/4	107	4 1/4
52	2 1/16											74	2 13/16		
52	2 1/16	Av. 80.1	3 3/16									77	3 1/16	Av. 87	3 7/16
52	2 1/16	Total No. 16.										79	3 1/8		
55	2 3/16	Average increase in length since May 31, 66 per cent.													
57	2 1/4											Av. 56	2 3/16		
57	2 1/4											Total No. 19.			
												Average increase in length since May 31, 55.5 per cent.			
Av. 48.2	1 15/16														
Total No. 22.															

The Migration of Adult Lobsters Along the Coast, and to and from Deep Water. — These are extremely important questions, in view of the relations of the fisheries of adjoining stations. Migrations of both kinds doubtless occur, but to what extent, and for what reasons, is not understood. Off the shores of Nova Scotia and Maine the lobster-fishing smacks follow the seasonal migration to and from the cars, and it is said that a "late season" retards the approach of lobsters toward the shore in the spring. On the other hand, winter catches near shore are often considerable, and male and female lobsters sometimes differ in the extent of their movements. It is not impossible, moreover, that the apparent disappearance from certain localities may be due in part to a sort of hibernation.

Very interesting information has been obtained in regard to the movements of egg lobsters, liberated from Woods Holl.* Four hundred seventy-nine lobsters, from which the eggs had been removed, were tagged and liberated from several points near Woods Holl. Later, seventy-six of these were recaptured by fishermen, and the copper tags returned. Many other tagged specimens were doubtless caught, which were not heard from, and some lobsters probably moulted, and so lost the tags.

The data gained by these experiments, however, showed great variation in the movements, and a remarkable rapidity of migration in certain cases; while many of the lobsters were recaptured in the same locality three or four weeks after they were liberated, others had travelled at an average rate of a mile a day for ten to twelve days. One, for example, was liberated at Woods Holl, July 2, and was caught at Cuttyhunk, twelve miles distant, on July 13. It had travelled twelve miles in eleven days. Whether these specimens were seeking better food, warmer water, deeper water; whether they were following a general direction, or were impelled by a home instinct, cannot at present be said with certainty.

*H. C. Bumpus, on "The Movements of Certain Lobsters Liberated at Woods Holl During the Summer of 1898." Bulletin of U. S. F. C., 1899.

During the past summer a total of 112 lobsters, to which had been fastened a small copper tag, bearing a number and the words "Return to the Rhode Island Fish Commission," were liberated at various times near Wickford lighthouse. Sixteen of the tags were recovered, and the data concerning the migration are given in the accompanying table. Although the greater number of those returned had not wandered far, some had made their way southward for several miles, and when recaptured were already outside the Bay. The lobster bearing the tag "103," which was caught one mile southwest of Beaver Tail, holds the record up to date for fast traveling, having covered a distance of 10 statute miles in less than eight days. The method of tagging the lobsters is illustrated in the accompanying picture, reproduced from the photograph, and a little under natural size. It is impossible, of course, to be sure that all of these lobsters which were recaptured have been heard from, for in these experiments we must depend entirely upon the courtesy of the lobster fishermen, who may sometimes not take the trouble to return the tags. These experiments have not been carried far enough to allow us to arrive at any very general conclusions, but it is hoped that in the coming seasons much more may be learned by this method, or an improved one, concerning the movements of adult lobsters.

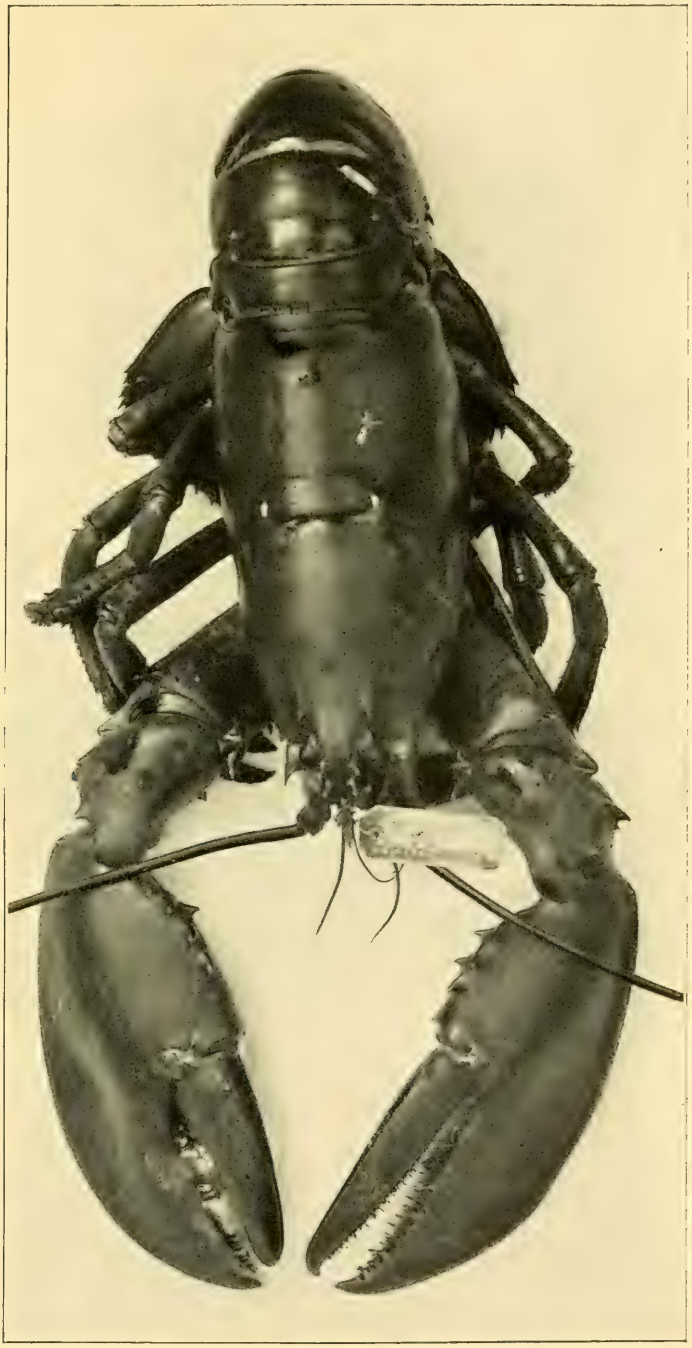


FIG. 24.—Adult lobster with copper tag attached to beak. Lobsters thus tagged are liberated at certain stations, and lobstermen are requested to return such tags, if retaken, to the Commission, giving date and place of capture. Valuable information on the movements of lobsters has also been obtained by this method.

TABLE No. 10.

Table Showing the Movements of Female Lobsters from which the Eggs have been Stripped, Which Were Liberated from Wickford Light House, Each Lobster Bearing a Copper Tag, with the Words, "Return to the Rhode Island Fish Commission."

Tag No.	LIBERATED. Locality.	Date.	RECAPTURED. Locality.	Date.	Number days free.	Distance in miles (statute.)	Direction.
147	Wickford Light House....	July 7.	Whale Rock Light.....	Aug. 1.	25	9	E. of S.
103	" " "	" 7.	1 mile S. W. Beaver Tail...	July 15.	8	10	E. of S.
5	" " "	June 4.	2 miles S. Beaver Tail.....	" 7.	33	11	E. of S.
25	" " "	" 4.	South end Conanicut.....	Aug. 18.	75	7	E. of S.
22	" " "	" 4.	.....	July 1.	27	....	E. of S.
36	" " "	" 5.	West Passage.....	.....	....	....	E. of S.
64	" " "	" 7.	West Passage.....	.....	....	....	E. of S.
148	" " "	July 7.	West Passage.....	.....	....	....	E of S.
151	" " "	" 7.	West Passage.....	.....	....	....	E. of S.
156	" " "	" 7.	West Passage.....	.....	....	....	E, of S.
43	" " "	June 5.	1 mile S. of Plum Beach...	June 8.	3	4½	E. of S.
58	" " " ...	" 7.	Coon's Ledge.....	" 27.	20	1	N. E.
75	" " "	" 21.	Wickford Light House....	" 28.	7	0	.....
18	" " "	" 4.	Stone Beacon, Wickford..	" 16.	2	1	N. E.
149	" " "	July 7.	Whale Rock.....	Aug. 10.	34	9	E. of S.

Number liberated..... 112
Number recaptured..... 16

The Rate of Growth of Large Lobsters, and the Limits of Size and Age. — We have unfortunately little information on the rate of growth of adult lobsters, although we greatly need it. It would seem probable that there is a difference in the rate of growth among individuals, according to circumstances, like that which is so remarkable in the case of younger lobsters. They increase in length only directly after moulting, and this increase is, on an average, about 15 per cent. of the original length, according to the observations of Herrick, but we do not know how often

the lobsters moult. We have ascertained that the fry, immediately after hatching, shed their skins three times during the first two weeks, and afterwards less frequently, but with no fixed period between moults. It is certain, also, that in the case of egg-bearing lobsters, the moulting cannot take place while the eggs are carried, from July or August to the following June, without loss of the eggs. Until some way shall be devised of putting a mark upon the lobster which can easily be recognized after the shell is shed, we can hardly expect to settle the question definitely.

There is apparently no definite limit to the size attained by lobsters. There are authenticated published records of several large specimens, measuring 20 inches or over from the beak to the end of the tail. Two of the largest of these were taken off Atlantic Highlands, in the spring of 1897, and are now preserved in the American Museum of Natural History. They measure respectively $23\frac{3}{4}$ inches and $21\frac{1}{2}$ inches from beak to end of tail, not including hairs. The larger specimen, which was for a time exhibited in Castle Square Aquarium, weighed thirty-four pounds when alive; the smaller one about thirty-one pounds. Herrick described a large male specimen which was caught in Penobscot Bay, in May, 1891. The length as measured was 20 inches, but would have been about 21 had the beak been perfect; the living weight was about twenty-three pounds. He also mentions two large female egg-bearing lobsters caught by Vinal Edwards, fifteen miles south of No Man's Land, in 1894. One of them was 19 inches long, and carried 91,350 eggs (estimated); the other was only 16 inches in length, but carried 97,440 eggs. During the last fall a lobster of unusual size for our waters was taken in a fish trap off Newport. It weighed nineteen pounds, and measured $15\frac{3}{4}$ inches in length. This specimen is now in the museum of the commission at the State House.

These descriptions of large specimens of modern times, and their actual measurements, seem tame beside the tales of giant lobsters in literature and tradition. Alice Morse Earle, in her "Colonial Days in Old New York," says: "Patriarchal lobsters

five and six feet long were in the bay. Van Der Donck says, 'those a foot long were better for serving at table.' Truly, a lobster six feet long would seem a little awkward to serve. W. Eddis, in his 'Letters from America,' written in 1792, says these vast lobsters were caught in New York waters, until revolutionary days, when, 'since the late incessant cannonading, they have entirely forsaken the coast, not one having been taken or seen since the commencement of hostilities.'" So far as this commission has been able to ascertain, they have not yet returned.

Artificial Hatching of Lobster Eggs and the Distribution of Newly-Hatched Fry. — For years the United States Fish Commission has hatched at Woods Holl, at Glocester, and at some other stations, many millions of eggs annually, and have set free the young as soon as possible after they were hatched. The theory which warrants this practice is, that the fry, which are thus distributed in deep water, are in less danger from their natural enemies, which, like the mummychog and shrimp, abound in shallow water. The apparatus used in hatching is the well-known McDonald jar, into which the eggs are placed immediately after they are "combed" from the females. In these they are kept swirling sometimes for weeks, by a constant stream of salt water. We have found that the apparatus described below, devised at our floating laboratory for rearing the young fry, is equally good for hatching eggs. It has also the advantage of the usual method in the matter of simplicity and expense.

The Possibility, Feasibility, and Methods of Protecting the Newly-Hatched Fry. — The steady decline of the lobster fishery, notwithstanding the restrictive laws and the large output of newly-hatched fry, emphasized the need of other methods. In restocking streams with fish, the fry are not only hatched, but are often raised for a time after hatching, and protected from their natural enemies during their early, most precarious period of life. There are most excellent reasons why this method might be expected to succeed in the case of the lobster: First, the fatal conspicuousness of the lobster fry in the early stages; and second, the sudden-

ness with which, at the third moult, they assume the new form and habits which render them comparatively secure. The advisableness of this procedure was long ago recognized, and experiments in this line were tried in many places; but there were certain difficulties presented by the peculiar habits and requirements of the fry which, until the last three years, proved unsurmountable. The main difficulties were those of confining and feeding the fry, and of preventing the growth of parasites on the shell. (See reports of the R. I. F. C. for 1899–1900–1901.)

In 1898 Dr. H. C. Bumpus commenced a systematic re-investigation of the whole problem. Experiments were carried on in 1898 and 1899 at Woods Holl, and in 1900 some of them were transferred to the house-boat laboratory of the Rhode Island Fish Commission at Wickford. Up to this time a great many devices for enclosing the fry were tried, and proved to be impracticable, and the one which finally promised the best results was a scrim bag, suspended in the water so that the movements of the tide and wind would frequently change its shape and prevent the fry from collecting too densely in any one place. The meshes of the scrim, of course, allowed a free circulation of water through the bag; but even in this apparatus, when the weather was calm, the lobster fry, together with unused food, would settle into the pockets which were made by the weights necessarily used to keep the bag under water. When the weights were taken off, the least wind would blow the bag out of the water, and this was very trying to the young lobsters. Near the end of the season of 1900 a new principle was applied, on which has depended in a large measure the success of the subsequent work.

"After making numerous experiments and watching the results for about five weeks, we gradually came to the conclusion that the secret of success in rearing the young lobsters was to keep the water in continuous motion. This accomplishes two things: it prevents the fry from settling into pockets to smother or devour one another, and it keeps food in suspension, so that the fry can obtain it.

FIG. 20.—House-boats and floats with lobster-raising apparatus installed. At the far end of the float the large canvas bag is shown lifted out of the water, giving a view of the frame and one side window. The other two bags of this float are in place. The propeller used in one of these bags is shown resting against the house.

"To prove the correctness of this conclusion with the material and apparatus at hand, it was decided, on July 6, to experiment with lobsters which were at that time in small bags. Accordingly the force at the laboratory was divided into watches, and the water in the bags was thenceforth stirred with an oar continuously until July 12. The result was ample proof that the conclusion was correct. There were two lots of lobsters which received this treatment, namely, experiments 9 and 10 (tables on page 78). Neither of these lots was considered to be as promising as the average. However, from No. 9 there were obtained 748 lobsters in the first stage. This is a larger number than were obtained in any other experiment, either at Wickford, Woods Holl, or in any other station where lobster-culture has been tried, so far as I am aware. From lot No. 10, 319 were obtained in the fourth stage; but as one of the bags was old, and had a hole in it, the figures fail to give a correct idea of the results of the experiment. One of the most encouraging results of this method was the clean and healthy appearance of the fry in all stages. The continual stirring prevented the accumulation of parasites found on the body of nearly all of the specimens in the other lots.

"It is intended during the next season to follow up this experiment with others, working upon the same theory, namely, that the water should be constantly stirred. To do this it will be necessary to invent a mechanical device which will take the place of the oar, and designs for such an apparatus are now being made." *

The mechanical device referred to was put into successful operation in the season of 1901 at Wickford, and is described in the report for that year. The apparatus consisted of a number of rotating horizontal paddles, one in each bag, run by a gasoline engine. The movement of the paddle blades created a constant upward current of water in the bags, which kept the fry off the bottom and kept the food suspended in the water. Through its use 9,000 lobsters were raised to the fourth stage, and in some experiments 50 per cent. of the newly hatched fry were carried through to this stage. That this was a decided step in advance of the old methods will readily be admitted by those who have followed the course of previous experiments.

* Report of Rhode Island Commission of Inland Fisheries for 1900, p. 71.

The success of these experiments led the commission the past year, 1902, to enlarge the plant and to attempt to raise to the fourth stage a large number of lobsters, hoping to show that lobster culture upon a large scale is practicable. The apparatus used in 1901 was correct in principle, but there were three objections to it: first, the bags were too small for work upon a large scale; second, the material used in construction was not very durable, and also became foul quickly; and third, the rope-belts were troublesome on account of their shortening and lengthening, and also because they were more or less in the way. To correct these difficulties, larger bags of two different sizes were used:— The smaller ones were 6 feet square and 5 feet deep, and each had a capacity of 151 cubic feet. Three of these occupied the well between the pontoons of the house-boat, and took the place of the twelve smaller bags of the previous year, and had nearly twice their capacity. Besides these, six others, 12 feet square and 5 feet deep, were placed in two large floats built especially for this purpose, and moored on either side of the house-boat. The nine bags which were used in this summer's experiments had a total capacity of 3,955 cubic feet, which is sixteen times the total capacity of the twelve bags used last year.

The material which was used in the construction of the bags was 8-ounce canvas, and was, of course, much more durable than the scrim which had been used previously. In order to admit a free circulation of water in these bags, windows of copper screening were placed in the bottom and in the sides near the top. The rotating propellers created an upward current through the bottom windows and flowed out through the windows at the side. The rope-belts were displaced by a system of worm wheels and matched gears which gave a neater construction and a more direct transmission of power, and which had the additional advantage of not being affected by the weather. All of these changes proved to be advantageous, and the apparatus is now so satisfactory that the commission propose few changes during the coming year.

One chief object which has been kept constantly in mind in the construction of this apparatus is the possibility of its use at any station where the water is comparatively quiet, and also the possibility of extending indefinitely the capacity of the apparatus without the expense of a large amount of additional machinery. The floats, such as were attached to either side of the house-boat, can be attached to one another, and the power transmitted from one float to another by the coupling shafts, such as were used between the house-boat and the float; and it is probable that the 2½ H. P. engine which we have used is capable of running three or four times as many paddles.

The accompanying photograph and drawing will illustrate, without much further description, the essential features of the construction and proportions of the apparatus, but there are a few features to which we may refer especially: The canvas bags seem to become foul much less quickly than those made of scrim, and the small windows in the former provided a sufficient area for the incoming and outgoing currents of water. The current created by the moving paddles tended to draw in the bottom of the bags, but this tendency was easily counteracted by laying strips of furring across the bottom framework. The bulging out at the sides, from the same cause, was a distinct advantage. An experiment was tried with a bag of the small size (6 x 6 feet square) made of tarred bobbinet. This bag, whether from the fact that it was tarred, or that its meshes were larger than those of the scrim bags, became less foul than the others; but since it was fragile and expensive to construct, only one of these was put into use.

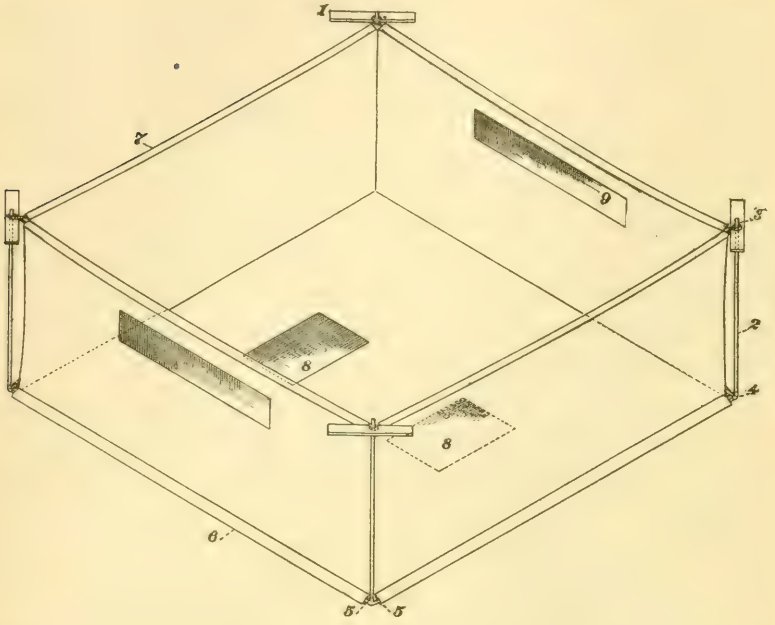


DIAGRAM OF THE LARGE CANVAS BAG USED IN LOBSTER CULTURE.

The bag is 11 feet 8 inches square and 5 feet deep, made of 8-ounce canvas, and is supported by a gas pipe frame.

1. Small boards nailed across the corners of the bag compartments of the floats.
2. Vertical pipe, 5 feet long, which passes through a hole in the board (1).
3. Coupling screwed on the top of vertical pipe (2). This coupling rests upon an iron washer through which the pipe passes. The whole frame may be raised out of the water by drawing the vertical pipes upward.
4. Three-way coupling, into which two horizontal pipes (5) are screwed.
5. 5 feet horizontal pipes 12 feet long. Four of these pipes make a square frame upon which the bottom of the bag is stretched. All pipes are ½-inch galvanized gas pipe.
6. Hem 3 inches broad around the bottom of the bag. The pipes of the frame are slipped through these hems before the frame is put together.
7. Hem 2 inches broad at top of bag. A small rope run through this hem and looped over the tops of the corner pipes (2) holds up the sides of the bag.
8. Bottom windows (20 x 30 inches) through which water enters the bag.
9. Side windows (5 feet long, 10 inches broad, and placed 10 inches from the top) through which the water escapes from the bag. These windows are covered on the inside with linen scrim, which prevents the lobsters from being caught in the copper screen. The windows are made of No. 16 copper screen.

DIAGRAM OF THE FLOATS AND MACHINERY FOR LOBSTER CULTURE.

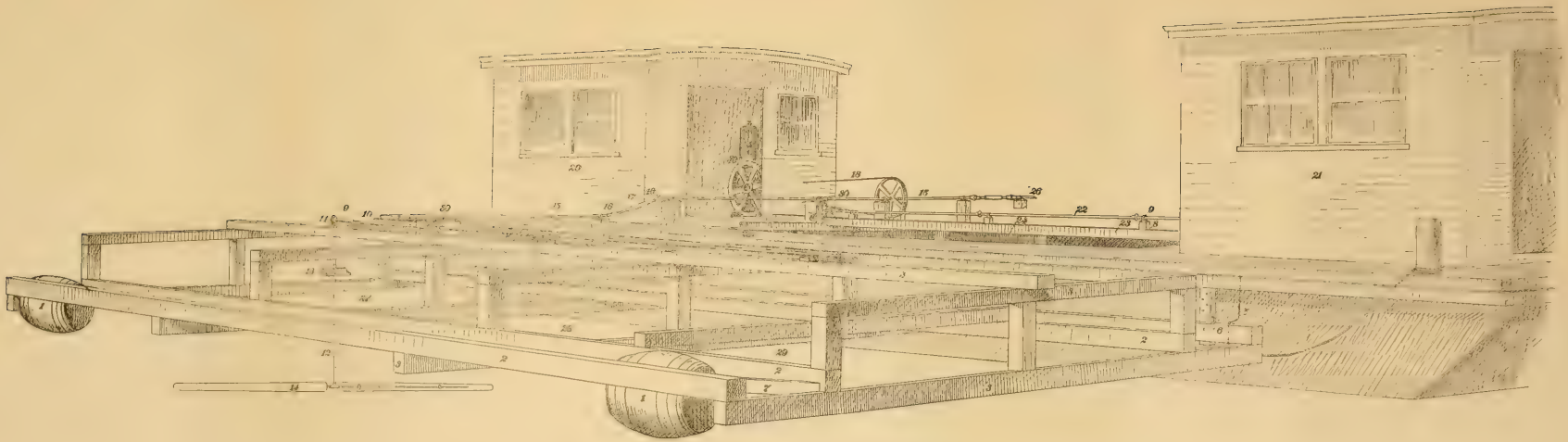
1. Barrels for support of float. Three barrels on the near side, and all on the far side, are omitted.
2. Longitudinal beams, 6 x 6 inches x 39 feet.
3. Transverse beams, 6 x 6 inches x 19 feet.
3. Upper transverse beams, 4 x 6 inches x 13½ feet.
4. Upper longitudinal beams, 4 x 6 inches x 39 feet.
5. Mooring chain; two others do not show in drawing.
6. Mooring iron and buffer; three others do not show in drawing.
7. Corner brace of float.
8. Wooden blocks supporting shafts.
9. Shaft hangers. All unbabbited, save those supporting transverse shafts.
10. Longitudinal shaft of float; 1 inch in diameter, 26 feet long.
11. Match gear wheels fixed to shafts by set screws.
12. Vertical or paddle shaft supported by longitudinal beam (4). This shaft is 6½ feet long and is made of two pieces (5 feet and 1½ feet long) of ¾-inch galvanized gas pipe.
13. Movable transverse beam which forms lower bearing of shaft. The beam of the middle, and the greater portion of the beam of the forward compartment are not represented.
14. Paddle. Blades 4 feet long and from 5 to 7 inches broad are fastened by bolts to pipes screwed into the tee at the lower end of the shaft.
15. Transverse shaft of float, 10 feet long. This shaft makes 108 revolutions per minute, and by means of a worm and wheel transmits power to the longitudinal shafts which revolve 9 times per minute.
15. Transverse shaft of house-boat, 16 feet long. This shaft receives power from the engine by means of a 2-inch belt running on an 18-inch pulley, and transmits the power to the longitudinal shaft (22) of the house-boat, and the transverse shafts (15 and 26) of the floats.
16: 17. Universal joints and sliding joints which connect the transverse shafts of the house-boat and float, and allow motion in all directions so that the swell and wave motions do not disturb the operation of the machinery.
18. Belt from engine.
19. Gasoline engine 2½ horse-power, speed 329 revolutions per minute.
20. House on bow of boat.
21. House on stern of boat.
22. Longitudinal shaft of house-boat 19 feet long. The vertical shafts and the lower match gear wheels are omitted.
23. Longitudinal beam across the middle of the well of the house-boat. This supports the longitudinal shaft (22).
24. Well of house-boat containing three bags 6 x 6 feet x 5 feet.
25. Transverse beam across well of house-boat for support of transverse shaft, 15 feet.
26. Shaft and block of starboard float.
27. Forward compartment of float.
28. Middle compartment of float.
29. Rear compartment of float. Each compartment holds a canvas bag (page 80) 12 feet square and 5 feet deep.
30. Worm and worm wheel to reduce speed twelve times.

Experiments with the New Apparatus in 1902.— Nearly everything in the way of apparatus used during the past season was new in pattern and in material, and, owing to unexpected delays at the factory, considerable time was lost at the beginning of the season. Nevertheless, the number of "lobsterlings" raised to the fourth stage was several times greater than the number carried through at any other stage, or at this stage in previous years. The total output for the summer was 27,300. The largest output for one experiment was 12,750. This number was reared in one of the large canvas bags. The following brief statement gives the essential facts concerning the six principal experiments of the season:

Date of experiment.	Origin of Fry.	Kind of bag used.	No. in 4th stage.	Remarks.
June 7–July 2.	Eggs hatched in bags.	Small scrim and canvas.	3,600	Many lost through hole in bag.
June 19–July 5.	"	Large scrim 12 x 12 x 5.	750	hole in bag.
June 20–July 5.	Fry from Woods Holl.	Large canvas 12 x 12 x 5.	12,750	
June 25–July 10.	"	"	8,700	
June 28–July 15.	Eggs hatched in small scrim bag.	Reared in large canvas bag.	1,500	
July 3–July 15.	Eggs in large canvas bag failed to hatch.			Total failure.

With the exception of a few hundred specimens kept for further experiments in growth, all these lobsterlings were set free in the Bay.

During the latter part of the season a great number of microscopic animal and plant forms, consisting mainly of diatoms and stalked protozoa, appeared in the water and upon the lobsters. These growths are very injurious to the fry. They encumber its



movements and interfere with its feeding and moulting. As we mentioned in the report for 1900, they are less troublesome when the lobsters are constantly stirred. At Woods Holl they are a more serious menace to the fry than at Wickford. The whole investigation of the character, time, and cause of their appearance etc., has been undertaken by Professor F. P. Gorham, who will soon make his report to the U. S. Fish Commission. Thus far we have endeavored to counteract the effect of these pests by keeping the bags as clean as possible with frequent washing in fresh water and by regulating the light which falls upon the bags. The principle of the latter procedure is that the movements of these microscopic organisms, as well as those of larger animals, like the fry themselves, are affected by the direction and intensity of the light. The development of adequate methods of preventing these parasites from gaining access to the lobsters is one of the many problems which must be solved.

The Efforts of the Commission to Prevent the Illegal Taking of Short Lobsters.

At the January session of the General Assembly, 1901, your honorable body passed the following act:

AN ACT FOR THE BETTER PROTECTION OF THE LOBSTER FISHERIES.

It is enacted by the General Assembly as follows:

Section 1. Every person who catches, takes, or has in his possession any lobster less than nine inches in length, measuring from one extreme of the body to the other, exclusive of claws and feelers, or any female lobster bearing eggs or from which the eggs have been brushed, shall forfeit for every such lobster five dollars, one-half thereof to the use of the complainant and one-half thereof to the use of the state; but a person catching or taking any such lobster and immediately returning the same alive to the water from which taken shall not be subject to such penalty.

Sec. 2. All lobster pots, cars, and other contrivances used for the catching or keeping of lobsters shall be plainly marked with the name or

names of the owner or owners. And every person who shall not have his lobster pots, cars, and other contrivances so marked shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

SEC. 3. There shall be between the fifteenth day of November and the fifteenth day of April next succeeding a close time, during which time it shall be unlawful for any person to set or keep, or cause to be set or kept, within any of the waters of this state, any pots or nets for the catching of lobsters or to take any lobsters during such close time. Every person violating any of the provisions of this section shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

SEC. 4. No person shall be allowed to set or keep, or cause to be set or kept, within any of the waters of this state, any pots or nets for the catching of lobsters who has not had his home and residence in this state for the period of one year next preceding the time of his catching such lobsters. Every person violating any of the provisions of this section shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

SEC. 5. Every person, except the commissioners of inland fisheries and their deputies, who shall lift or raise any pot or net set for the catching of lobsters, without the permission of the owner or owners thereof, shall be fined ten dollars for each such offence.

SEC. 6. Possession by any person of any lobsters between the fifteenth day of November and the fifteenth day of April next succeeding shall be *prima facie* evidence before any court of competent jurisdiction that such lobsters were taken in violation of this act; and every such person shall be fined twenty dollars and be imprisoned not more than thirty days for each such offence.

SEC. 7. The commission of inland fisheries shall appoint at least two deputies, whose duties shall be the enforcing of the provisions of this act. Each of said deputies appointed as aforesaid shall be by virtue of his office a special constable and, as such deputy, may without warrant arrest any person found violating any of the provisions of this act and detain him for prosecution not exceeding twenty-four hours. Said deputies shall not be required to enter into recognizance or become liable for costs.

SEC. 8. Each of said deputies shall have the right to go upon any boat or vessel used in the catching or transporting of lobsters and search for and seize any such lobsters that they believe to have been taken in violation of any of the provisions of this act.

SEC. 9. Fines incurred under any of the provisions of this act shall

inure one-half thereof to the use of the complainant and one-half thereof to the use of the state.

SEC. 10. The several district courts shall have concurrent jurisdiction with the common pleas division of the supreme court over all offences under this act, and to the full extent of the penalties therein specified: parties defendant, however, having the same right to appeal from the sentences of said district courts as is now provided in law in other criminal cases.

SEC. 11. Sections 8, 9, and 10 of Chapter 173 of the General Laws, entitled "Of certain fisheries," and also Chapter 316 of the Public Laws, and all acts and parts of acts inconsistent herewith are hereby repealed.

SEC. 12. This act shall take effect from and after its passage.

The deputies appointed to enforce the provision of this law have been actively engaged in this work during the past two years.

A large number of short lobsters have been returned to the water, many of these having been shipped into the State from abroad. A much greater number probably never have been brought to shore, which, except for the enforcement of the law, would have been sold. It is, in the nature of the case, impossible to determine accurately the benefit of this or any other protective measure; but the general opinion of the best class of lobster fishermen, dealers, and others interested is that the benefit is worth the effort. It is still very much to be regretted that the provision and enforcement of the lobster law are not the same in adjoining States. The present differences give rise to much jealousy, and are the cause of much actual injustice to the fishermen on the border line between adjoining States. Uniformity in legislation and enforcement of lobster laws is greatly to be desired.

APPENDIX.

The following list of special papers represents the more extended investigations of the commission for the last five years, and is introduced here for the convenience of those who wish to refer to these papers.

The report for 1897 contains:

1. A preliminary report on the star-fish.

The report for 1898 contains:

2. A record of the dredging of the United States Fish Commission steamer "Fish Hawk," in Narragansett Bay.
3. Investigations of the red-water plague, which destroyed multitudes of fish and crustacea during the fall of 1898.
4. Special report on the star-fish.
5. Life-history of the common clam (*Mya arenaria*).
6. Report on the tile fish (*Lopholatilus chamæleonticeps*).

The report for 1899 contains:

7. Observations on the soft-shell clam.
8. List of fishes known to inhabit Narragansett Bay.
9. List of diatoms found in the water over the clam, mussel, and oyster beds at Wickford, R. I.

The report for 1900 contains:

10. Observations on the soft-shell clam (second paper).
11. Habits and life-history of the scallop (*Pecten irradians*).
12. Further observations on the red-water plague, with notes on its occurrence elswhere.

13. Additions to the list of fishes known to inhabit Narragansett Bay, with remarks on rare specimens recently caught.
14. Habits and growth of young lobsters, and experiments in lobster culture.

The report for 1901 contains:

15. A description of the floating laboratory used by the commission as an experimental station.
16. Observations on the soft-shell clam (third paper).
17. Habits and growth of young lobsters, and experiments in lobster culture. (Second paper.)

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