THE UNIVERSITY OF NORTH CAROLINA

SURVEY OF MARINE FISHERIES OF NORTH CAROLINA

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BY

HARDEN F. TAYLOR

AND A STAFF OF ASSOCIATES

Chapel Hill

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FOREWORD

By Robert E. Coker, Chairman.

A request from President Graham of the University of North Carolina in October, 1944, for a project in marine biology led to the proposal of an Institute of Fisheries Research with a laboratory at a suitable place on the coast. Underlying the proposal was the thought that there was definite need for a State or regional agency through which the techniques and principles of the natural and social sciences could be applied to all manner of problems in the use and preservation of the State's marine resources. Hitherto North Carolina's valuable fish and shellfish have been virtually neglected so far as regards the application of scientific research or systematic studies such as have been so productive in respect to resources of the land. It was hoped that properly directed research on resources of the sea and the sounds might lead to greater profit in exploitation and to sounder practices in conservation.

The provisional draft of the project for fisheries research was considered successively by a number of committees and boards of the University, including the Division of Natural Sciences, the Advisory Committee, the Administrative Board of the Graduate School, the Administrative Council of the Consolidated University and the Executive Council of the Graduate School of the Greater University. After full approval by all such committees and boards, the President appointed an initial committee of organization with membership as follows: L. D. Baver, Director of the Agricultural Experiment Station, Raleigh; R. W. Bost, Head, Department of Chemistry, Chapel Hill; R. E. Coker, Department of Zoology, Chapel Hill, *Chairman;* William deB. MacNider, Department of Pharmacology, Chapel Hill; Z. P. Metcalf, Department of Zoology, State College; W. W. Pierson, Dean of the Graduate School, *ex officio.*

The committee met in Chapel Hill, August 9, 1945, with all members present, except that, in the unavoidable absence of Dean Pierson, his place was taken by John B. Woosley. Present also and participating by special invitation, were Harden F. Taylor of New York, recently President of The Atlantic Coast Fisheries Company, and Herbert F. Prytherch, Director of the U. S. Fisheries Laboratory at Beaufort. The group decided unanimously on the need for an Institute of Fisheries Research and on the desirability of its affiliation with the University in Chapel Hill. In the discussion it was brought out that the committee had only limited and fragmentary information with respect to the status of the fisheries in North Carolina, the nature and volume of the resources, and the potentialities of their development. It was decided, then, that the first need was a full compilation of available data concerning these basic conditions. The committee adopted unanimously a recommendation to the President that such a survey be organized, to be completed, if possible, in advance of the inauguration of a research program. Further procedures on the part of the committee were then delegated to a subcommittee.

Acting upon recommendation of the committee, President Graham authorized a "Survey of Marine Fisheries of North Carolina," appointing Robert E. Coker as Chairman of the Executive Committee, Rex S. Winslow as Secretary and Treasurer, and Harden F. Taylor as Executive Director. There was formed also an Advisory Board whose membership is listed on another page.

Consultations were had with Director R. Bruce Ethridge and Vice Chairman Josh Horne of the Department of Conservation and Development, both of whom welcomed the Survey and extended effective personal cooperation as well as the full aid of the Department.

Initial financial support for the Survey in the amount of $12,000 was secured from a grant to the University made by George R. Lurcy of New York. To this was added a grant in like amount from the General Education Board.

After a meeting of the Advisory Board in Chapel Hill May 5, 1946, the Survey was set in operation with responsibility for organization and conduct vested in the Executive Director. Because of special circumstances of the time, which was just after the close of war, the task of finding efficient and available personnel proved extraordinarily difficult. Difficulties and disappointments, particularly in respect to the biological, economic and legislative sections of the Survey, caused substantial delay in completion but in no way lowered the quality of what was done. Unexpected burdens were placed upon the Director, who had to complete the economic section with little aid, while entirely new arrangements for completion of the biological section had finally to be made.

It will be recalled that the Survey was originally intended to lay the groundwork for a projected Institute of Fisheries Research. It happened, however, that the Department of Conservation and Development obtained by purchase in 1946 the former Marine Section Base at Morehead City (site of old Camp Glenn) and promptly made available for such an Institute an excellent laboratory building and other facilities of the Base. In the following year a grant from the Knapp Foundation, Inc., of New York, matched by funds allotted from State appropriations to the Department of Conservation and Development and the Shrimp Commission, made possible and desirable the inauguration of the Institute. This was established by action of the President and the Executive Committee of the Trustees September 29, 1947. Actual operations of the Institute began with the inception of the Shrimp Survey January 1, 1948. The establishment of the Institute comes into the story of the Survey, not only because the Survey was intended to give a foundation to the Institute, but also because the Institute was able later to make substantial contribution to the Survey. Its biological staff, working under Dr. Taylor's direction, completed the greater part of the biological section, including all such parts as had not previously been drafted.

The general purpose of the Survey was not to gain new knowledge by observation, experimentation or research in the ordinary sense. Rather it was to assemble wherever it could be found and to digest and summarize all discoverable records and reports with respect to physical, chemical, and hydrobiological conditions of coastal waters, the several fishery resources of the State, the current status of the commercial and sport fisheries, and the potentialities in development. The report of the Survey, as it was planned, should make it hereafter unnecessary to go back ordinarily to the extremely scattered original records. The Survey should mark the point of departure from which future researches might begin. All materials gathered would be critically examined and so presented with comments and interpretations that, not only scientists, but also any interested, intelligent reader might gain a fair conception of the magnitudes and potentialities of the State's fisheries and might sense the general directions in which further research would likely prove most productive.

The program of the Survey divided itself along natural lines into fairly distinct parts. Part I would deal with the basic inorganic determinants of life in the region under consideration: that is to say, the chemical, physical, and hydrographic conditions of the State's coastal and estuarial waters. Part II would treat the plants and animals upon which the fisheries and fishery industries must be based—the marine algae, the shell fishes of various kinds, and the fin fishes. In Part III concern would be with economic conditions in the broadest sense, including procedures and potentialities in exploitation, processing, and marketing. Finally, Part IV would embrace a comprehensive study of public attitudes and acts with respect to exploitation and conservation as these are expressed in legislation and administration affecting the resources and their utilization; it was planned to include a far-reaching study of the history of fishery regulation with analyses of its motivations and common guiding principles.

As it turned out, the fourth part had to be abandoned for the time. This is only because it has not yet been possible to find an available person properly qualified by legal training and experience to carry out so difficult a task. It is hoped that at some future time this important service can be completed as a separate undertaking of the Institute.

The third part presented exceptional difficulties for the basic reason that the economics of the fisheries has never anywhere been the subject of comprehensive and critical analysis. Accepting the broad challenge, Dr. Taylor has substantially extended the scope of the economic section of this Survey to consider the fisheries of the whole country and, to an extent, of the world. The results provide essential background for proper appraisal of the conditions and potentialities of the fisheries of North Carolina or of any other state or region.

In this comprehensive report, completed now except for the part on legislative and administrative conditions of the fisheries, we have, not only a set of summaries and analyses of conditions in North Carolina, but also an intensive and competent study of the peculiar nature of fisheries and fishery industries wherever they may be. Originally intended to afford base and background for research on problems of the fisheries in North Carolina, the report should be of much wider interest and significance. Such an assembly of facts concerning fisheries, with basic analyses and interpretations, has never hitherto been available.

It is to be expected, indeed it is to be hoped, that the report will provoke wide discussion. Whether or not there should be differences of opinion as to interpretations and conclusions, there can be no question as to the high and enduring value, not only of the data assembled in this report, but also of their treatment in the light of the Director's long and broad experience in scientific studies of fish, of fishery technology, of processing and marketing, and of administration of fishery industries.

SURVEY OF MARINE FISHERIES OF NORTH CAROLINA

Advisory Board

As appointed, February, 1946.

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The University of North Carolina

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Director of the United States Fisheries Laboratory
Beaufort

HARDEN FRANKLIN TAYLOR
Executive Director

* Succeeded in 1948 by James H. Hilton, Director of the Agricultural Experiment Station.
† Deceased.

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by Harden F. Taylor

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By Nelson Marshall

The University of North Carolina *

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* Later, the College of William and Mary and the Virginia Fisheries Laboratory.

INTRODUCTION

Fisheries productivity is but a factor of productivity in general and this in turn is based on the hydrography, or physical-chemical conditions, of the waters involved. Though these conditions are obviously basic, it is seldom that we have approached a problem in fishery yields from this standpoint. The importance of soil, weather, and climate have not been overlooked in agriculture or other aspects of production on land. We must realize that comparable determinants are equally important in aquatic habitats. Scientists recognize this; yet studies in hydrography and in the specific effects of hydrographic features on production are in their infancy. The public has responded slowly to such concepts, for underwater conditions do not speak for themselves, as do droughts on land, for example. This is unfortunate and must be remedied, for in the final analysis it is the public that makes policy in fisheries utilization, management, etc., and sponsors much of the necessary fisheries research.

The objective of the present study is to present and discuss the significance of pertinent hydrographic information relative to North Carolina marine waters. An attempt is made to utilize all accumulated information up to the year 1947. Such available facts are so scarce and so widely scattered, and have been accumulated for such diverse purposes that one might consider it a wasteful objective; however, when brought together they do give a general picture. Certainly this is the logical first step in analyzing the merits of the many optimistic guesses as to the great potentialities of North Carolina's marine waters, and it is the obvious basis for planning the necessary further research in this field.

This, and several related studies, were visualized and guided by Dr. Robert E. Coker and Dr. Harden F. Taylor. These two scientists have been a great inspiration to the writer and have been of special assistance in helping him obtain and analyze the available facts. An attempt to include the numerous others whose contributions are so greatly appreciated would take many pages. The paper itself is, in a sense, a continuous account of contributions from one person or organization after another. I hasten to add that all involved (see the numerous references to data sources) have not only been exceedingly generous in supplying information but have also given the matter much time and thought in discussion and correspondence. I am especially indebted to Dr. Gordon Riley for his helpful criticisms.

HYDROGRAPHY OF NORTH CAROLINA MARINE WATERS

Gross Geography of the Sounds and Neighboring Waters

The sandy offshore beach which is more or less continuous from Sandy Hook, New Jersey, to Miami, Florida, is well developed in North Carolina, where it is interrupted by a few relatively narrow inlets. Along the northeastern half of the State this bank, as it is called locally, lies as a prominence far to the east of the mainland and the broad river mouths. This results in broad, shallow sounds (Figure 1 and Table 1) quite different from the narrow

TABLE 1

The Approximate Area and Volume of the Larger North Carolina Sounds

Sound	Square Miles *	Acres *	Acre-Feet †
Currituck, including Back Bay	160	102,400	512,000
Albemarle	500	320,000	5,440,000
Croatan	35	22,400	179,200
Roanoke	25	16,000	32,000
Pamlico	1,700	1,088,000	16,320,000
Core	120	76,800	268,800
Bogue	35	22,400	34.000
Total	2,575	1,648,000	22,786,000

* Estimates made with the aid of a planimeter. The elongate broad mouths of tributaries, such as the Alligator, Pamlico, Neuse, North, and Newport rivers were not included.
† Approximate area × estimated average depth.

lagoons usually formed behind such beaches. Johnson (1919, reprinted 1938) refers to this North Carolina coast as a compound shoreline, the offshore bar suggesting emergence and the drowned-valley appearance of the river mouths indicating later submergence.

Four major river systems flow into the sounds, and a fifth, the Cape Fear River, flows into the ocean to the southeast. The total drainage area, 30,290 square miles (see Figure 18 for the extent of the individual drainage basins), is largely confined to the low, flat Coastal Plain, but the Roanoke-Dan basin to the north also drains the more rolling Piedmont Plateau and the eastern slope of the Appalachian Mountain Region. In general the drainage is in forest land that has been stripped extensively for agriculture.

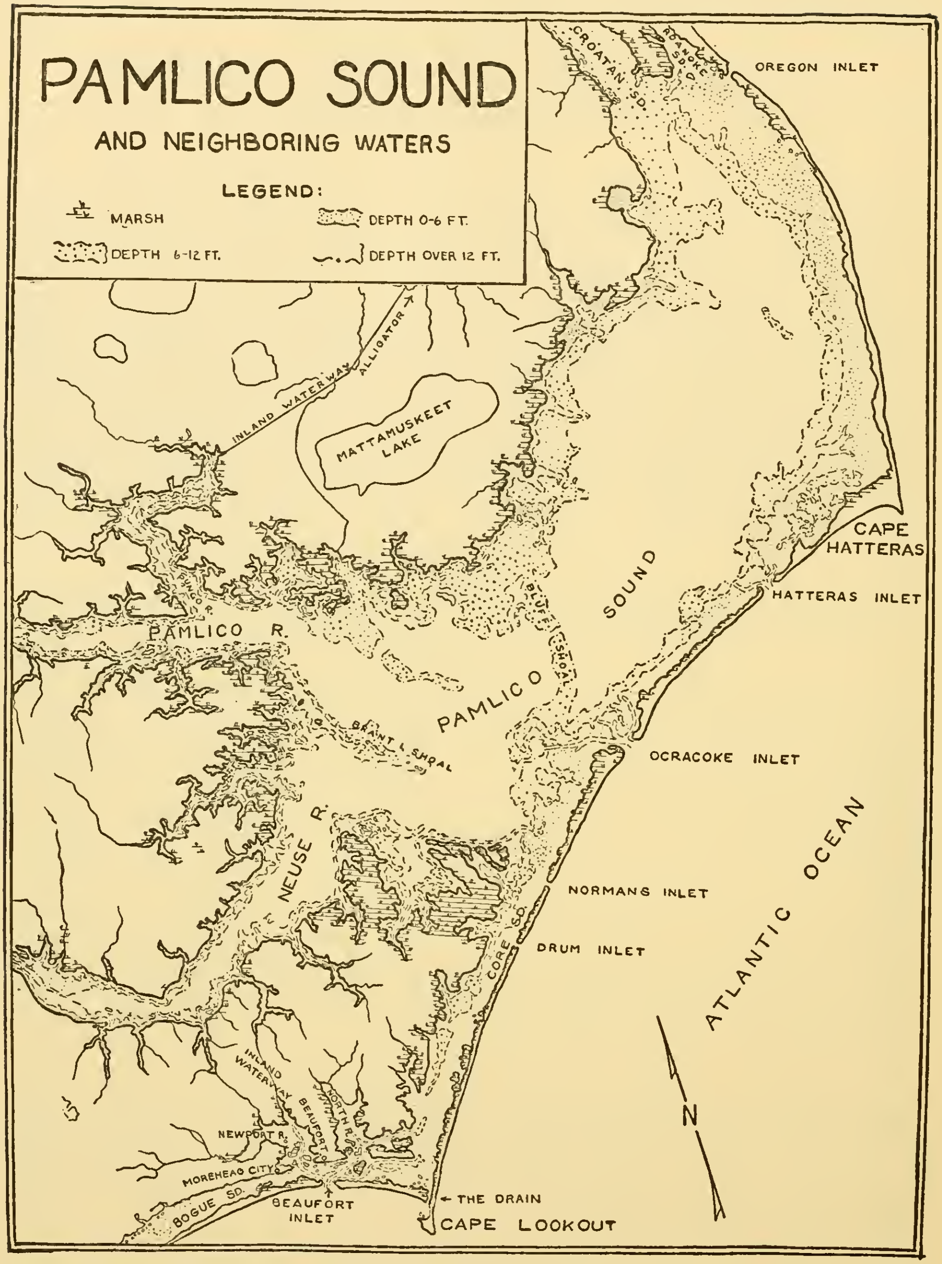
PAMLICO SOUND
AND NEIGHBORING WATERS
LEGEND:
MARSH
DEPTH 0-6 FT.
DEPTH 6-12 FT.
DEPTH OVER 12 FT.
OREGON INLET
CROATAN SD.
ROANOKE SD.
MATTAMUSKEET LAKE
INLAND WATERWAY
ALLIGATOR
PAMLICO R.
PAMLICO SOUND
BLUFF SHOAL
BRANT SHOAL
CAPE HATTERAS
HATTERAS INLET
OCRACOKE INLET
NEUSE R.
NORMANS INLET
DRUM INLET
CORE SD.
ATLANTIC OCEAN
N
INLAND WATERWAY
NEWPORT R.
NORTH R.
BEAUFORT
MOREHEAD CITY
BOGUE SD.
BEAUFORT INLET
THE DRAIN
CAPE LOOKOUT

Fig. 1.

Currituck Sound, the northernmost of the twelve named sounds in the State, is about 40 miles long,[1] 3 to 4 miles wide, and less than 7 feet[2] deep over most of the area. It is essentially a lagoon and drains the bordering swamps and lowlands. It opens into the eastern end of Albemarle Sound to the south, and Inland Waterway canals link it with Norfolk to the north and the North River tributary of Albemarle Sound to the southwest. Its mouth is about 24 miles from Oregon Inlet, the nearest opening to the ocean; consequently its waters are fresh to brackish and are notable for supporting water fowl, freshwater game fish and such migrants to fresh water as striped bass and alewives.

Albemarle Sound has an east-west dimension of about 55 miles, averages about 7 miles wide, and has a rather level bottom about 18 feet deep. Eight rivers, including the Roanoke and the Chowan, and Currituck Sound drain into this body of water which in turn drains through Croatan and Roanoke sounds and into the upper part of Pamlico Sound. Inland Waterway canals connect with Currituck Sound to the northeast, with the lower Chesapeake Bay at Norfolk by way of the Pasquotank River and the Dismal Swamp, and with Pamlico Sound to the south by way of the Alligator River. Since Albemarle Sound has such a large river drainage and the exchange with sea water is about as indirect as it is for Currituck Sound, it is essentially fresh water. As such it has proved to be an exceptionally favorable habitat for anadromous fishes (those that seek fresh water to spawn), which may spawn in the sound proper or in its tributaries. The resulting fish migrations and the shallow, level bottom suitable for staking nets form the basis for the intensive fishery of the area.

Roanoke and Croatan sounds parallel each other and extend south from eastern Albemarle into northeastern Pamlico Sound. Roanoke Sound, just west of the offshore bar, is about 8 miles long and ½ to 2 miles wide, and has a depth of only 1 to 3 feet over most of its area. West of Roanoke Island, which separates these two bodies of water, is Croatan Sound. This is also about 8 miles long but is 2 to 4 miles wide and generally 7 to 10 feet deep. Undoubtedly it is the more important in the circulation and drainage from Albemarle to Pamlico Sound. Accordingly, its fisheries potentialities as a bottle-neck for anadromous fishes entering Albemarle Sound are probably greater than those of Roanoke Sound; however, because of its higher fresh-water circulation it has not been as productive of oysters.

Pamlico Sound is approximately 70 miles in its long northeast-southwest dimension and varies from 10 to 30 miles in width. In the basins the bottom

1. This includes Back Bay, a branch of the sound north of the Virginia line.

2. The depths listed here and elsewhere in this section are characteristic depths, no consideration being given to narrow channels, especially those man-made ones that do not alter the basic physiography.

is rather level, with a depth of about 20 feet, but there are extensive shoals distributed in the Sound as follows:

1. Completely around the shoreline grading into the extensive bordering marshes.

2. As deltas at the four existing inlets (see the section below on The Offshore Bar and Its Inlets).

3. Between the converging mouths of the rivers, particularly the two larger ones, the Neuse and the Pamlico.

4. Extending northward from Ocracoke Inlet as Bluff Shoal.

The latter shoal is apparently the result of the deposition of suspended matter where waters draining from the north, Albemarle Sound, etc., meet drainage from the southwest, Neuse and Pamlico rivers, etc. (Winslow, 1889). Thus the merged estuaries of the latter rivers form one basin in southeastern Pamlico Sound, while another lies to the northeast of Bluff Shoal. The Inland Waterway connection with Albemarle Sound is cut by way of the Pungo River to the northwest, and the connection with the Beaufort area starts in Adams Creek from the south shore of the Neuse River. The salinity in Pamlico Sound varies with location (see below, the section on Salinity and Nutrient Salts), and the sessile fisheries forms are distributed accordingly: clams about the mouths of inlets, oysters along the opposite shores. The Sound also abounds with the previously mentioned anadromous fishes, which tend to linger prior to entering the estuaries or enroute to the northern sounds. Numerous other characteristically marine fishes: mullet, spot, croaker, gray trout, shrimp, and others, populate Pamlico Sound in accordance with the tendency for such forms to prosper in such extensive shallow, brackish areas.

Core Sound begins at the southern part of Pamlico Sound and extends southwesterly about 36 miles to the vicinity of Beaufort, where Bogue Sound begins and stretches about 25 miles westerly. These sounds vary from 1 to 6 miles in width and are extremely shoal, Core Sound averaging about 3½ feet of water and Bogue about 2½ feet. There is considerable drainage from the surrounding lowland by way of marshes and small creeks. Three large arms of these sounds, referred to as rivers, are the North River and the Newport River, both of which are opposite Beaufort Inlet at the intersection of these sounds, and the White Oak River opposite Bogue Inlet at the western end of Bogue Sound. The Inland Waterway from Pamlico Sound cuts through to the Newport River and at Beaufort it takes a westerly course through Bogue Sound. In addition to the Beaufort and Bogue inlets, already mentioned, there are two that cut through the banks to Core Sound. The salinity varies with the locality, being highest near the inlets, particularly near Beaufort Inlet. The fisheries resources are in a very general way much like those of Pamlico Sound.

Beaufort Inlet and the adjacent intersection of the sounds and "rivers" afford a terminal for coastal, inland-water, and land transportation which has resulted in the rise of Beaufort and Morehead City. This twin-city fishing and general coastal port is quite distinct from the other sizeable North Carolina ports which are more inland, up the larger estuaries, and have not depended so definitely on marine enterprises.

To the southwest from Bogue Inlet to the mouth of the Cape Fear River, a distance of about 75 miles, the coast is fringed with numerous small, shallow lagoons interrupted by marshes. Streams and creeks of varying volume flow into these so-called sounds and several small inlets connect them with the sea. A sizeable river, New River, drains across the marshes between Bogue Sound and Stump Sound and into the ocean by way of New River Inlet. The larger of these lagoons are Stump Sound to the northeast, then Topsail, Middle, Masonboro, and finally Myrtle Sound to the southwest. The fisheries potentialities of such waters are too varied for generalization since they differ so much in area, depth, and drainage.

There is very little open lagoon water westward along the coast from the Cape Fear River to the State line about 32 miles away. The Inland Waterway, which has continued southwestward through the sounds and marshes mentioned above, is cut through the marshes here, connecting eventually to Charleston, South Carolina, and other southern ports.

Gross Geography of the Continental Shelf

A zone of relatively shallow water extending many miles from the coastline is a general characteristic of continental sea coasts (Figure 2). Typically, as off North Carolina, this continental shelf has a gradual slope to about 100 fathoms (600 feet or 200 meters) where the gradient increases more or less abruptly, forming a continental slope to the deep ocean basin. The shoulder in the region of the 100-fathom contour is thus the real edge of the continent. Experience and available knowledge indicate that it is the shelf waters inside this contour that offer most of the known and anticipated offshore or so-called deep-sea fisheries resources. The bulge in the coastline of North Carolina is not duplicated by the 100-fathom and other deep shelf contours; consequently the area of the continental shelf off this state is relatively small, especially when contrasted with extensive areas such as Georges Bank and the Grand Bank, off New England and Newfoundland respectively. At Cape Hatteras the 100-fathom contour is only 21 miles offshore. From here to the Virginia line, where 100 fathoms lies 64 miles offshore, there are about 3,800 square miles of shelf area. From Hatteras to the South Carolina line, where the 100-fathom contour lies 78 miles along an imaginary southeastward

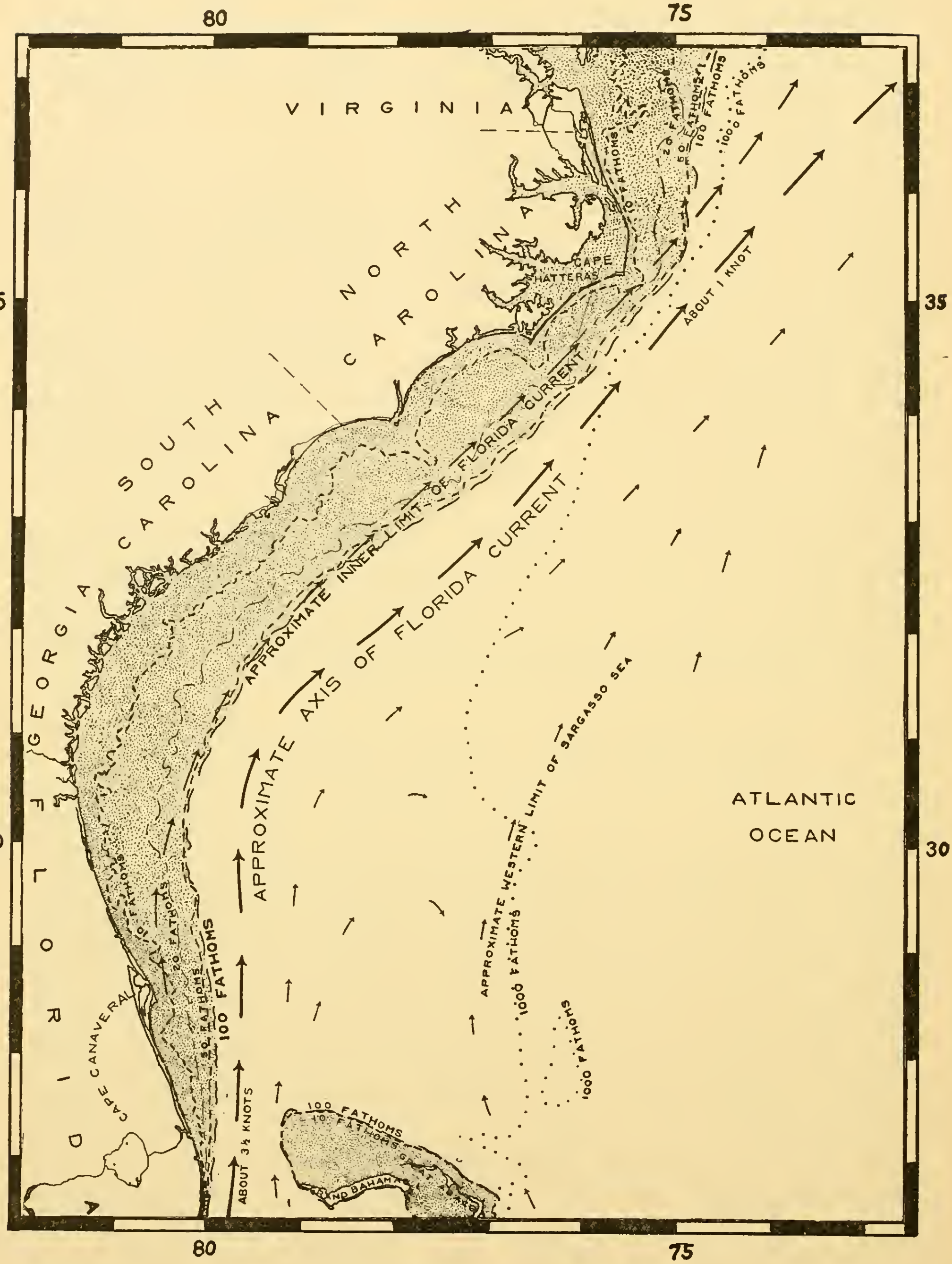

FIG. 2. The Continental Shelf.

continuation of this state boundary, there are 10,450 square miles of continental shelf.[3]

The more modern sounding techniques have not been continued on the shelf south of the North Carolina–Virginia line. To the north such sounding clearly outlines numerous canyons indenting the continental slope and it is probable that such canyons are present to the south as well. Knowledge accumulated by the experience of fishermen and others, which has acquainted us with the shelf off New England, for example, is very limited off North Carolina, but it is probably a safe generalization to say that inshore the bottom tends to be sandy and that a combination of mud and rock exists in deeper waters. Much of the rock south of Hatteras is in the form of coral patches (see section below on Nature of the Bottom).

The contours of the shoals of the continental shelf are well mapped. Three prominent ones, Diamond Shoal off Hatteras, Cape Lookout Shoals, and Frying Pan Shoals off Cape Fear, are extensions of the cuspate shoreline and project seaward almost half way across the shelf.

The shelf waters off North Carolina are directly affected by the Florida Current of the Gulf Stream System, a deep-sea current that overlaps the 100-fathom contour, by the coastal waters from the north and south, and by brackish water from the inlets. This complex interaction will be mentioned frequently in this chapter, and a comprehension of it, especially as discussed below in the section on Temperatures Offshore, is probably the most important item to be considered in trying to evaluate the State's offshore fisheries potentialities.

Circulation in the Sounds

Factors that interact to produce the circulation in the sounds include:

1. Wind.
2. River discharge.
3. Evaporation and rainfall over the sound waters.
4. Tide.
5. Corioli's force, which tends to deflect currents to the right in the northern hemisphere but has little effect in shallow waters such as these sounds.

Finally, to arrive at the probable resultant effects, all these must be considered in terms of the coastal physiography.

Chiefly as the result of oyster investigations planned with the knowledge that currents are important in the ecology of this species, many investigators have made current observations in North Carolina coastal waters, but the scattered nature of these observations and the fact that the many interacting

3. These continental shelf measurements are from planimeter readings by the author.

influences were not determined simultaneously prevent a comprehensive analysis of circulation. Winslow's (1889) observations [4] are the most complete in terms of area represented and, as with those offered by the other authors, they do at least corroborate the effects expected from the considerations offered below.

The net effect of the currents and much of the over-all circulation might be revealed by adequate simultaneous current records taken in the inlets, especially if a full account of modifying factors accompanied these. Table 2, referring to Oregon Inlet, presents one of the few such tidal prisms that have been made. Being of such short duration and without simultaneous records at other inlets, it merely offers a few clues as to circulation. It shows that wind currents may direct volumes of water away from such an inlet to the extent that the expected net discharge to the ocean is reversed. It also gives some idea of the general magnitude of circulation through such an inlet. This flow must be considered relatively small, however, when compared with that of Ocracoke Inlet which, from indirect evidence, seems to greatly exceed the others in circulation (see the section below on Salinity and Nutrient Salts).

TABLE 2

Volume of the Tidal Prism in Oregon Inlet *

Date	Wind	Total flow on flood tide, acre-feet	Maximum instantaneous flood flow, cubic feet per second	Total flow on ebb tide, acre-feet	Maximum instantaneous ebb flow, cubic feet per second	Maximum velocities knots per hour	
						Ebb	Flood
Sept. 9, 1931	Northeast	47,769	134,050	37,399	89,150	1.3	1.5
Aug. 31, 1932	West	42,726	129,100	40,054	102,700	1.5	1.4
Oct. 11, 1932	Southwest	34,873	126,500	57,208	127,300	1.9	1.4

* As reported by Corps of Engineers, U. S. Army, in House Document No. 155, 74th Congress, 1st Session, 1935.

Numerous authors have mentioned the wind currents of the sounds. All agree that the wind effect is a direct one, with minor complexities including lag, and that wind is in general the greatest current-producing force in the sounds. Extensive records showing the wind current to be expected with any

4. Winslow's paper merely gives descriptive, summarizing comments on the currents observed in different areas. On page 122 he describes three charts of Pamlico Sound (not published with his report) on which are entered the specific gravity of the water, the direction of the wind, and the simultaneous direction of the current. Photostatic copes of these charts (the originals have disintegrated) are in the Division of Tides and Currents, U. S. Coast and Geodetic Survey, Washington, D. C.

given wind are not available. From the *United States Coast Pilot* (1936) it is noted that the wind-driven water may range about 2 feet above and below normal in the open sounds, and the funneling of this water, such as may occur at Washington up the Pamlico River or at New Bern up the Neuse River behind an easterly wind, may give tides 3 or 4 feet above normal.

Obviously the net seaward flow through the sounds is positively correlated with river discharge. Direct rainfall on the sounds is to be added to this effect and evaporation from the sounds subtracted. The Corps of Engineers (1935) attempted to compile figures that would indicate these net results. The basic source of data used is not indicated and I have been unable to learn of this through correspondence. If, as is quite possible, the discharge was taken from so-called downstream gaging stations, the data are of a sort that I have deliberately avoided using for this purpose. Such stations are placed well upstream from sea level and tidal influences; consequently actual discharge may be greatly modified over the remaining miles from rainfall, evaporation, and transpiration from the vegetation. With this reservation, it is interesting to consider the figures obtained by the Engineers. The stated daily discharge into Albemarle, Pamlico, and Core sounds is 44,464 acre-feet. The daily evaporation given (from figures on Lake Michie, Durham, North Carolina) is 25,392 acre-feet. In the report the authors subtracted evaporation from discharge without mentioning rainfall on the sounds, and reported a daily net of 19,072 acre-feet to flow into the ocean. This would be a relatively minor item in sounds that total 1,648,000 acres (Table 2 shows that on October 11, 1932, the net seaward flow through Oregon Inlet alone was greater than this).

Of course freshets and seasonal highs and lows in river discharge, all of which are discussed below in the section on Salinity and Nutrient Salts, directly affect circulation in the sounds and generally cause the greatest seaward flow to occur in the early spring. The discussion of salinity also mentions density stratification, a factor which may cause shoreward countercurrents along the bottom.

It is commonly stated that there are no lunar tides in the North Carolina sounds except at the inlets (Table 3) which, of course, implies a general lack of tidal currents. The sounds are too small to have an appreciable tide generated within;[5] consequently what tide there is must issue from the ocean by way of the inlets. Such tidal effects are rapidly dampened with distance from these inlets as is clearly illustrated in Figure 3, which compares simultaneous gage readings inside Oregon Inlet, at Fort Raleigh 15 miles to the north on Roanoke Island, and at Munden Point in northern Currituck Sound, an additional 48 miles away. It follows that near inlets, currents would be more regular and stronger than elsewhere within the sounds. Many

5. In Lake Superior, for example, there is a tide of about 2 inches (Stewart, 1945).

TABLE 3

Tides Along the North Carolina Coast as Listed in the U. S. Coast and Geodetic Survey, *Tide Tables, Atlantic Ocean, 1947* *

	Mean Range	Spring Range
Outer coast	Feet	Feet
Currituck Beach Light	3.6	4.3
Cape Hatteras	3.6	4.3
Cape Lookout	3.7	4.4
Carolina Beach	4.2	4.8
Cape Fear	4.5	5.1
Inlets		
Oregon Inlet	1.8	2.2
Hatteras Inlet	2.0	2.4
Ocracoke Inlet	1.9	2.3
Beaufort	2.5	3.0
Bogue Inlet	2.2	2.6
New River Inlet	3.0	3.6
Lockwoods Folly Inlet	4.2	4.8
Tubbs Inlet	4.5	5.1
Cape Fear River		
Southport (near mouth)	4.1	4.6
Wilmington (about 28 miles from mouth)	3.2	3.4

* Albemarle and Pamlico sounds are listed but with the comment "except near the inlets, the periodic tide is negligible."

such areas are described by Winslow (1889) as having currents of a knot and more (the tidal currents in the inlets proper are given in Table 5).

Circulation Offshore

The near-by Gulf Stream System (Figure 2) is the outstanding feature of the offshore circulation. From the Straits of Florida to Cape Hatteras the western margin of the stream follows the edge of the continental shelf. In this sector, where it is referred to as the Florida Current (Iselin, 1936), the stream has a velocity decreasing from about 3 knots off Cape Canaveral, Florida, to about 1 knot off Cape Hatteras,[6] and it has a depth of about 450 fathoms, extending well down the continental slope toward the bottom of the shallow Blake Plateau, which lies beyond. The axis of maximum strength is near the western margin of the Florida Current and there is a strong flow right to the border where a vivid line of the stream's deep blue indicates the abrupt transition to the coastal waters of weaker and variable currents. Off Hatteras the Florida Current is about 50 miles wide (Church, 1932) but has

6. Recent oceanographic studies have raised some question as to the accuracy of these generally accepted velocities.

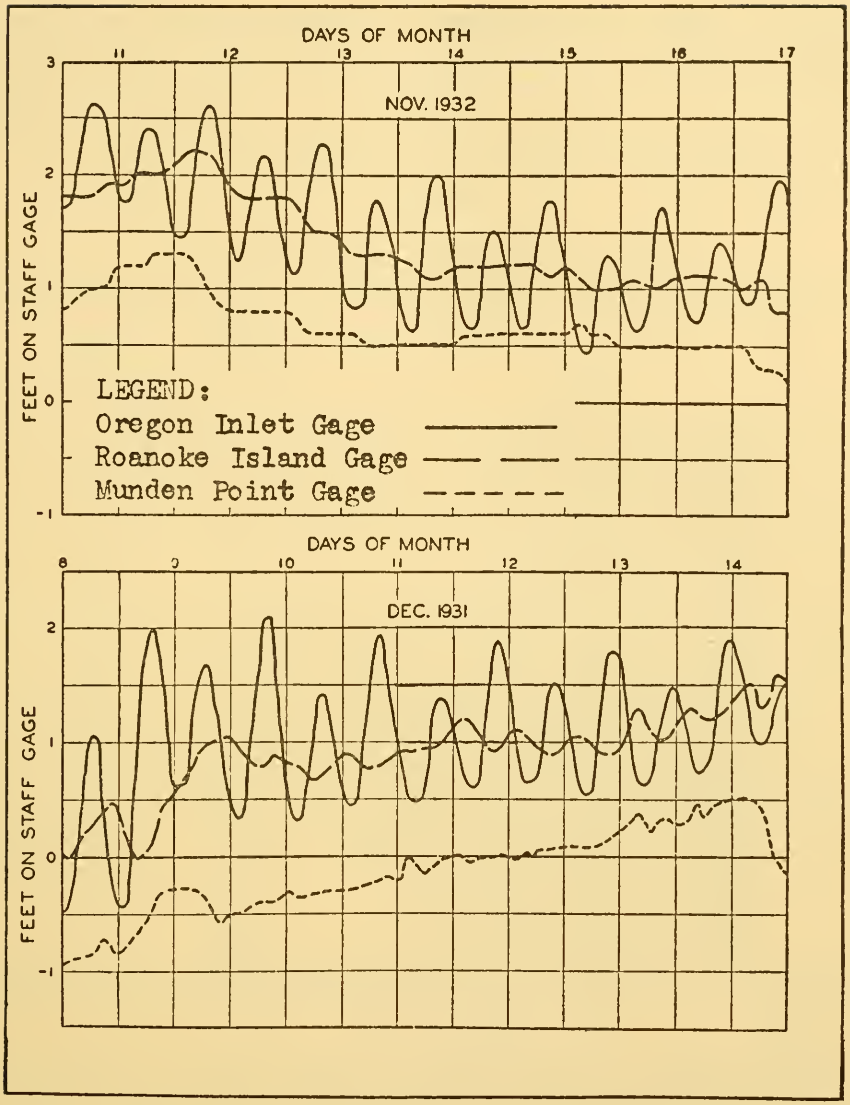

FIG. 3. Tidal gage records at Oregon Inlet and northward to Munden Point in Currituck Sound. Adapted from Fig. 8, in *Beach Erosion at Kittyhawk, Nags Head and Oregon Inlet, N. C.*, by Corps of Engineers, U. S. Army (1935).

a rather vague eastern margin as the Sargasso Sea and Antilles Current merge from the east and southeast respectively.[7]

As is well known, the Florida Current is near shore off Florida; however, with the widening of the continental shelf and the receding coastal profile of

7. The importance of these merging waters in the dynamics of the Gulf Stream System, particularly in the pronounced volume increase of the Florida Current and the Gulf Stream just beyond it, is a subject of controversy. For a discussion of this see Sverdrup, Johnson, and Fleming, *The Oceans* (1942), pp. 675-680.

Georgia and South Carolina, the stream is many miles offshore. Off North Carolina the shelf narrows again and there is a decided coastal prominence. Together these bring the coast and Current into such proximity that the latter is as near Cape Hatteras and Beaufort as it is to Cape Canaveral and Daytona, Florida, respectively (Table 4 and Figure 2).

TABLE 4

Approximate Mean Position of the Gulf Stream *

Locality	Inner edge Nautical miles	Axis Nautical miles
North of Habana, Cuba	—	25
Southeast of Key West, Fla.	—	45
East of Fowey Rocks, Fla.	—	10
East of Miami Beach, Fla.	—	15
East of Palm Beach, Fla.	—	15
East of Jupiter Inlet, Fla.	—	20
East of Cape Canaveral, Fla.	10	45
East of Daytona Beach, Fla.	25	75
East of Ormond Beach, Fla.	25	75
East of St. Augustine, Fla. (coast line)	40	85
East of Jacksonville, Fla. (coast line)	55	90
Southeast of Savannah, Ga. (coast line)	65	95
Southeast of Charleston, S. C. (coast line)	55	90
Southeast of Myrtle Beach, S. C.	60	100
Southeast of Cape Fear, N. C. (light)	35	75
Southeast of Cape Lookout, N. C. (light)	20	50
Southeast of Cape Hatteras, N. C.	10	35
Southeast of Virginia Beach, Va.	85	115
Southeast of Atlantic City, N. J.	120	—
Southeast of Sandy Hook, N. J.	150	—

* From U. S. Coast and Geodetic Survey, *Current Tables, Atlantic Coast, North America for the Year 1947.*

To the northeast of Hatteras the Gulf Stream System, called the Gulf Stream from here to a region east of Grand Bank (Iselin, 1936), continues as a well defined and relatively narrow current. It increases in depth as it leaves the Blake Plateau, but more important from the fisheries standpoint is the fact that it leaves the continental shelf. There is, as a result, a water mass of considerable depth between the Stream and the coastal waters over the shelf. This slope water, as this intervening region is called, has varying currents including eddy effects from the Gulf Stream. The water is somewhat similar to that of the Stream but shows some seasonal variations in temperature and salinity from the influence of the coastal waters and the climate.

There has been considerable speculation linking the recent warm-phase in our climate with a supposed shift in the course and transport of the Gulf

Stream System. The existence of a warm-phase, nation-wide and perhaps even world-wide in effect, has been established by Kincer (1946). Any correlation with the Gulf Stream System is, however, without foundation for the following reasons:

1. The warmer climate is not restricted to regions near the stream.

2. The weather and thus the climate of temperate regions comes chiefly from the west.

3. There are no data from which the history of the stream and its flow can be described accurately. Those who have probed into the pronounced short-term changes in course and volume, Iselin (1940), Hachey (1939), and Church (1932), have not found evidence of a change in course to fit such speculation.

Off the North Carolina coast, where the Florida Current is bounded by the continental shelf, the short-term shifting is slight (Church, 1932). Perhaps this is due to a stabilizing influence of the shelf and such an influence would also tend to minimize in this region any long-term changes that might occur.

Shoreward from the Gulf Stream System the North Carolina coastal waters have a varied circulation which has not been studied to any extent. Factors that contribute to this circulation include tides, winds, Corioli's force, the discharge from inlets, and the indirect effects of the Gulf Stream System.

The tidal influence, shown in Figure 4, is greater to the southwest than immediately off Hatteras. In open waters there are rotary tides, whereas in the inlets the tide is stronger with distinct ebb, flood, and slack conditions (Table 5).

TABLE 5

Tidal Currents in North Carolina Inlets *

	Velocity at strength of current, flood tide		Flood interval †
	Average tide knots	Spring tide knots	
Hatteras Inlet	2.0	2.4	7 hr. 20 min.
Ocracoke Inlet	1.4	1.7	7 hr. 25 min.
Beaufort Inlet	2.2	2.6	5 hr. 50 min.
New River Inlet	1.5	1.8	7 hr. 15 min.
Mouth of Cape Fear River at Bald Head	1.5	1.8	6 hr. 00 min.

* From U. S. Coast and Geodetic Survey, *Current Tables, Atlantic Coast North America for the Year 1947.*

† The average interval between the time of the moon's meridian passage and the time of the following strength of flood. At these stations the time for maximum ebb strength is approximately 6 hours greater or less.

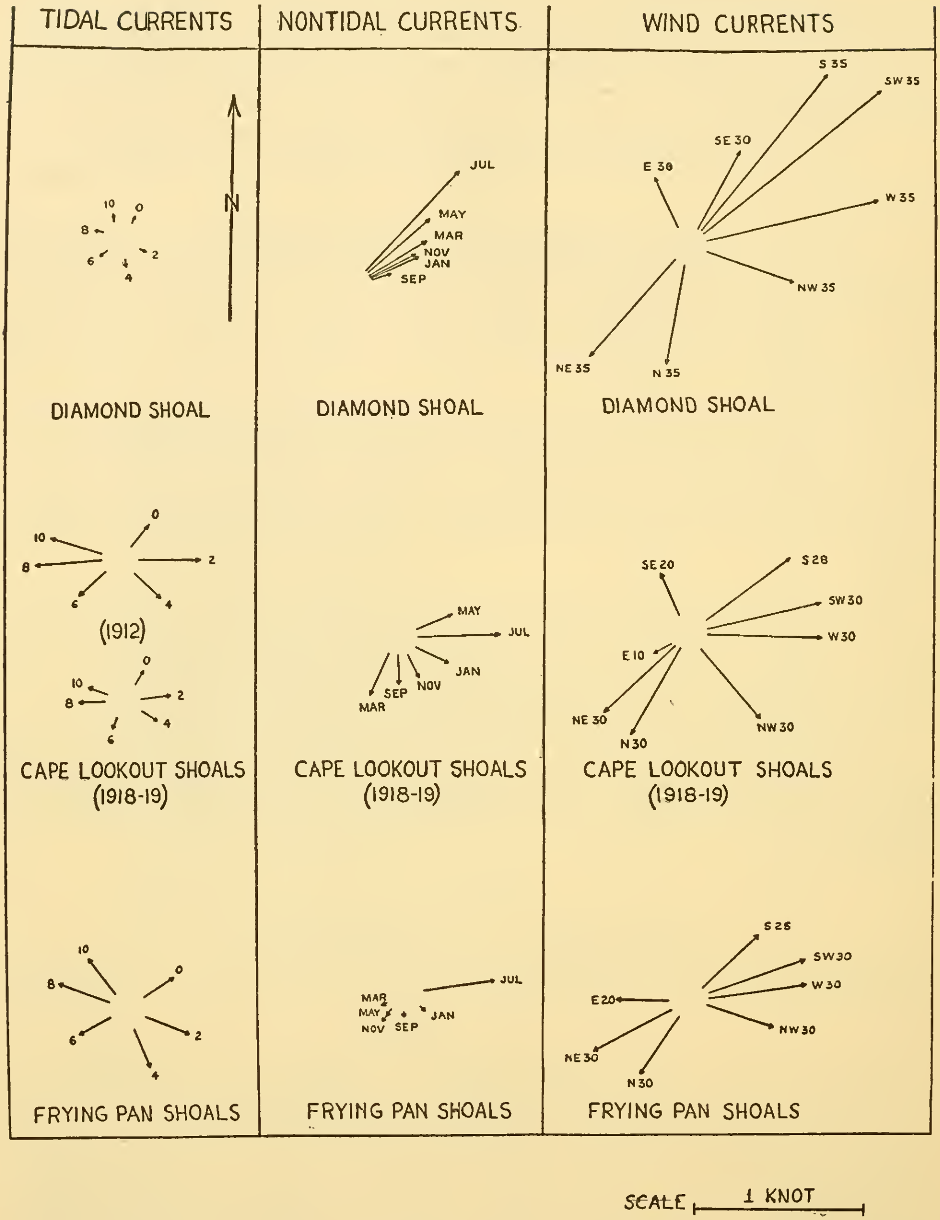

FIG. 4. Currents at three lightship stations off the North Carolina coast. Adapted from Haight (1942).

Figure 4 also shows the current produced there by the average winds from the eight major directions. These prove to be a much greater force than the tides at the coastal lightship stations. Of course these wind currents are extremely variable, as is evident from Table 6, in which the number of observations at a given wind direction and velocity indicates the proportionate number of times each wind prevailed.[8] From this tabulation the approximate frequency of a characteristic current effect is evident and, when the information in Table 6 is supplemented by that in Figure 26, frequencies for specific months can be estimated. The decreasing of the wind currents from the Diamond Shoal to the Cape Lookout to the Frying Pan Shoals Lightship correlates with the location of these stations, the lightship farthest offshore showing the greatest current, and so on. Also, all three of these show stronger wind currents than other lightships along the eastern coast of the United States.

In oceanic waters of limitless depth, Corioli's force directs a surface current 45 degrees to the right of the wind's path (this increases with depth; so the deeper currents may literally flow against the wind). The Corioli's effect is greatly minimized over the continental shelf, however, because the water is comparatively shallow. In addition the shoreline and bottom configurations have effects on wind currents to the extent that some are actually guided to the left instead of the right (Table 6).

The little that is known regarding the flow from the sounds and rivers has been discussed in the section on Circulation in the Sounds and will be mentioned further in the section on Salinity and Nutrient Salts. All that can be added is that this flow simply augments the ebb of the tide through inlets, etc., that it may have pronounced local influence but little gross effect on currents, and that its effect will tend to be deflected to the south and southeast by Corioli's force.

The effect of the Gulf Stream System on these coastal waters remains questionable. A widely accepted theory proposed by Abbe (1895) relates the peculiar cuspate shoreline of North Carolina to hypothetical counterclockwise back eddies of the Florida Current (Figure 5). Supporting this hypothesis are the south and southwestward migration of inlets and shore prominences (see section below on the Offshore Bar and Its Inlets) and MacCarthy's (1931) interpretation of the currents as indicated by the distribution of sand grain sizes. Rude (1922) has opposed Abbe's theory, however, on the grounds that his observations in the area show currents setting approximately with the wind, that the winds blow from southerly directions about as often as from northerly, and that since storm winds are chiefly from the north and northeast, the stronger currents resulting from these occasional high winds

8. The wind velocities for such observations were determined subjectively by the observers, which greatly limits their accuracy.

TABLE 6

Wind Currents at Lightship Stations off North Carolina

Diamond Shoal Lightship, 1919–28, 9 Years

Direction of wind (All directions true)	Current: Number of observations	Current: Velocity (knots)	Current: Direction (degrees)	Current: Number of observations	Current: Velocity (knots)	Current: Direction (degrees)	Current: Number of observations	Current: Velocity (knots)	Current: Direction (degrees)	Current: Number of observations	Current: Velocity (knots)	Current: Direction (degrees)	Current: Number of observations	Current: Velocity (knots)	Current: Direction (degrees)	Average of velocities: Wind (m.p.h.)	Average of velocities: Current (knots)	Average of velocities: Ratio of current to wind	Average of current directions (degrees)	Current sets to right of wind (degrees)
	At winds about 15 miles per hour			At winds about 25 miles per hour			At winds about 35 miles per hour			At winds about 45 miles per hour			At winds about 55 miles per hour							
N	2,592	0.23	173	2,132	0.45	189	545	0.65	193	399	0.84	194	86	1.10	205	35	0.65	0.019	191	11
N N E	1,494	0.19	198	1,021	0.42	204	175	0.41	208	73	0.88	202	10	1.04	213	35	0.59	0.017	205	3
N E	2,170	0.15	208	1,220	0.45	219	393	0.85	220	201	1.13	224	33	1.51	238	35	0.82	0.023	222	—3
E N E	127	0.39	31	58	0.54	250	11	0.53	276							25	0.29*	0.012	284*	36
E	407	0.28	10	178	0.49	23	39	0.60	280	14	0.50	329				30	0.35*	0.012	335*	65
E S E	136	0.55	33	48	1.06	14	13	0.44	347	15	0.99	45				30	0.76	0.025	20	88
S E	1,003	0.52	23	292	0.75	29	75	0.62	35	53	0.45	29				30	0.58	0.019	29	74
S S E	202	0.84	32	84	1.14	27	28	1.12	32							25	1.03	0.041	30	52
S	1,156	0.88	40	602	1.20	39	143	1.28	40	103	1.35	43	12	1.61	39	35	1.26	0.036	40	40
S S W	862	1.20	42	453	1.46	44	66	1.45	45	53	1.35	43				30	1.36	0.045	44	22
S W	4,175	1.06	51	2,283	1.32	52	431	1.32	55	207	1.54	52	43	1.90	48	35	1.43	0.041	52	7
W S W	1,022	1.06	55	435	1.13	57	84	1.38	60	34	1.49	62				30	1.26	0.042	58	—10
W	1,264	0.67	66	603	0.90	73	121	1.16	75	93	1.14	76	21	1.52	95	35	1.08	0.031	77	—13
W N W	297	0.70	71	166	0.62	83	46	1.08	95	27	0.76	132				30	0.79	0.026	95	—17
N W	1,388	0.38	85	945	0.45	119	298	0.57	137	150	0.84	29	31	0.59	122	35	0.57	0.016	110	—25
N N W	256	0.38	104	221	0.46	155	91	0.57	129	48	0.72	156	11	0.75	196	35	0.50*	0.014	154*	—4
Average		0.59			0.80			0.88			1.00			1.25				0.026		20
Ratio C/W		0.039			0.032			0.025			0.022			0.023						

Cape Lookout Shoals Lightship, 1918–19, 1 Year

	At winds about 10 miles per hour			At winds about 20 miles per hour			At winds about 30 miles per hour			At winds about 40 miles per hour			At winds about 50 miles per hour							
N	255	0.52	209	98	0.36	222	102	0.48	184	18	0.70	222	12	0.97	214	30	0.61	0.020	210	30
N N E	90	0.49	237	16	0.57	237	51	0.34	208				23	0.81	221	28	0.55	0.020	226	24
N E	797	0.42	227	176	0.52	227	215	0.50	227	89	0.68	227	143	0.91	226	30	0.61	0.020	227	2
E N E	45	0.41	257				11	0.89	242							20	0.65	0.032	250	2
E	96	0.13	241													10	0.13	0.013	241	—29
E S E																				
S E	159	0.15	0	28	0.33	314	24	0.38	335							20	0.29	0.014	336	21
S S E	26	0.49	58													10	0.49	0.049	58	80
S	192	0.52	55	35	0.64	50	58	0.59	47				12	0.92	63	28	0.67	0.024	54	54
S S W	47	0.76	63		0.72		15	0.61	48				14	0.88	48	30	0.75	0.025	53	31
S W	721	0.59	79	90	0.55	76	120	0.82	72	11	0.73	83	34	0.79	74	30	0.73	0.024	77	32
W S W	39	0.61	89	11	0.62	78	14	0.84	100							20	0.67	0.034	89	21
W	212	0.53	88	39		96	62	0.69	87	20	0.94	94	21	0.84	97	30	0.72	0.024	92	2
W N W	31	0.38	130													10	0.38	0.038	130	18
N W	207	0.41	133	50	0.30	134	51	0.57	134	11	0.59	186	16	1.08	113	30	0.59	0.020	140	5
N N W	39	0.43	143	16	0.34	135	18	0.22	180							20	0.33	0.016	153	—5
Average		0.46			0.50			0.56			0.73			0.90				0.025		19
Ratio C/W		0.046			0.025			0.019			0.18			0.018						

Frying Pan Shoals Lightship, 1919–20, 2 Years

	At winds about 10 miles per hour			At winds about 20 miles per hour			At winds about 30 miles per hour			At winds about 40 miles per hour			At winds about 50 miles per hour							
N	616	0.17	204	544	0.31	222	241	0.40	221	147	0.58	222	10	0.68	202	30	0.43	0.014	214	34
N N E	353	0.22	231	448	0.42	243	232	0.53	238	133	0.68	231	39	0.80	235	30	0.53	0.018	236	34
N E	1,322	0.22	246	1,161	0.46	247	677	0.59	243	200	0.65	236	37	0.85	243	30	0.55	0.018	243	18
E N E	231	0.23	263	134	0.36	252	52	0.36	247							20	0.32	0.016	254	6
E	587	0.18	273	148	0.40	270	20	0.40	273							20	0.33	0.016	272	2
E S E	114	0.17	301	36	0.21	289	13	0.35	312							20	0.24	0.012	301	9
S E	406	0.13	347	186	0.16	4	55	0.24	345	14	0.20	37				25	0.18	0.007	3	48
S S E	135	0.16	22	115	0.29	41	57	0.38	39	10	0.41	29				25	0.31	0.012	33	55
S	500	0.29	52	424	0.45	55	156	0.54	43	33	0.64	44				25	0.48	0.019	48	48
S S W	383	0.34	73	302	0.63	70	107	0.66	63	18	0.45	35				25	0.52	0.021	60	38
S W	1,195	0.39	81	814	0.58	76	267	0.70	73	75	0.71	62	10	0.90	61	30	0.66	0.022	71	26
W S W	298	0.46	91	231	0.59	85	82	0.71	77	27	0.78	73				25	0.63	0.025	82	14
W	565	0.31	92	449	0.46	89	124	0.61	83	70	0.86	77	22	0.87	72	30	0.62	0.021	83	—7
W N W	107	0.25	113	124	0.41	105	50	0.62	89	39	0.64	94				25	0.48	0.019	100	—12
N W	419	0.24	114	263	0.32	112	153	0.47	110	64	0.58	103	10	0.58	100	30	0.44	0.015	108	—27
N N W	126	0.14	141	71	0.30	153	35	0.31	161	18	0.27	153				25	0.26	0.010	152	—6
Average		0.24			0.40			0.49			0.57			0.78				0.017		18
Ratio C/W		0.024			0.020			0.016			0.014			0.016						

* Resultant velocity and direction. Current directions for the several wind velocities differ considerably.

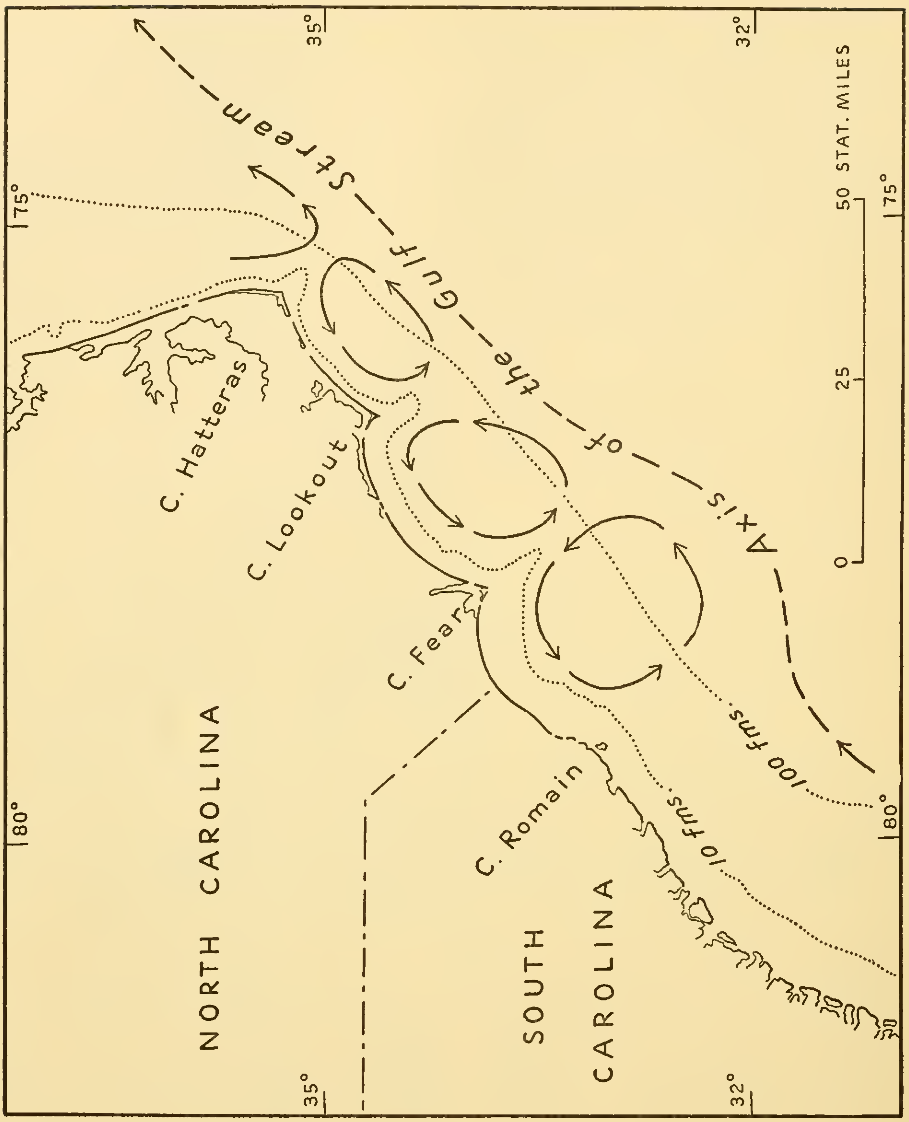

Fig. 5. Diagrammatic map to illustrate Abbe's theory of the Carolina cusps. From Daly (1942).

must be the agent molding this coastline. Johnson (1919, 1938) discusses certain types of normal wave action and the influence of prominences of the inner shoreline as alternative explanations for this cuspate coast.

Comparing these factors influencing the coastal currents off North Carolina, it is obvious that tidal effects are small and tend to cancel out because of their rotary nature. The non-tidal currents for representative months, as shown in Figure 4, are essentially the over-all resultant of (1) wind currents, (2) whatever Florida Current influence there might be, and (3) a variety of minor influences. The Florida Current influence is more or less direct and strong at the Diamond Shoal station, of course, whereas at Cape Lookout and Frying Pan Shoals it is indirect. That the resultants at the latter stations are compatible with Abbe's (1895) concept (Figure 5) and not with the wind roses of Figure 26 seems to indicate a weak, variable back-eddy circulation repeatedly modified by winds, tides, etc.

According to Bigelow (1933), and Bigelow and Sears (1935), there is nothing to indicate that waters from the Hatteras region and southward move in appreciable quantities into the coastal waters off the Middle Atlantic States. Whether there are frequent or occasional southward invasions of the latter waters has not received appreciable attention, but I have found nothing in the literature to suggest such a coastal influence from the north.

Temperatures Offshore

The Hatteras region has long been referred to as a temperature barrier to the distribution of marine forms; however, as coastal temperature gradients and information on actual distribution are analyzed, it is learned that this region is not only a barrier but is also a wintering area for migratory populations, and even, to some extent, a center of dispersal. The fisheries potentialities suggested by these unusual temperature influences merit considerable study, as is suggested, for example, by the large wintering populations that have been discovered in the last two decades by trawlers working off southern Virginia and North Carolina.

The most complete temperature records for our Atlantic coast are the surface temperatures taken at lightships and at lighthouses on the ocean shore. These were first taken during the years 1881-85 and were analyzed by Rathbun (1887). Later Parr (1933) analyzed records for 1928-30, included selections from Rathbun's publication for comparison, and elaborated extensively on the ecological significance of this temperature information.

Such continued records adequate for a discussion of the coastwise temperature cycle are surface records only; consequently, it is important to consider the depth to which these apply in continental shelf waters. Parr (1933) has

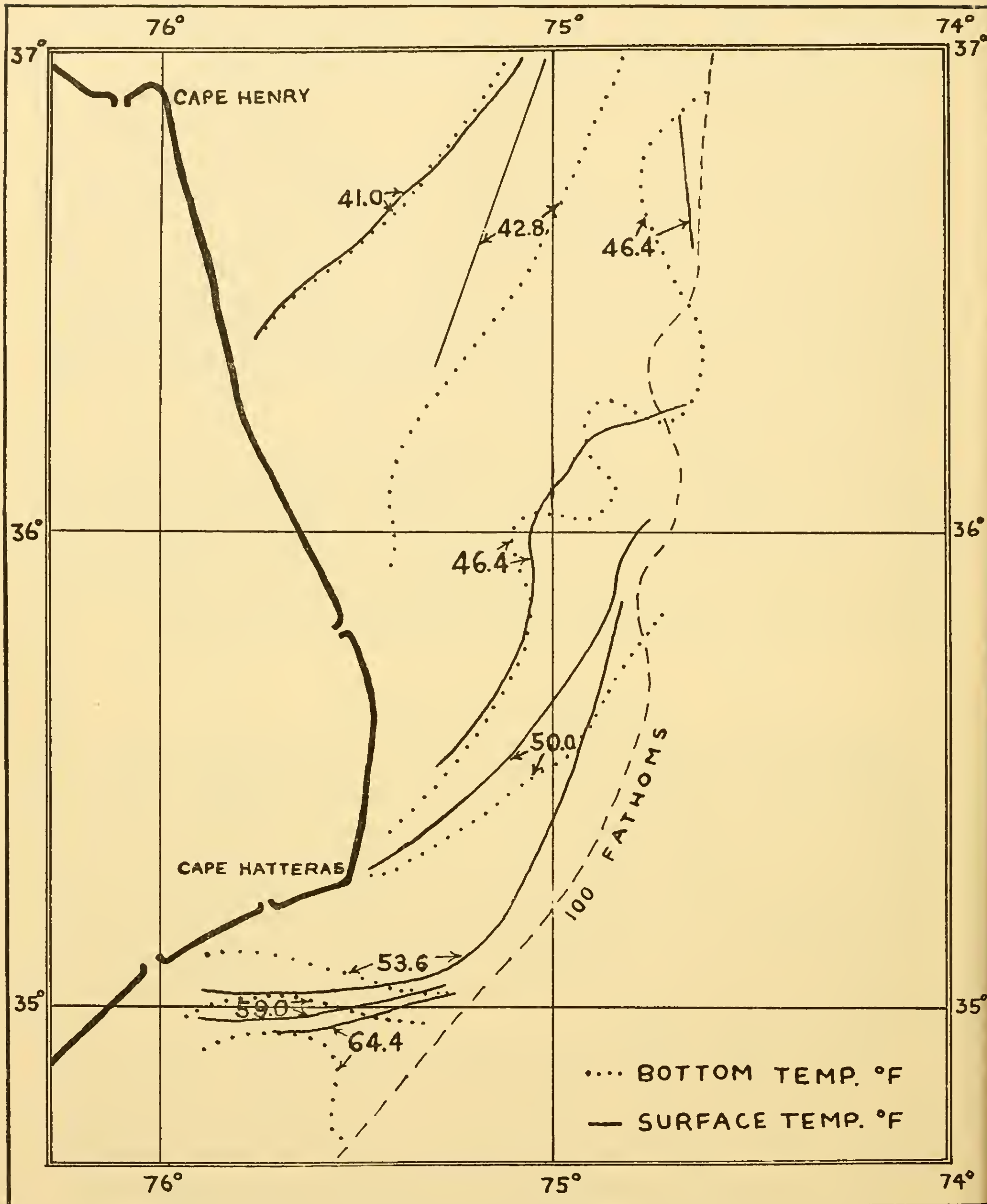

FIG. 6. Temperature near the bottom and at the surface, February 22-26, 1931. Adapted from two figures on Chesapeake Bay profile to Cape Hatteras by Bigelow (1933)

discussed this, both theoretically and on the basis of available evidence, and has presented the following conclusions for the lightship and lighthouse records:

1. During the warm season surface temperatures may be considered directly representative of conditions to a depth of at least 5 fathoms and indirectly indicative of the stage of seasonal development of the entire epithalassa, i.e., within at least the upper 10 fathoms of water.

2. During the winter, surface temperature conditions generally represent a layer of uniform temperature of about 10-50 fathoms depth.

The second point is too conservative for the Hatteras region, which will be the center of the present discussion, for here the surface temperatures are indicative of conditions to the bottom. This is shown in Figure 6, a selected illustration that agrees with other available data such as that tabulated by Pearson (1932) and that which has been summarized and made available by the Woods Hole Oceanographic Institution.[9]

Parr (1933) has also discussed his reasons for believing that records from the Diamond Shoal Lightship, directly influenced by the Gulf Stream System, apply to the narrow Cape Hatteras shelf area shoreward of this point. He has written as follows: "... an elevated ridge less than five fathoms deep extends outward nearly two-thirds of the way from Cape Hatteras to Diamond Shoals Lightship, with a complex group of shoals of even less than three fathoms depth reaching to within five miles from the lightship location [Figure 7]. With a topography of this character, particularly in a prominent region such as that of Cape Hatteras, a very high degree of turbulence affecting the distribution and mixing of the water both in its horizontal and vertical aspect is plainly to be expected ... we furthermore see that the approximate inner limit of the Gulf Stream, as determined by the United States Coast and Geodetic Survey, cuts across the outer edge of the shoals less than three fathoms deep off Cape Hatteras, and it therefore seems fairly certain that at least the marginal warm waters of the Gulf Stream will commonly, to a greater or less extent, be drawn into the turbulent mixing over these shoals. While it is probable that the average inshore surface temperatures at Cape Hatteras in mid winter may be somewhat lower than the average surface temperatures at Diamond Shoals Lightship, it is therefore, on the other hand, very improbable that the difference at this point should be nearly as great as in the waters to the southwestward, and it is clear that the inshore belt of lower temperatures, such as they may be, must under any circumstance be greatly restricted in its width in the region of the shoals off Cape Hatteras."

Figure 8 is a graphic representation of the surface temperature isotherms

9. Functioning under contract with the Division of Oceanography, Hydrographic Office, U. S. Navy.

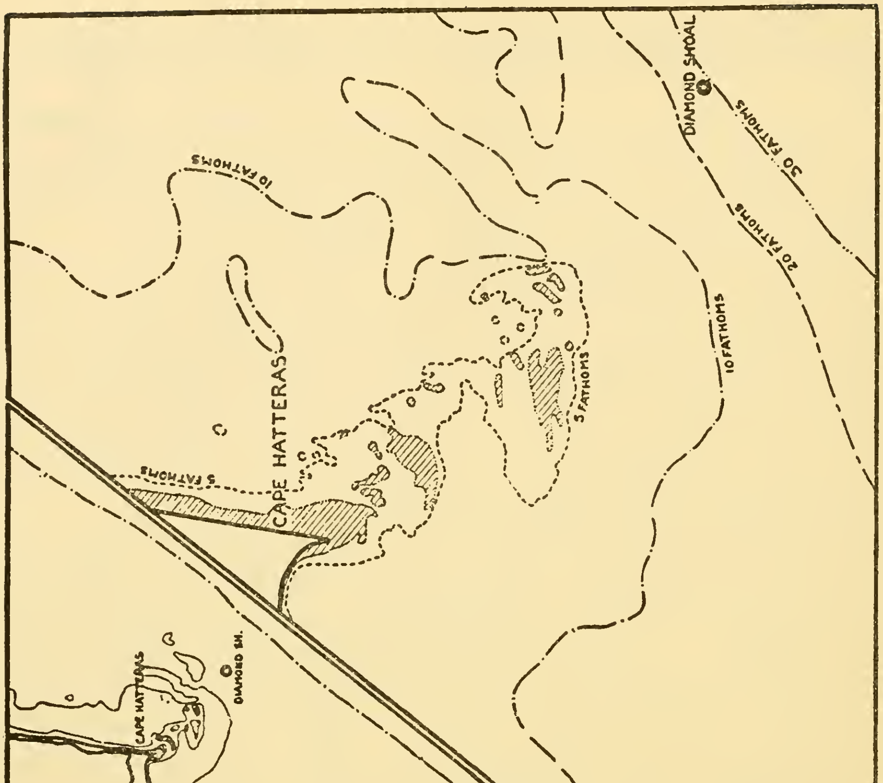

FIG. 7. Left: Chart of the region from Cape Hatteras to Cape Lookout. Right: Large-scale chart of the shoals between Cape Hatteras and Diamond Shoal Lightship. From Parr (1933).

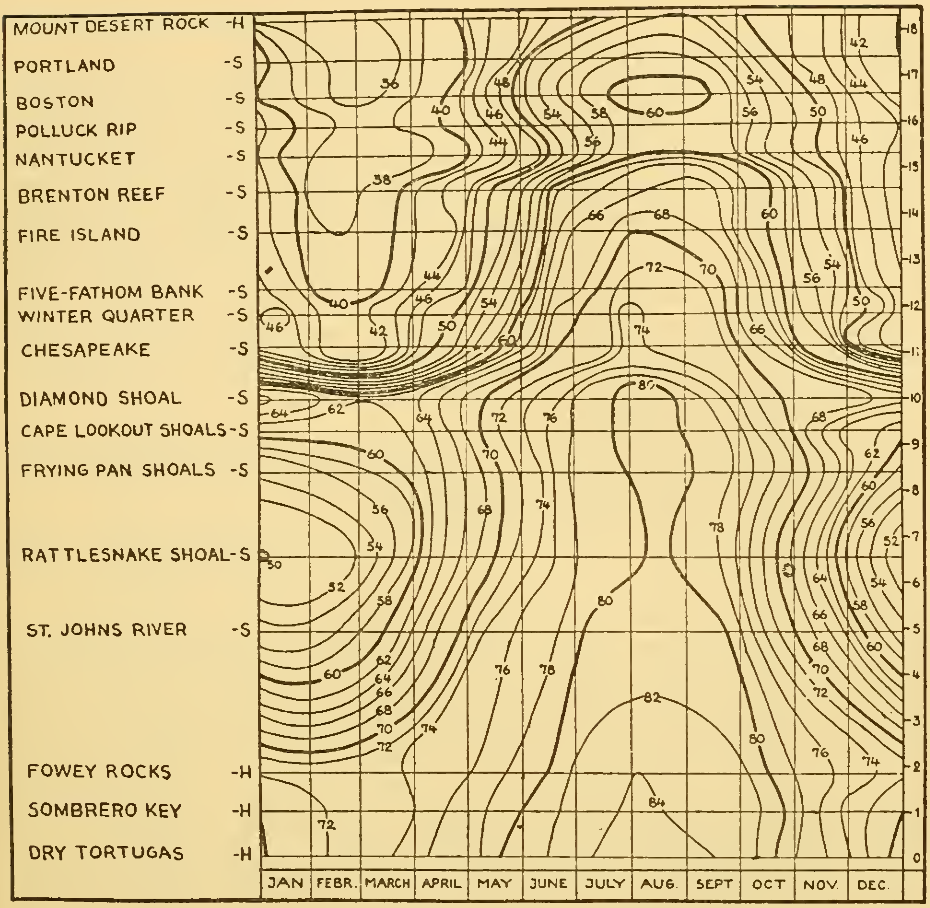

FIG. 8. Average annual surface temperature cycle in shallow water (averaging about 8 fathoms) according to records for 1928-30. The annual course of an isotherm may be read from left to right. On the left are the lightship "S" and lighthouse "H" stations, from which the records were taken. On the right are coastwise distances in hundreds of miles. Modified from Parr (1933).

throughout the year close to the shoreline along the Atlantic Coast. In the warmer months, as can be seen by reading from the bottom to the top of the graph over the month of August for example, rather uniform temperatures prevail from southern Florida to Cape Hatteras (Diamond Shoal). North of Hatteras there is a moderate gradient of decreasing temperatures but no temperature discontinuity or barrier short of the cold area around Nantucket and south of Cape Cod. Later in the fall a temperature discontinuity appears in the form of warm water in the Hatteras region (read Figure 8 for the month of February for example) and this remains till spring. This is obviously due to the Gulf Stream System, which is within a few miles of the coast at this point (Figure 2) and warms the Cape waters in spite of the seasonal cooling of shelf waters to the north and south.[10]

Parr (1933) plotted the individual temperature averages for five-day periods at the Diamond Shoal Lightship off Hatteras (Figure 10) and noted that by far the widest fluctuations occur during winter, early spring, and late fall, while there is little deviation from the normal during the summer. This is what would be expected in a region warmed by the near-by Gulf Stream System, which is forever shifting position. In contrast to this, a station such as Five Fathom Bank Lightship off Delaware Bay, which is influenced by seasonal temperature changes that affect water very slowly, shows a much smoother record as plotted on the same graph. The fluctuations at Hatteras are very significant ecologically in that:

1. They subject the biota to pronounced short term fluctuations, which are generally difficult for organisms to adapt to, even though the gross average temperatures indicate year-around warmth.

2. They may offer temporary breaks in the barrier effects of the average temperature conditions.

From the above discussion it is apparent that with increased proximity to the Hatteras region there is a decrease in seasonal change, also an increase in temperature fluctuations during winter. Much the same effects must also occur with increased distances from shore along the continental shelf to the southwest of Hatteras, where the Florida Current lies at the shelf's edge (see

10. The following extracts from the "Summary of Annual Geographic Temperature Cycle" on pp. 61-62 of Parr's (1933) paper will, with the aid of Figure 8, orient the reader as to coastwise temperature relationships for the entire coastline:

"...we thus have seasonal temperature barriers established at Cape Hatteras during the winter and in the neighborhood of Cape Cod during the summer, but the impression often given, that there should be a set of more or less permanent temperature barriers at these two points, is entirely erroneous and contrary to the facts. In the winter there is a free access for all the migratory cold water forms to penetrate as far south as to the neighborhood of Cape Hatteras, and in the summer the southern forms may move as far north as Cape Cod encountering only a slow and gradual decline in temperature on the way....

"It is also suggested that the transition from the midwinter temperature conditions in the southern section of the Atlantic coastal waters of the United States to the midwinter temperatures of the Straits of Florida may take the form of a relatively abrupt warm front somewhere in the neighborhood of the region between Jupiter Inlet and Cape Canaveral, Florida, rather than the form of a gradual and equally distributed increase in temperature. On the basis of this assumption we should, therefore, expect to find a critical and perhaps limiting point for the winter migrations of subtropical species in the vicinity of Cape Canaveral. During the summer the temperatures in the Straits of Florida are uniform with the shallow water temperatures to the northward as far as the region of Cape Hatteras, from which point a gradual change begins to become noticeable. [Author's note—The description by Green (1944) of a summer cold area at Daytona (Figure 9) seems to indicate a summer barrier to northward coastwise migration in the Cape Canaveral region in addition to the winter "warm front" described by Parr.] Although no abrupt temperature barrier is to be found at Cape Hatteras during the summer time, it is, therefore, nevertheless to be expected that this point will form the northern limit of distribution for the stenothermal tropical forms during the warm season.

"In the Straits of Florida we find the northern boundary of the Tropical American Seas with a winter temperature above 70° F. in which the stenothermal tropical forms may remain all year around."

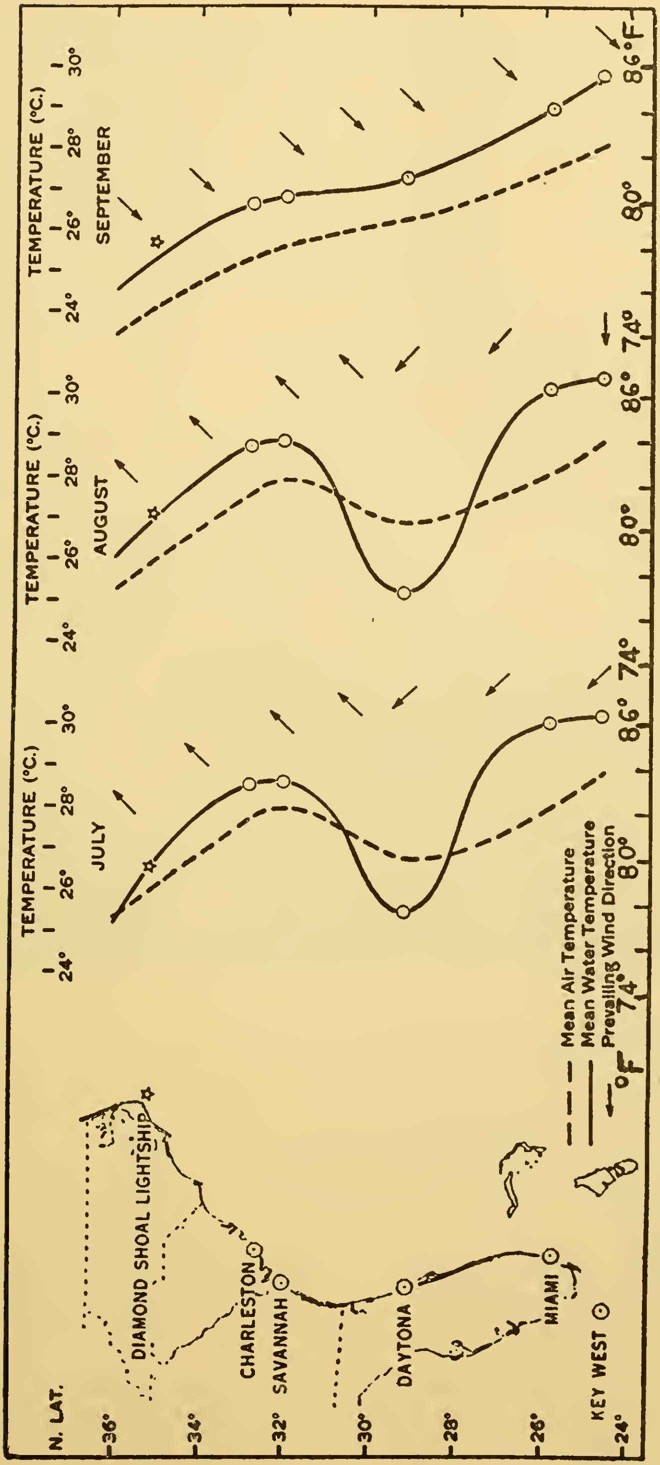

FIG. 9. A graphic representation of the summer cold wave north of Cape Canaveral. Adapted from Green (1944).

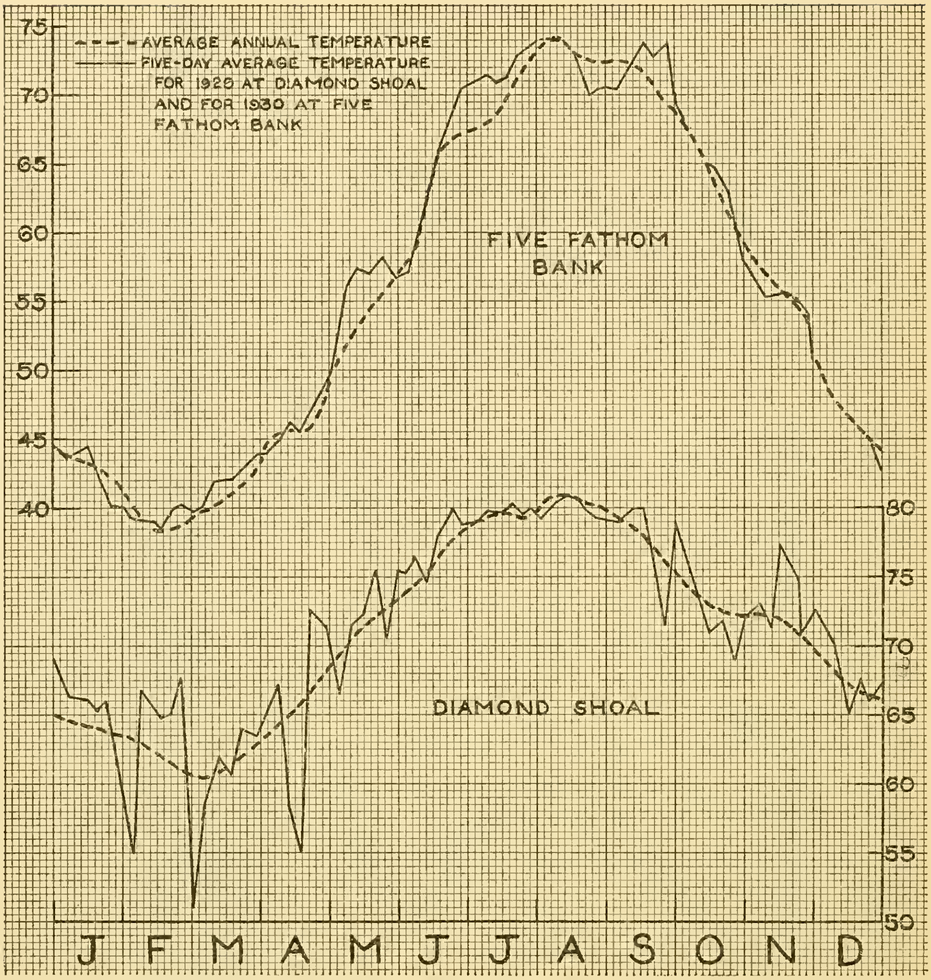

FIG. 10. A comparison of average temperatures with fluctuations in a selected representative year at Diamond Shoal and Five-Fathom Bank. Adapted from Parr (1933).

Figure 11, which compares the lighthouse and the lightship temperatures off Cape Lookout, for an example of this).

These temperature gradients suggest that non-migratory organisms that require year-around warm waters might be missing along the coast from northern Florida to southern North Carolina, yet be present around Hatteras and offshore to the southwest of Hatteras to the extent that their other ecological needs are met at increasing depths. This would result in a coastal skip distribution from south of Cape Canaveral to the region of Cape Hatteras.

Other non-migratory forms that tolerate moderate winter cooling but not the extremes found off the Middle Atlantic States might have a continuous coastal distribution northward to Cape Hatteras and little or no farther. Those that require cooler waters would encounter such north of this cape.[11]

Though the above are theoretical considerations and the ecological role of temperature is known for but few species, it is obvious from the literature and from discussions with students of the area that many known distributions of non-migratory forms fit these expectations.

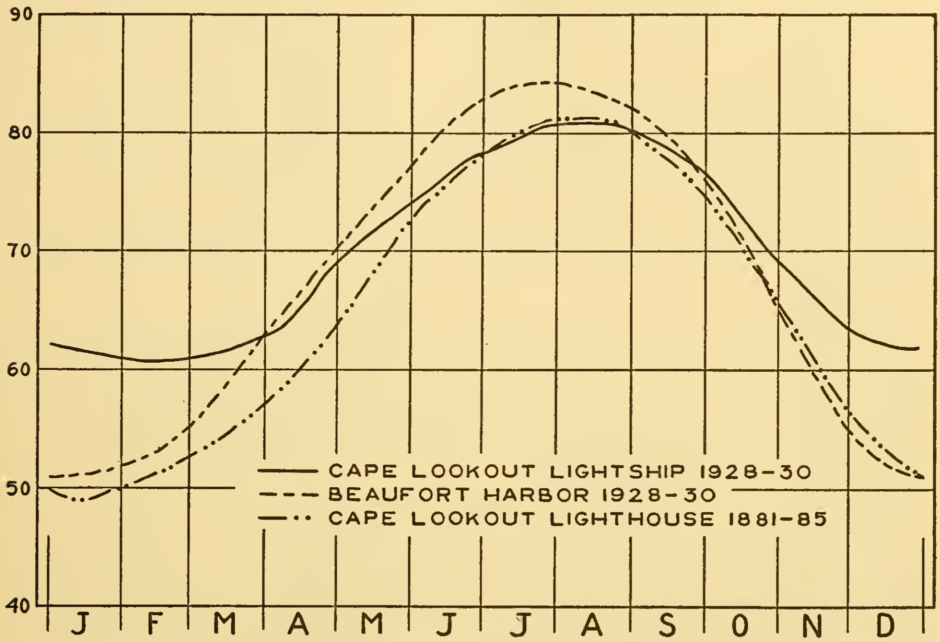

FIG. 11. Average annual temperature curves at (1) Cape Lookout Lightship, (2) Cape Lookout Lighthouse, and (3) Beaufort Harbor. Source of data and method of smoothing as follows: (1) average annual range by 25-day periods plotted on Fig. 22 of Parr (1933); (2) average annual range by 10-day period from the temperature charts of Rathbun (1887) as plotted on Fig. 17 by Parr (1933); (3) average annual cycle by 5-day periods smoothed by hand.

Most of the known migrators that frequent our coast seem to prefer warm waters or at least to avoid cooling waters. There is a group of typically southeastern fishes, like the striped mullet, *Mugil cephalus,* the spanish mackerel, *Scomberomorus maculatus,* and various shrimps, which are more or less restricted to high temperatures, that do not extend far north of Hatteras. This fauna is said to retreat southward along the coast for the winter, though it is possible that some take an offshore retreat to warmer waters at the edge of the continental shelf near the Florida Current or even a northeastward coastal migration toward the warm Hatteras region.

11. All these non-migrators must be considered in terms of the suitability of temperatures not only for the survival of adults but also for reproduction. It is not implied, however, that without reproduction the populations will not continue, for the conditions which first introduced an organism may repeatedly stock any area in question.

Other migrators seem to require still warmer, subtropical temperatures. Coastwise these temperatures may be found as far north as Hatteras in midsummer, though the summer upwelling of cold water off Daytona, Florida (Figure 9), reported by Green (1944) may partially interrupt this continuity. Offshore in or near the Florida Current subtropical temperatures prevail for a greater part of the year and thus a coastal skip distribution from Cape Canaveral to Cape Hatteras again appears as a possibility. This is important in anticipating the occurrence of the fishes variously referred to as Gulf Stream, big game, and tropical marine species. Many of these are known off the coast of North Carolina but it is not known whether their occurrence is regular or sporadic. Even if this area is far from their centers of abundance, the hypothetical skip distribution, which is applicable whether they are migrators, residents, or stragglers, makes their presence off North Carolina seem, in some respects, more probable than off coastal areas immediately to the south.

Certain fishes like the tuna, *Thunnus thynnus,* and the white marlin, *Makaira albida,* perform long migrations from tropical waters to cooler seas off the northern states. It is thought that in so doing they partially follow the warm course of the Gulf Stream System and thus come close to the North Carolina coast in passing Hatteras.

Many that characteristically migrate northeastward along the Middle Atlantic States in the spring, such as scup, *Stenotomus chrysops,* and sea bass, *Centropristes striatus,* were once thought to retreat to deep waters off the Middle Atlantic States in the fall, but it is now known that vast quantities, if not all, of these populations migrate to the warm Hatteras region in winter. Also many fishes from the North Carolina sounds, and perhaps to some extent from the coast far south of these sounds, migrate to the warmer Hatteras area in winter. In the last two decades a large winter trawl fishery has developed from catches of such fishes off the Virginia capes and the Carolina coast.

In describing this winter trawl fishery, Pearson (1932) distinguished two general areas, one to the north and one chiefly south of Hatteras (Figure 12):

"Area A extends roughly from latitude 35° 50′ to 37° N. and from longitude 74° 50′ to 75° 30′ W. The vessels usually sail a southeast or southeast by south course from Cape Henry Light, Va., to reach this general fishing area. The distance offshore extends from 15 to 60 or more miles and the depth of water ranges from 20 to 50 fathoms. Inshore, the ocean bottom appears to be generally sand or shell but mud or rocky bottom becomes more typical in the deeper offshore water. The fishermen have learned to recognize that rough, shell or 'rock' bottom usually yield catches of scup and sea bass while a sandy and smoother bottom will produce largely flounders and possibly croakers.

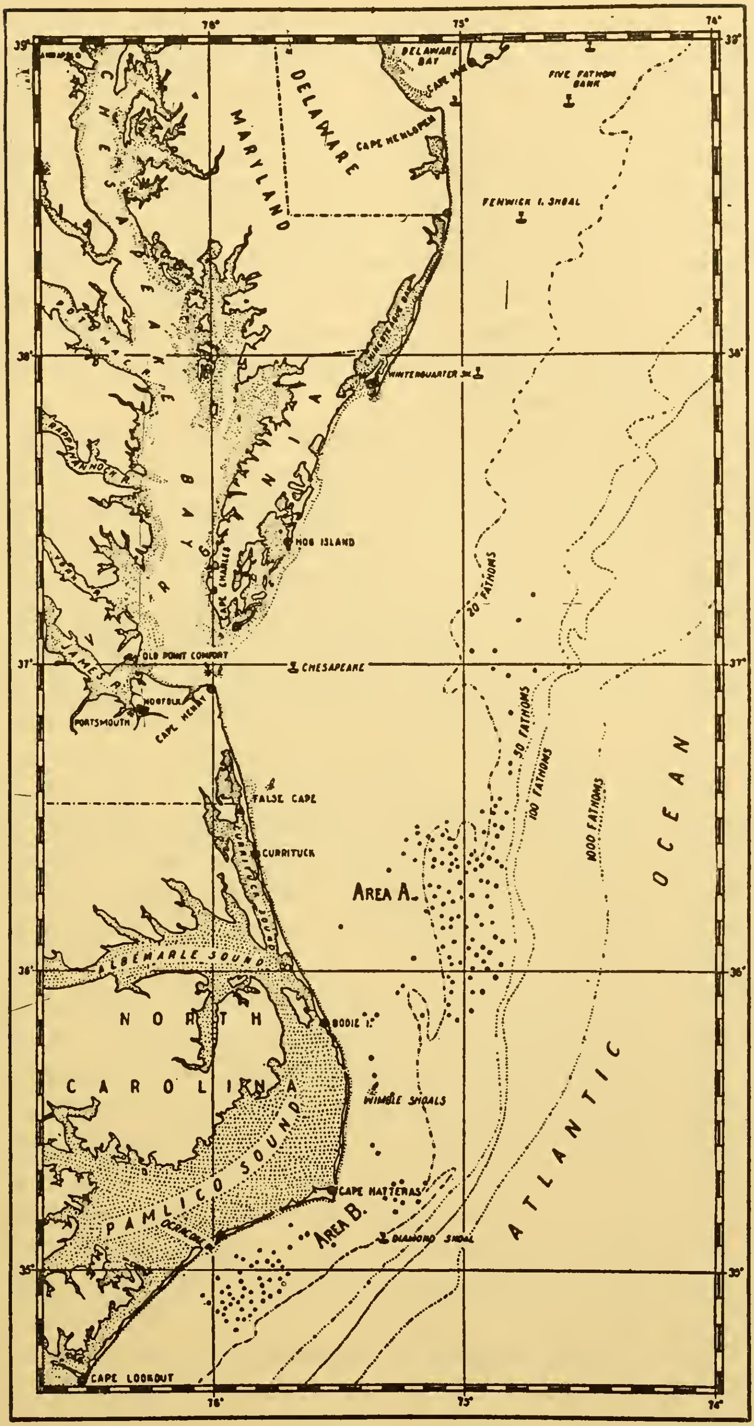

Fig. 12. Location of the winter trawl fishery effort as described by Pearson. From Pearson (1932).

"Area B lies approximately from latitude 34° 50′ to 35° 50′ N. and from longitude 75° 20′ to 76° 10′ W. This territory covers the Ocracoke Inlet fishing grounds, Hatteras Inlet and Cove, and the Carolina coast as far north as Bodie Island. The fishing grounds extend from 3 to 30 miles offshore in water from 10 to 30 fathoms in depth. Along this section of the coast the 100-fathom line runs close inshore, as does the inner limit of the Gulf Stream, and tends to restrict the fishery closer to shore than in area A."

From the trawling activities in the combined areas, Pearson (1932) records 55 species, a list which includes almost all the principal fishes common off the Middle and South Atlantic States, such as scup, *Stenotomus chrysops,* sea bass, *Centropristes striatus,* summer flounder, *Paralichthys dentatus,* and croaker, *Micropogon undulatus.*

Unlike the fishing to the north of Hatteras, the fishing effort in area B has been confined chiefly to the more inshore, sandy bottoms of less than 30 fathoms depth. This is evidently due to the scattered coral growth and other rough bottom conditions offshore (see below, the section on Nature of the Bottom) that prevent trawlers from exploring and working these waters. There are reasons to believe that this offshore region has great potentialities because the warm winter temperatures are continuous with those to the north of the Cape, the rough bottom has some physical similarity to muddy and rocky bottom well offshore in area A north of the Cape as described by Pearson (1932), and Radcliffe (1914) has demonstrated that quantities of sea bass and other fish occur the year around over reefs and rocky bottom at Cape Lookout and westward beyond the offshore limits of area B. Fishermen are apparently aware of these untapped resources, and such steps as the development of methods for fishing this area and the exploration of the bottom with modern detecting equipment may lead to fisheries expansion in this region.

On a theoretical basis Parr (1933) discussed regions with moderate seasonal temperature change—homothermous regions to use his expression—as areas of concentration and as potential centers of dispersal to neighboring regions during the favorable warm season. The offshore Hatteras area is a homothermous region and, as discussed above, it is an area of concentration in winter, but there is no indication that it is a dispersal center. Perhaps the limitation of space alone hinders this development. The coastal waters of the State when considered as a whole, however, do seem to serve as a dispersal area for some species, which apparently thrive in the extensive sounds during the long warm season, retreat to the warm offshore waters in the fall, and, in part at least, migrate elsewhere in spring and summer as mature or advanced immature fish. This seems to be the general life history pattern of vast populations of gray sea trout, *Cynoscion regalis,* and rock, *Roccus saxatilis.*

Temperatures in the Sounds, etc.

The only continuous temperature records that have come to my attention for the inland waters are those taken at the Fish & Wildlife Service Laboratory located in Beaufort Harbor. In Figure 13 the air temperature at this station is indicated and the individual surface temperature records on ebb and flood tides are plotted. This shows that water temperature (1) is essentially the same on ebb and flood tides, (2) corresponds closely to the air temperature through the year, and (3) is usually slightly lower than air temperature. Since the offshore waters show much less seasonal change (Figure 11), it is apparent that it is the atmosphere and the factors which heat the atmosphere,[12] and not oceanic waters that exert the major influence on the harbor water temperature. From the geography of the region it is also apparent that most of the sounds and other inland waters would be similarly influenced by atmospheric temperatures; consequently Figure 14 has been prepared to present the average monthly air temperatures at coastal weather stations and to imply thereby the water temperatures in the inland waters. For considering digressions from long-term averages, reference should be made to Table 10, which presents the records for a period of seventy-two years at the centrally located Hatteras station.

TABLE 7

Monthly Maximum and Minimum Water Temperatures (° F) at Pivers Island, 1924-1928, Based on One Reading Daily *

Year	Month											
	January	February	March	April	May	June	July	August	September	October	November	December
Maximum												
1924	59.0	57.2	60.8	68.0	77.0	86.0	87.8	82.4	84.2	73.4	68.0	64.4
1925	53.6	59.0	62.6	73.4	80.6	84.2	84.2	82.4	86.0	77.0	66.2	59.0
1926	59.0	59.0	66.2	71.6	78.8	86.0	89.6	91.4	89.6	86.0	68.0	60.8
1927	57.2	68.0	71.6	73.4	78.8	86.0	87.8	87.8	84.2	80.6	78.8	73.4
1928	59.0	57.2	62.6	73.4	80.6	86.0	86.0	89.6	86.0	96.8	77.0	64.4
Minimum												
1924	41.0	44.6	46.4	57.2	68.0	75.2	73.4	75.2	69.8	57.2	48.2	42.8
1925	41.0	46.4	44.6	53.6	64.4	73.4	75.2	73.4	77.0	53.6	50.0	39.2
1926	46.4	48.2	48.2	59.0	68.0	71.6	82.4	82.4	78.8	60.8	55.4	42.8
1927	37.4	51.8	42.8	55.4	68.0	69.8	78.8	73.4	71.6	62.6	55.4	46.4
1928	39.2	46.4	50.0	57.2	60.8	73.4	78.8	82.4	71.6	60.8	46.4	41.0

* From Gutsell (1931).

12. Of course the offshore waters are among the factors governing the atmospheric temperature along the coast and in this way they indirectly influence the inland waters.

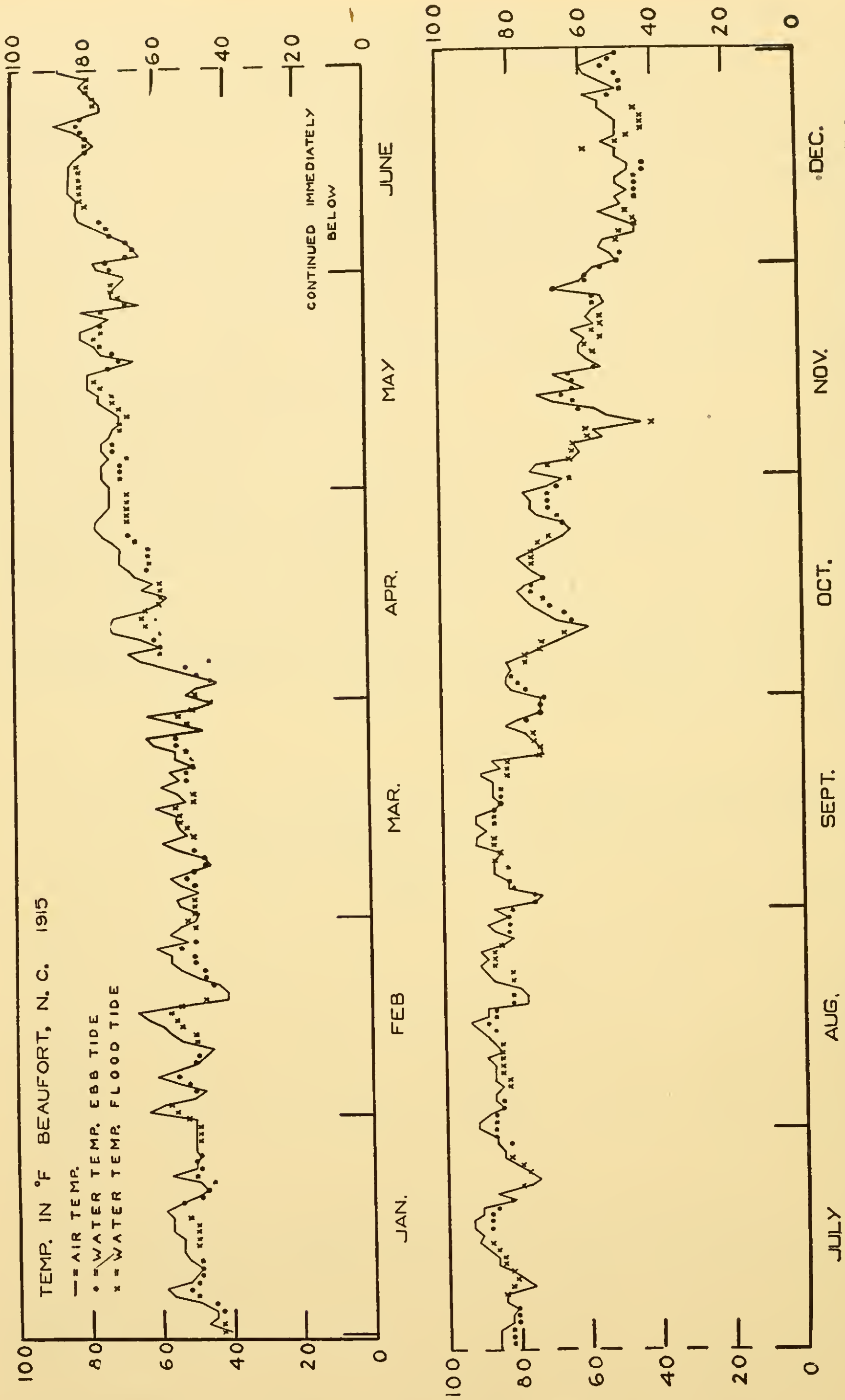

Fig. 13. Air and water surface temperatures through a year at Beaufort, N. C. Records kept by the U. S. Bureau of Fisheries Laboratory.

Fig. 14. Average monthly air temperatures at localities along the coastal area of North Carolina. Data from Martin, editor (1933), *Climatic Summary of the States.*

There are, of course, pronounced short-term fluctuations within any given month and thus the averages tell but part of the story. Figure 13 and Table 7 indicate such fluctuations in Beaufort Harbor, and shallow flats probably show even greater extremes. One extreme condition for these waters is described by the following statement from the *Supplement to the U. S. Coast Pilot* (1945): "Ice may be expected as far south as the headwaters of the North River and Pasquotank River, and Albemarle Sound, and in very severe winters, farther south."

Since the North Carolina inland waters are generally shallow in proportion to area, continuous mixing is likely to offset tendencies toward temperature stratification. It is possible, however, that the latter may develop for short periods, especially as a secondary effect of salinity stratification (see the following section on Salinity and Nutrient Salts).

The seasonal relationships between temperatures in sounds, etc., and those offshore are of considerable ecological significance. Figure 11 indicates the typical comparison, the inland water temperatures being higher in summer and lower in winter. Warm-water fishes that are in the sounds during the summer always have a retreat, unobstructed as far as temperature is concerned, to the more temperate offshore waters when the inland waters cool.

Salinity and Nutrient Salts

The dissolved salts[13] in the ocean average about 35 parts per thousand. The percentage composition of these as found dissociated or ionized is:[14]

Sodium (Na^+) 30.4%	Chlorine (Cl^-) 55.2%
Magnesium (Mg^{++}) 3.7%	Sulphate (SO_4^{--}) 7.7%
Calcium (Ca^{++}) 1.16%	Bromine (Br^-) 0.19%
Potassium (K^+) 1.1%	Boric acid (H_3BO_3) 0.07%
Strontium (Sr^{++}) 0.04%	Bicarbonate & carbonate (HCO_3^{--} & CO_3^{--}) 0.35%

Minor constituents 0.02—0.03%

This well buffered, slightly alkaline solution contains all elements known to be required by living things but there are limitations in quantity and availability which in turn may limit productivity. So limited are the supplies of phosphates and nitrogen salts and so great is the demand by living things that the quantities of these nutrients in aquatic habitats vary considerably as they are consumed and later returned to solution. Numerous factors may affect the availability of such important dissolved materials. Dead organisms, which sink to great depths, drain nutrients from the productive photic zone.

13. In referring to the concentration of these salts we use the expression salinity which is defined, on the basis of a standardized chemical procedure, as: The total amount of solid material in grams contained in one kilogram of sea water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter completely oxidized.

14. From Harvey (1945).

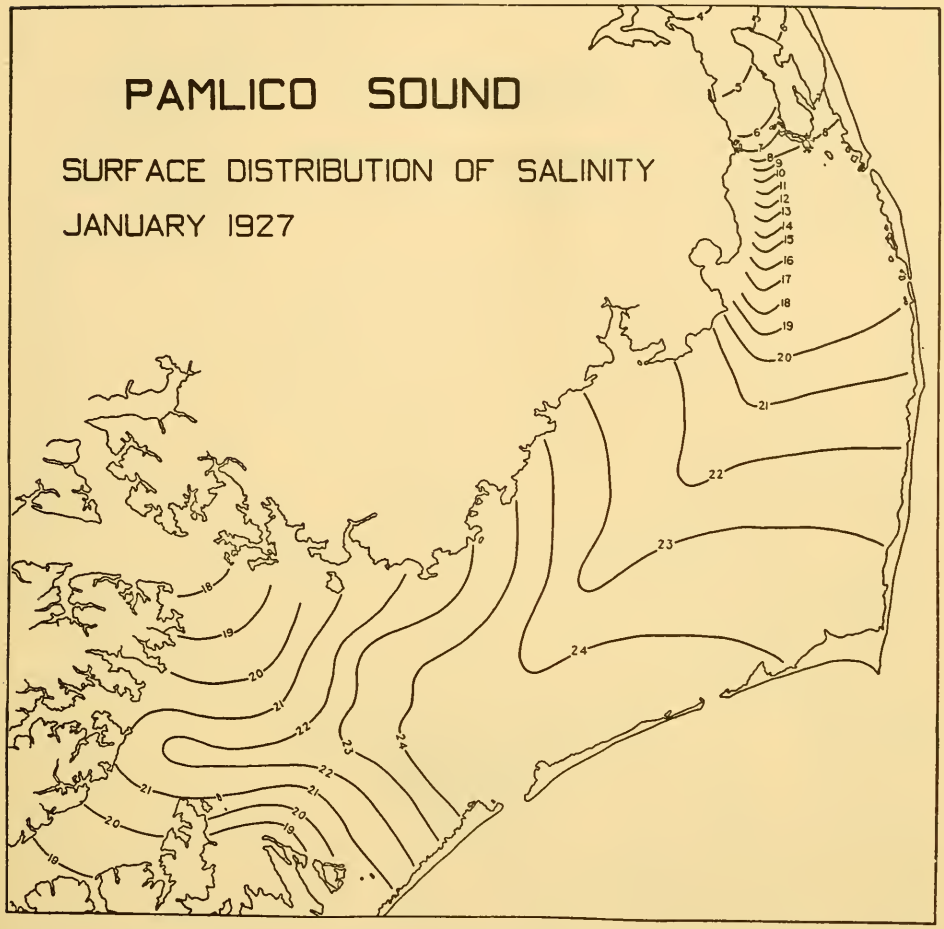

FIG. 15. Surface distribution of salinity in Pamlico Sound, January, 1927. Chart prepared by H. R. Seiwell and published here through the courtesy of the U. S. Fish & Wildlife Service.

On the other hand, in shallow waters such as in sounds or over the continental shelf, the limited depth checks this loss, and turbulence and upwelling replenish the supply. In addition, such shallow waters are usually so located as to be replenished with nutrients carried by the rivers from adjacent land.

Little is known as to the availability of such limiting nutrients or of hydrographic features that might add nutrients to the continental shelf off North Carolina. Upwelling is not known to occur, and additions through the river discharge, discussed below, are not great. As suggested in the section above on Temperatures Offshore, winds, currents, and physiographic features may cause considerable turbulence in the Hatteras region. Land drainage may prove important in contributing nutrients and it may be that a counterclockwise circulation (see the section above on Circulation Offshore) augments this by directing southward the discharge from Chesapeake Bay.

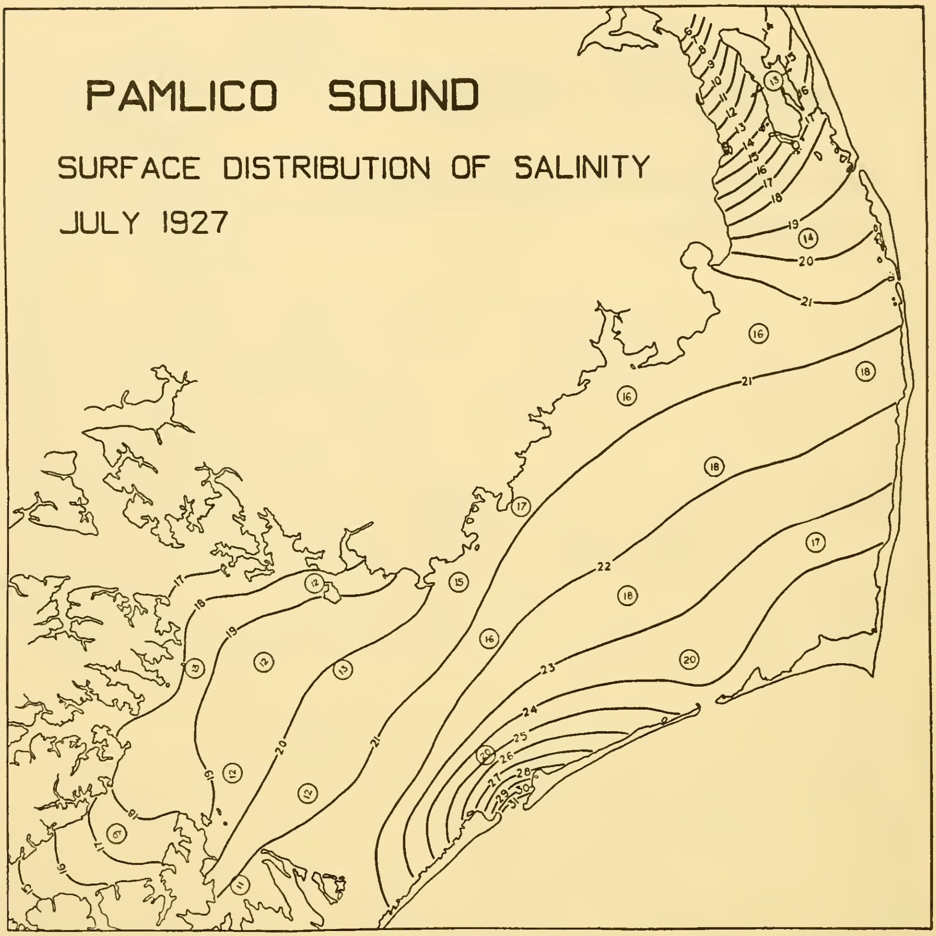

Fig. 16. Surface distribution of salinity in Pamlico Sound, July, 1927, represented by the isohalines. Added and encircled are the average surface salinities as given by Winslow (1886) for the year 1886. The isohalines were drawn by H. R. Seiwell and are published here through the courtesy of the U. S. Fish & Wildlife Service.

Density records, convertible to salinity, are available for the Diamond Shoal Lightship station for the period April, 1923, through April, 1928 (U. S. Coast and Geodetic Survey, 1945). It is doubtful that the hydrometer method used for such measurements is sufficiently accurate to evaluate slight salinity changes that would be significant in these oceanic waters. The mean for this series, namely 35‰ is, however, unquestionably representative of the station. Other data for these shelf waters include (1) the salinity tabulations of the Woods Hole Oceanographic Institution,[15] including Böhnecke's (1938) records but not the U. S. C. G. S. records mentioned above, and (2) hydrometer readings taken by the U. S. Bureau of Fisheries for the Cape Lookout

15. Compiled for the Division of Oceanography, Hydrographic Office, U. S. Navy.

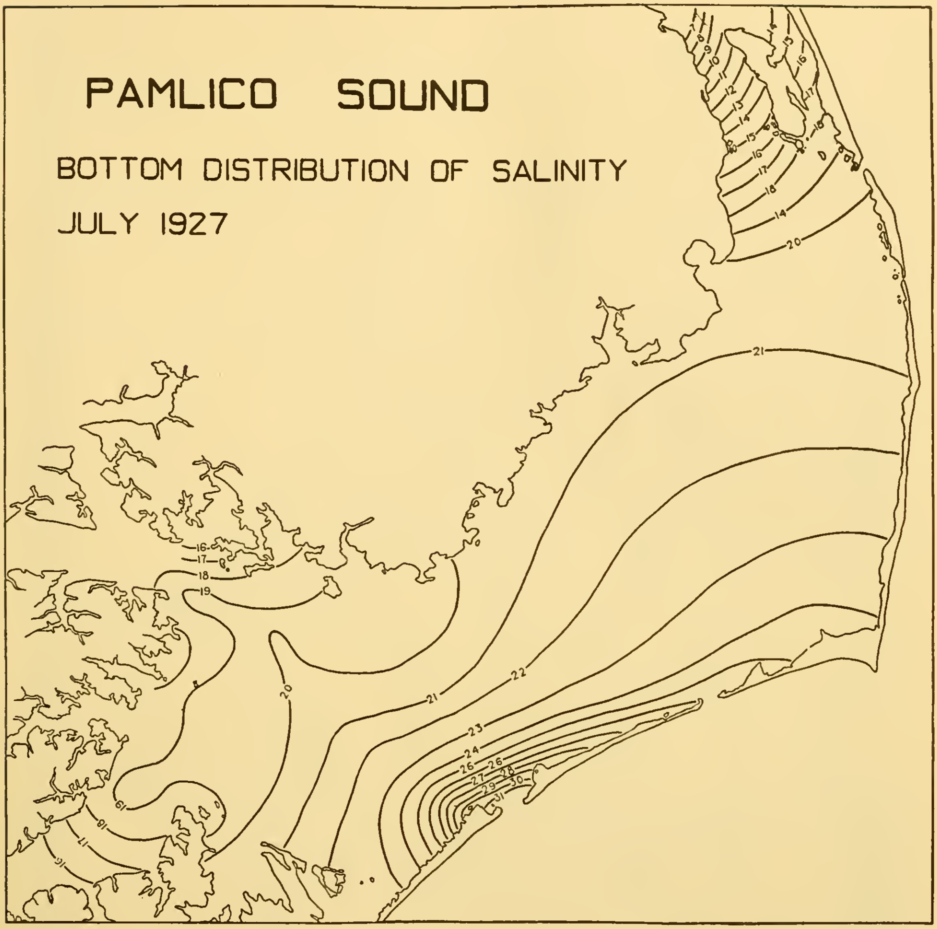

FIG. 17. Bottom distribution of salinity in Pamlico Sound, July, 1927. Chart prepared by H. R. Seiwell and published here through the courtesy of the U. S. Fish & Wildlife Service.

area and the seaward end of Beaufort Inlet. The only conclusion justified from this miscellany of records is the simple one expected for coastal regions affected by river discharge, namely, that the salinity is slightly lower over the continental shelf than in the ocean beyond, the latter being 36.0‰ and over (Böhnecke, 1938) off North Carolina.

The brackish water behind the offshore banks, Figures 15-17, is a mixture of (1) ocean waters coming through the inlets, (2) river discharge, (3) rainfall, and (4) underground seepage, an unknown factor which may drain as well as add to the water of the sounds. These waters are also affected by evaporation from the water surface and transpiration from the emergent vegetation of the marshes.

The area drained by each major river basin contributing to North Caro-

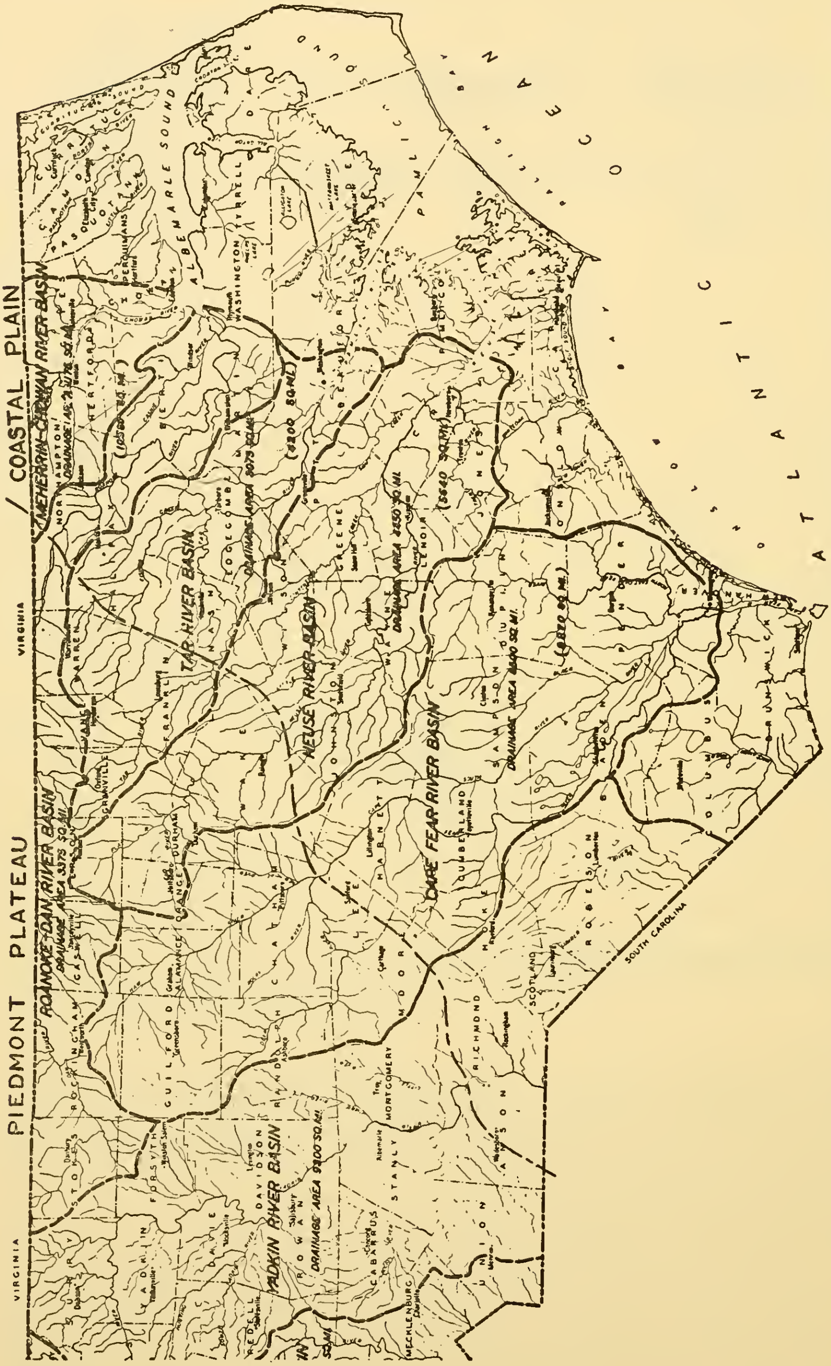

Fig. 18. River basins draining to the North Carolina coast. Figures in parentheses indicate square miles involved when the basins are interpreted as including all the coastal tributaries. Adapted from drainage map issued by the North Carolina State Planning Board (1937).

lina's inland waters is shown on Figure 18. According to this, the Cape Fear River Basin has the largest drainage and is about twice the size of the three main basins that drain into the sounds. Another interpretation issued by the North Carolina State Planning Board extends the drainage basins to include all the coastal tributaries as though part of the major basins; for example, the Meherrin-Chowan River Basin and all the waters tributary to Albemarle Sound, including Currituck Sound, are considered as in the same basin with the Roanoke River. This interpretation, the figures for which are in parentheses on Figure 18, is especially significant, for it shows that the northern drainage into Albemarle Sound equals the combined areas of the Neuse and the Tar which flow into Pamlico Sound. The Corps of Engineers (1935) states that the average daily run-off for the area tributary to Albemarle, Currituck, Croatan, and Roanoke sounds is 26,950 acre-feet as compared with 17,504 acre-feet for the drainage tributary to Pamlico and Core sounds. As mentioned above in the section on Circulation in the Sounds, the source of these data is unexplained and rather questionable; nevertheless, there is a noteworthy correlation between these discharge figures and the over-all areas just mentioned.

Figure 19 shows the rate of discharge from these river basins as it varies with the seasons over a period that was selected as having the most complete records and including both drought and wet conditions. The most downstream permanent gaging stations were used for the flow data under consideration, but even these stations were some distance from the river mouths, beyond any backing-up effects characteristic of estuaries; consequently, the actual discharge from the rivers may be quite different when rainfall, evaporation, and transpiration effects are considered. For this reason only the figures for run-off in inches,[16] which are on a per unit of area basis, have been used. This gives all four rivers approximately equal weight in the computed averages and demonstrates seasonal and annual changes in relation to rainfall. A correlation with precipitation is noticeable in the fall, winter, and spring. The fall often has little precipitation and little discharge. The winter and spring have more rainfall, greater discharge, and, according to Figure 20, a high frequency of floods and freshets. Summer is usually a rainy period, but apparently because of transpiration and evaporation, the discharge does not always rise accordingly and floods are not as frequent as the precipitation data at first suggest. On an annual basis there is more agreement between discharge and precipitation, though the latter still fluctuates more than the former.

Other factors being equal, these fluctuations in river discharge must cause inverse fluctuations in salinity in the sounds. Such a relationship has been

16. Run-off in inches is the depth to which a drainage area would be covered if all the water draining from it in a given period were uniformly distributed on its surface.

FIG. 19. The first 13 graphs show the monthly average stream discharge from the following stations: Fayetteville on the Cape Fear River (not included for the years 1940-43); Kinston on the Neuse River; Tarboro on the Tar River (not included for the year 1931); and Roanoke Rapids on the Roanoke River; also monthly average precipitation from the following five selected stations: Chapel Hill, New Bern, Tarboro, Weldon, and Wilmington. The graph at the bottom right shows the yearly average stream discharge from the four stations mentioned above; also the yearly average precipitation for these stations. Data from the U. S. Geological Survey Water-Supply Papers.

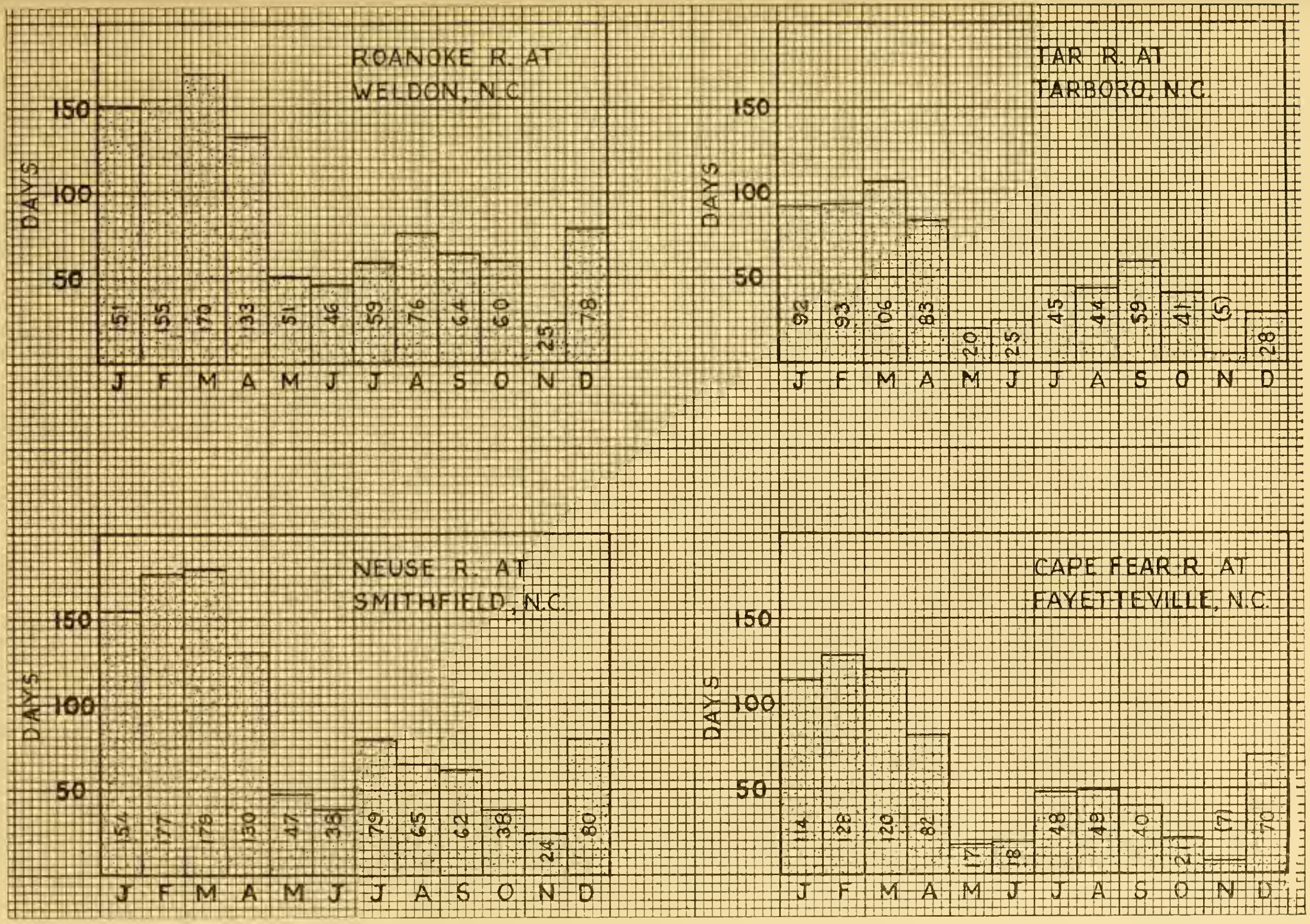

Fig. 20. Number of days (indicated in vertical bars of histogram) when the river level was in a severe flood condition during the period January, 1905, through December, 1945. The criteria used to define severe floods were the following heights above normal levels:
25 feet or above in the Roanoke River at Weldon, N. C.
15 feet or above in the Tar River at Tarboro, N. C.
12 feet or above in the Neuse River at Smithfield, N. C.
25 feet or above in the Cape Fear River at Fayetteville, N. C.

From unpublished graph by G. P. Weber of the U. S. Weather Bureau.

demonstrated for Chesapeake Bay waters by Beaven (1946) who further noted that periods of high stream flow have a cumulative effect such that "when salinity is depressed it does not recover fully for a period of weeks or months."

Rain falling directly on the sounds (see the precipitation data of Figure 19) must also be considered as a major factor reducing salinity. As with river discharge, its effects are minimized by evaporation and transpiration. The Corps of Engineers (1935), using rates determined at Lake Michie near the inland city of Durham, set the average evaporation from the sounds at 25,392 acre-feet per day but there are no figures for transpiration. Though seasonal or even annual evaporation–transpiration totals are not available, it is obvious that these are very significant considering the 1,648,000 acres of water surface in the sounds, their lengthy coastlines with vast areas of emergent vegetation, and the fact that the evaporation figure alone is more than half the river discharge estimated by the Corps of Engineers. Both the evaporation and transpiration are probably greatest in the late spring and summer; so their role in offsetting rainfall and river discharge is probably at a minimum in winter and in early spring when the river flow is often at a peak. Figure 21 showing monthly changes in salinities at Beaufort shows this seasonal effect.

Winds, currents, and diffusion tend to mix the fresh water flowing in a general seaward direction from the river mouths with the ocean water entering the sounds through the inlets. Because of differences in density, however, some stratification of fresher water over that from the sea is to be expected even in such shallow estuaries as Pamlico Sound. In numerous papers Nelson (1928 and 1931, for examples) has described the existence of salinity strata in Barnegat Bay and vicinity in New Jersey, where the depth is considerably less than in much of Pamlico Sound.[17] Also, Figures 16 and 17 suggest slight

17. There is some evidence of this for North Carolina waters in the published records of Grave (1904) as offered in the following two tables. This is relegated to the status of a footnote here, however, because accompanying temperature records are not given, and the consistently higher densities toward the bottom may be, in part at least, a result of temperature and not salinity.

Average densities at 3 stations over an oyster bed in North River

High Tide		Low Tide	
Surface	Bottom	Surface	Bottom
1.0221	1.0227	1.0172	1.0173
1.0206	1.0207	1.0181	1.0183
1.0197	1.0199	1.0169	1.017

Average depth 3½ to 4 feet at low tide. From Grave (1904)

Average densities at 4 stations over an oyster bed in Newport River

High Tide		Low Tide	
Surface	Bottom	Surface	Bottom
1.0182	1.0187	1.0164	1.017
1.0176	1.0177	1.0156	1.0158
1.0163	1.017	1.0128	1.0156
1.0168	1.0169	1.0146	1.0166

Depth 3 to 9 feet at low tide. From Grave (1904)

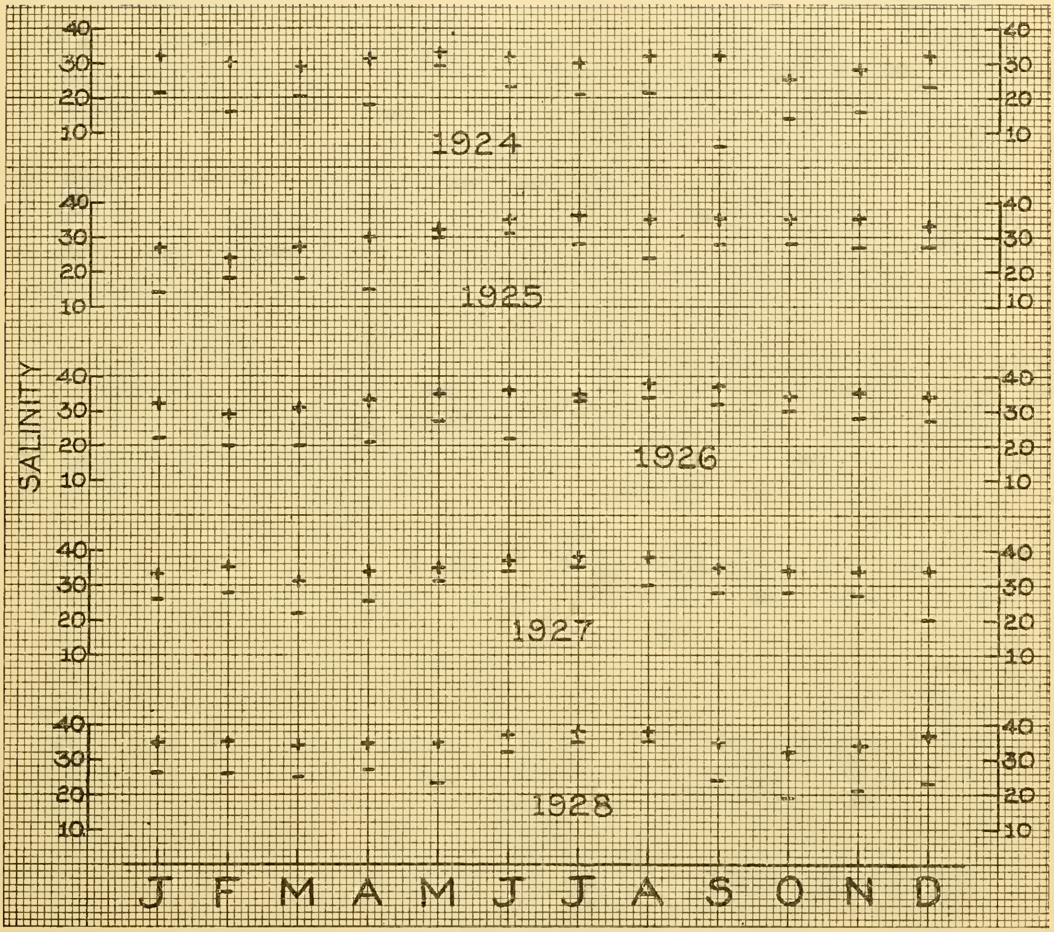

FIG. 21. Extreme monthly maximum and minimum salinities at Pivers Island, Beaufort, N. C., 1924-28. From Gutsell (1931).

stratification where bottom isohalines for July, 1927, are seen as tongues of high salinity pointing toward the river mouths. Since warm water is less dense than cold [18] and since there is a tendency for the surface to be heated during warm periods, temperature conditions may supplement the salinity stratification. On the other hand, when the surface water cools, its increased density opposes any stratification due to salinity but does not necessarily prevent it; consequently there may be a layer of colder, fresher water toward the surface (for an example of this in shallow waters see Nelson, 1928).

Currituck Sound, many miles from the nearest inlet, is considered essentially a body of fresh water. A salt-water guard lock prevents an inflow of brackish, polluted water from the Norfolk area into the sound by way of the Albemarle and Chesapeake Canal. The lock was removed in 1913 resulting in higher, more variable salinities. Largely because of the threat to the unusually good production of freshwater game fishes and related forms, a new guard lock was put in operation at Great Bridge in 1932. Figures 22 and 23 show the before and after effects of this installation.

Albemarle Sound is also essentially fresh water as its biota indicates. About the only salinity records available apply to the eastern end as given in Figure 22. Certainly to the westward, with the increased influence of the tributaries, salinities are no higher than this.[19]

The salinities in Pamlico Sound may be represented by Figures 15, 16, and 17. The isohalines indicated form inverted cones, each of which has its apex at Ocracoke Inlet and is not perceptibly modified about the other narrower and shallower inlets. This suggests that practically all circulation between the ocean and Pamlico Sound is through Ocracoke Inlet, or at least such was the case when the records were taken in 1927. On the other hand, in the earlier 1880's the salinity was high about the mouths of all the inlets, according to figures published by Winslow (1886) and shown within the circles of Figure 16.

Winslow (1889) did not publish all the substantiating data but gave the following very interesting account of the effects of winds on salinity in Pamlico Sound:

"It must be remembered that the condition of the water is not dependent upon the wind prevailing at any particular time, but upon the wind that has

18. Except near the freezing point. Maximum density of water is 4° C. (39.2° F.). It expands with the fall of temperature below this point until it freezes, thereafter it contracts on further cooling.

19. Robert W. Luther of the Public Utility Commission of Elizabeth City has submitted chloride determinations for points in the Chowan and Pasquotank rivers and Knobb Creek, tributary to the latter. None of these indicate salinities even approaching 1‰; however a note indicates that fishermen reported water too salty to drink about 8 miles upstream from the mouth of the Chowan in 1941. The note also indicates that, according to these fishermen, this was the first period of such high salinity in 70 years. Figure 19 of the present paper shows that 1941 was a drought year with low river discharge.

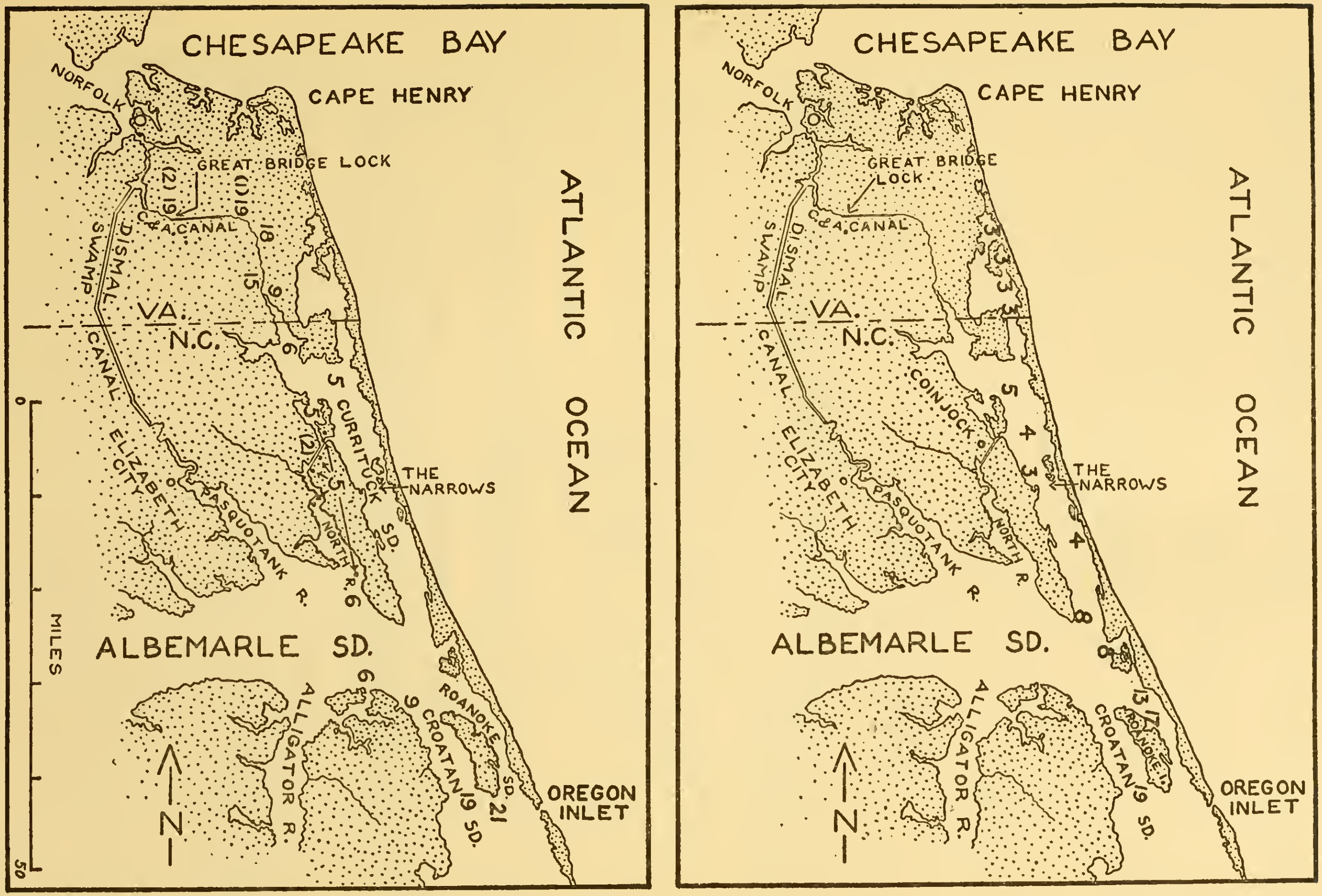

FIG. 22. Salinity in the northern sounds before and after the completion of the new guard lock at Great Bridge in 1932. Open numbers of both maps are salinities along different routes October 11-13, 1926. Figures in parentheses on map at left are salinities as of February, 1934. Data from Fig. 9, in *Beach Erosion at Kittyhawk...*, by Corps of Engineers, U. S. Army (1935).

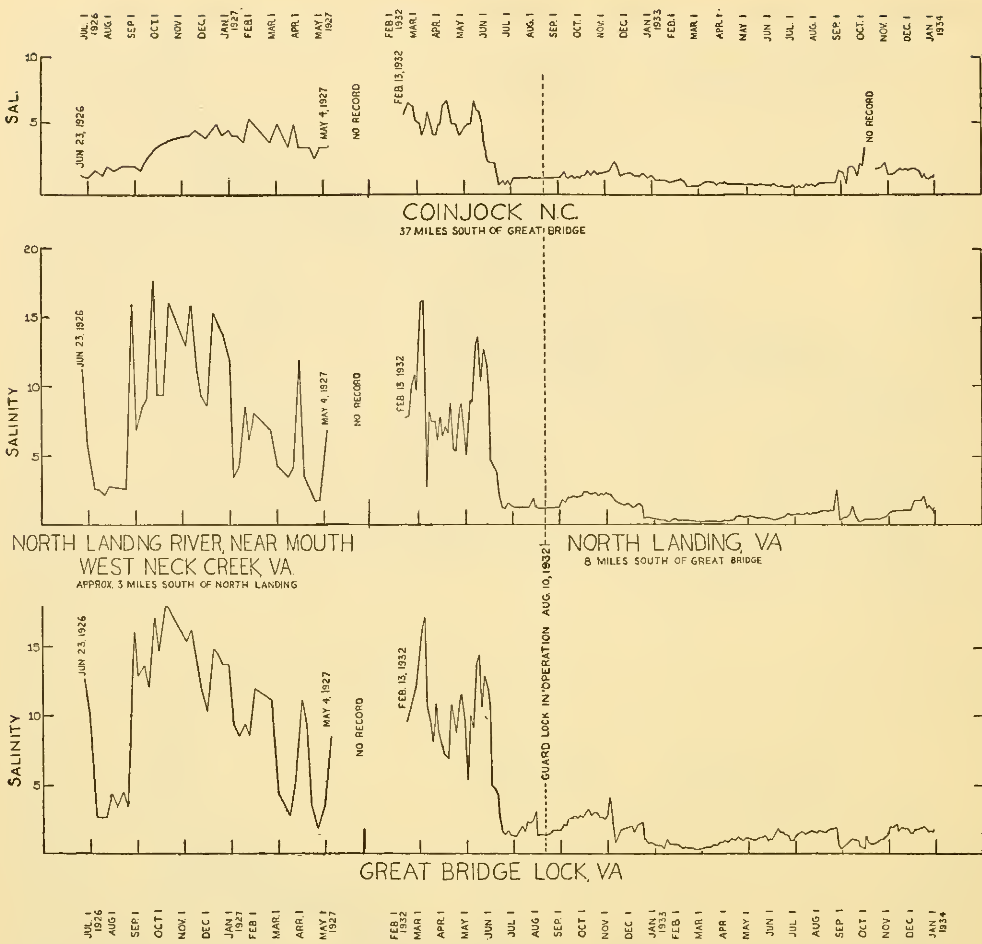

FIG. 23. Salinity observations before and after the installation of Great Bridge tidal guard lock. Adapted from unpublished graph supplied by the Corps of Engineers, U. S. Army.

prevailed; while, except in the neighborhood of the inlets, the exact opposite is the case with the currents. For instance, in the upper part of Pamlico Sound, the specimens taken during a strong northwesterly wind, and with a strong southerly current, may show a high specific gravity. But by consulting the weather record of the previous days or weeks it will be found that strong easterly and southeasterly gales have prevailed. The water of the ocean was thus driven into the Sound and then up it; the natural flow from the Albemarle was stopped, and the heavier, denser waters of the lower part of the Sound banked up against it. As the wind changed to the southward and westward, the pressure at the inlets was relieved and the water there began to flow out; but the direction of the wind would prevent any great change of conditions in the main body of the Sound, as its major axis extends nearly northeast and southwest. Upon the change of the wind to the northward, however, an immediate and comparatively violent movement of the water will take place in the direction of the inlets where the level has already been reduced, and though this movement is rapid, amounting sometimes to two knots per hour, yet considerable time is necessary to displace the salt water by the fresh, and consequently high densities may easily be found with northwesterly winds and southerly currents, and, vice versa, low densities with easterly and southerly winds and northerly currents. In the southern part of the Sound the rule will be modified somewhat owing to the trend of the land and lay of the shoals, the greater densities being found, as before, after easterly winds, but a southerly wind immediately effecting a diminution of gravity.

"From a careful inspection of the determinations of specific gravity and observations of winds and currents, the following are deduced:

"Easterly winds will cause high water and high densities.

"Westerly winds will cause low water and low densities.

"Southerly winds will cause low water and low densities in the southern part of Pamplico Sound and high densities in the northern part.

"Northerly winds will have an exactly opposite effect in each locality.

"The greatest density and the highest water will be coincident.

"The greatest density and the highest water will be found, after continued easterly weather—

"In the northern part of the Sound immediately before the shift of wind to the N. W.;

"In the southern part of the Sound immediately before the shift of the wind to the S. W.

"The strongest currents will be found immediately after a shift of wind.

"The weakest currents will be found immediately before a shift of wind."

Generalizations on the remaining sounds are difficult because they are so numerous, small, and varied. All generally extend with their long axes paralleling the coastline and in general they are well supplied with inlets; so salinities are usually high. Figure 21 for Beaufort is representative of conditions near an inlet. With respect to Core Sound, Winslow (1889) offers the following interpretation from his accumulated records: "Anomalous as it may seem, in Core Sound, its general direction being N. E. and S. W., a northeast gale will cause high water and high densities and a southwest gale the reverse—showing that the real outlet of that Sound is into Pamlico and not Beaufort Inlet as would be supposed." Inlet changes are such that this situation may have been altered since that time.

High productivity characteristic of coastal waters such as these North Carolina sounds is commonly attributed to the extra nutrients added by river discharge. Theoretically this discharge, operative since the seas first formed, has been the source of the dissolved salts characteristic of sea water. Important minerals, such as the phosphates and nitrates, the scarcity of which may limit production, are usually present in and added by the streams. The quantity of any critical nutrient entering the North Carolina coastal waters by this means is not known [20] and, if such data were available, they would mean very little till additional studies revealed their ultimate fate and use in the water in question. It is probable, for example, that many nutrients adhere to the silt in the stream and settle out of circulation when salting out [21] and other sedimentation processes carry the silt to the bottom at the river mouths. With erosion [22] as great as it is, heavy losses from this action are to be expected. Erosion also leads to unchecked and highly varied run-off conditions causing floods, sudden changes in salinity, and great variations in nutrients contributed by river discharge.

The Offshore Bar and Its Inlets

As mentioned in the discussions of geography, an offshore bar interrupted by a few narrow inlets extends the entire length of the North Carolina coast (Figures 1 and 24). Ocracoke Island, a typical segment of this coastline is described by Engels (1942) as follows:

"Through the greater part of its length of 17 miles, Ocracoke is only about ½ mile wide; near the southwest end it is at one point nearly two miles in width, but for a considerable distance, toward Hatteras Inlet, barely 200 yards separate the sound from the sea. Much of the island is less than one foot above sea level; little of it rises more than three feet above the sea. The dunes scarcely exceed 20 feet in elevation—most of them are much lower; they occur as scattered, isolated hills of sand, or as small clusters of hills, not forming a continuous barrier to the encroachment of the sea." That such an offshore bar persists is obviously due to the continuation of the dynamic forces that built it, for in itself the loose shifting sand comprising this barrier beach offers no stability.

A wealth of information on the history of the inlets through the bar is contained in the report issued by the North Carolina Fisheries Commission Board in 1923. Appendix III of this report is a letter from S. T. Abert to the

20. Studies to date have been planned primarily for industrial use of the water and have been made at more or less upstream stations not applicable to the river mouths. For the latest such records see Lamar (1947).

21. Neutralization of electric charges on the silt particles by charges on the salt ions of the sea water tends to destroy one of the major forces maintaining such material in suspension. As a result a pronounced settling, or salting out as it is called, may take place where fresh and salt water mix.

22. Available data on the degree of erosion in North Carolina applies to upstream localities and not to river mouths. A promising method for determining erosion is by comparing old and recent surveys of bottom contours in the river mouths as has been done by Gottschalk (1945) in other areas.

TABLE 8

Comparative Conditions of Inlets on the Coast of North Carolina at Different Dates *

Name of Inlet	Hariot 1585	Lawson 1708	Wimble 1738	Mouzin 1775	Atlantic Neptune 1780	Lewis 1795	U. S. Coast Survey 1875	Conditions in 1936	Remarks
	Conditions as Shown by Map of:								
Currituck	O	O	O	C	C	C	C	C	
New Currituck	C	—	C	O	O	O	C	C	Closed in 1828
Caffeys	O	—	C	C	C	O	C	C	
Roanoke	O	O	O	O	O	O	C	C	
Oregon	O	—	O	O	O	O	O	O	Known as New in 1838; as Hatorask in 1590; as Gunt in 1775 and as Gant in 1795.
Chickinoke	C	—	O	O	O	O	C	C	Known as Chickinock-comiock in 1775.
New (Dare Co.)	C	—	C	C	C	C	O	O Now closed (1947)	Closed in Jan. 1922. Artifically reopened in 1924 but closed immediately. Reopened by storm in March 1932.
Loggerhead	C	—	C	C	C	C	O	C	
Hatteras	O	O	O	O	O	O	O	O	
Ocracoke	O	O	O	O	O	O	O	O	Known as Wokoken in 1590; as Okeracock in 1738 and as Occacock in 1775.
Whalebone	—	—	—	—	—	—	O	C	
New	O	—	O	C	—	C	O	C	
Normans (Sand)	O	—	O	C	—	C	O	O	
Drum	O	—	O	—	—	C	C	O	Reopened by storm in September 1933.
Cedar	—	—	C	C	—	C	C	C	
The Drain (Lookout Bight)	—	—	—	—	—	—	—	O	
Beaufort	—	O	O	O	O	O	O	O	Known as Core Sound in 1708, 1738 and 1775.
Bogue	—	—	O	O	—	O	O	O	Known as Boug in 1738.
Bear	—	—	O	O	—	O	O	O	
Brown's	—	—	O	O	—	O	O	O	
Little	—	—	O	O	—	O	C	C	
New River	—	—	O	O	—	O	O	O	
Stump	—	—	O	O	—	O	C	C	
New Topsail	—	—	O	O	—	O	O	O	
Old Topsail	—	—	O	O	—	O	C	O	Known as Sandy in 1738.
Rich	—	—	O	O	—	O	O	O	Known as Reach in 1738.
Queen (Mason)	—	—	C	C	—	C	O	O	Open in 1868.
Barren (Moore)	—	—	O	O	—	O	O	O	
Sandy	—	—	C	C	—	C	O	C	Open in 1871.
Bread	—	—	O	O	—	O	C	C	
Shoal	—	—	C	O	—	O	C	C	
Masonboro	—	—	O	O	—	O	O	O	Known as Cabbage in 1738 & 1775.
New (Cape Fear)	—	—	C	C	—	C	O	C	Open in 1774 and in 1806. Closed by man in 1876.

* Adapted from table supplied by Corps of Engineers, U. S. Army, 1948. Does not include inlets west of the Cape Fear River.

Chief of Engineers of the U. S. Army, dated February 21, 1876, which contains a table stating the condition of the inlets at various dates according to old maps or other available source data. Table 8 is essentially a condensed and up-to-date version of Abert's table as supplied by the Corps of Engineers in recent correspondence. Figure 24 will orient the reader as to the location of the existing and past inlets as far south as Beaufort.

Through the years inlet changes due to natural forces have been rather great. Because of the obvious importance of these passages for navigation and from the standpoint of modifying the sounds for fisheries development, there have been many proposals for artificially developing inlets, reopening old ones, etc. The Division of Water Resources of the North Carolina Department of Conservation and Development and the Corps of Engineers, U. S. Army have conducted surveys that bear wholly or in part on such questions. A background in theory is indispensable for comprehending the problem involved and, since Johnson (1919, 1938) not only offers such theory but discusses its application to North Carolina, I will quote from him at length: [23]

"It is commonly assumed that the amplitude of the tide is the only factor involved in determining the number and width of tidal inlets through offshore bars. Both theoretical considerations and field observations negative this assumption. In addition to the varying strength of longshore action (mainly beach drifting), the volume of land water, the extent to which the lagoon is filled with sediment or marsh deposits, the abundance and rapidity with which débris is supplied, and the strength of storm-wave attack, are all factors of importance. With the same tidal range along two offshore bars, it may happen that longshore current action is weak on one, but vigorous on the other. Under such conditions the one with the weaker longshore currents will have more or wider inlets. Where large rivers empty into a lagoon, the ebb current of the tide is greatly reinforced by the land waters, and will keep open inlets which would otherwise be narrowed or closed. As sedimentation and marsh growth decrease the water space of the lagoon, the volume of tidal waters admitted and the strength of the tidal currents is reduced, in consequence of which longshore currents may be able to narrow or even close some of the inlets. If an abundance of débris is supplied to longshore currents with great rapidity, the closing of inlets will be more readily accomplished than if a smaller amount of débris is supplied very slowly. An inlet, once closed, might never be re-opened were it not for breaches made in the bar by storm-wave attack. Tidal action tends to keep inlets open; but, except in the case of an unusually high tide overflowing a low point on a bar, does not tend to produce inlets. Impounded land water may in rare instances open an inlet

23. Reprinted by permission from *Shore Processes and Shoreline Development* by D. W. Johnson, published by John Wiley & Sons, Inc., 1919. A similar discussion but in a more technical vein is offered by Brown (1928).

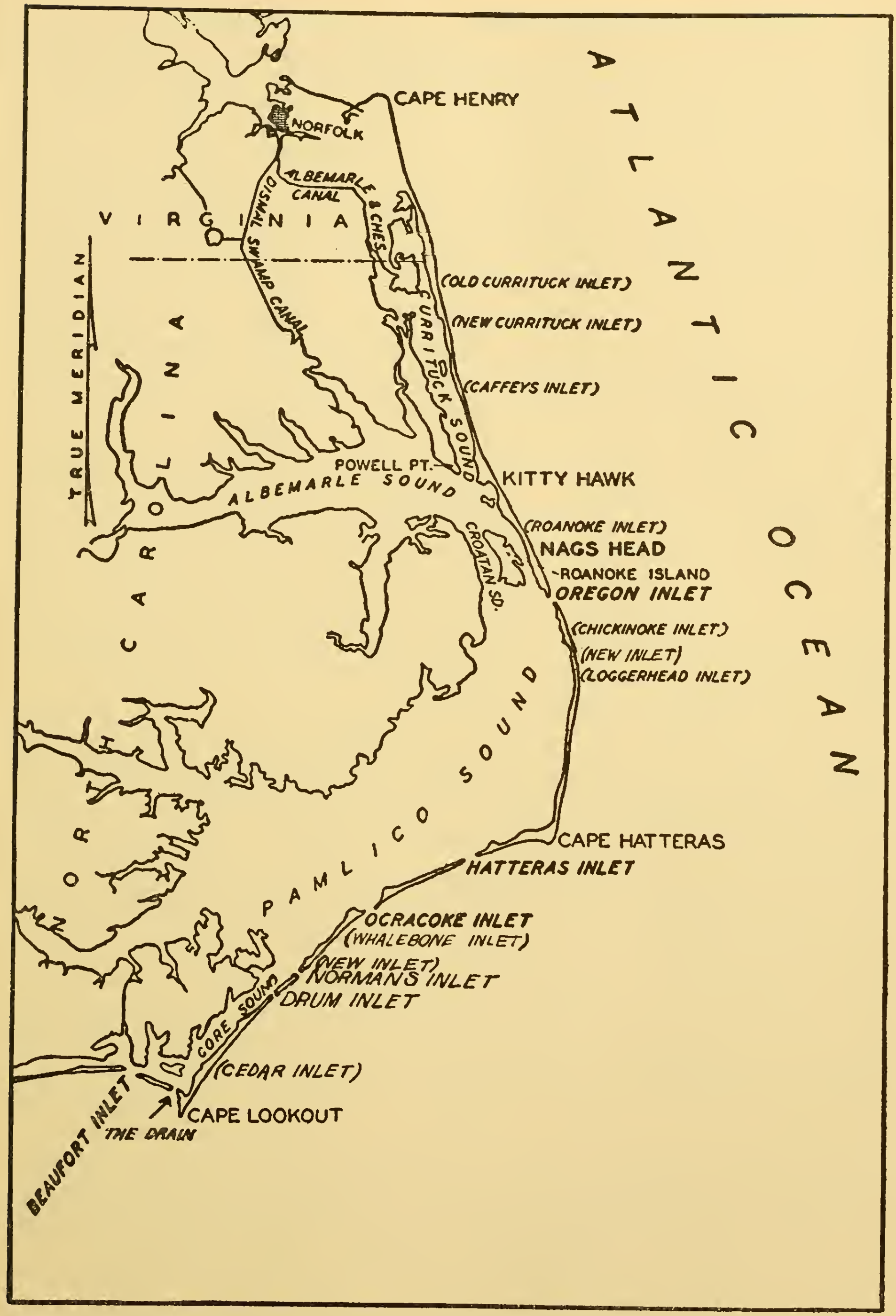

FIG. 24. Inlets from Cape Henry to Bogue Sound. Names in parentheses represent former inlets now closed. Adapted from *Beach Erosion at Kittyhawk,* etc., by Corps of Engineers, U. S. Army (1935).

after the manner described by Shaler; but inlets are more commonly reopened during exceptional storms by vigorous wave erosion. A bar exposed to the waves of an occasional great storm may thus be breached, where one less exposed would remain intact.

"On the other hand, it matters little how many inlets may be opened by the waves, longshore currents will soon close all except those kept open by tidal currents reinforced by outflowing land waters. If the tidal range is such as to generate currents capable of maintaining two inlets of a given breadth through a certain bar, and storm waves cut two additional inlets, the tidal waters will for a time flow through the greater number of openings with decreased velocities. Longshore currents will therefore dominate the tidal currents at the inlets, until deposition has narrowed all of the inlets, or closed two of them (often the older ones), leaving the other two of the required breadth and thereby re-establishing a condition of equilibrium. Or, if a storm drives waves obliquely upon a coast in such manner as greatly to accelerate the longshore transportation of débris, all the inlets through a bar may be closed by excessive deposition in spite of tidal currents. Once the inlets are closed, the tidal currents cease to exist; and the inlets will remain closed until storm waves or some other agency makes new breaches through the bar. In general we may say that waves tend to make inlets, tidal currents to preserve them, and longshore currents to close them.

"That the supply of débris brought by longshore currents may be more important than differences of tidal range in determining the number of inlets through a bar, is apparent from a study of certain offshore bars which are supplied with débris derived from headlands to which the bar is at one end attached. Let us deduce the conditions which theoretically should characterize offshore bar and lagoon development when the bar is attached to a headland, and longshore currents move from the headland toward the further extremity of the bar.

"In the first place, it is evident that while wave currents may remove much material from the face of the bar and transport it seaward to deeper water, near the headland the loss may be more or less completely made good by new débris brought from the adjacent source of supply by longshore currents. The effect of this accession of débris is two-fold; the bar withstands the normal tendency of the waves to drive it landward since the waves have all they can do to take care of the new material continually being added to its face; and for the same reason the waves are less apt to cut inlets through the bar, while longshore currents utilize the abundant débris to seal up such inlets as may occasionally be formed. Accordingly we should expect a tendency for lagoons to be broad and bars to be continuous in the vicinity of headlands.

"Toward that end of the bar most remote from the headland, conditions are very different. The débris from the headland has been ground fine in the course of its journey, and largely dissipated. Wave attack expends its full energy upon a bar which receives little material from the distant headland to offset the ravages of marine erosion. Hence the bar is driven landward with greater ease, and during its retreat the waves cut through first here, then there, forming inlets which are not closed as readily as where débris is more abundantly supplied. Far from headlands, therefore, there should be a tendency for lagoons to be narrow and for bars to be broken by frequent inlets.

".... The Carolina coast is so complicated by the three cuspate bars forming Capes Hatteras, Lookout, and Fear that one might scarcely expect to find the relationships characteristic of simple offshore bars. Yet if we compare different sections of the coast in a broad way, ignoring local abnormalities, we seem to see the working of the same laws controlling cases previously discussed. The headland for this section is the margin of the coastal plain of Virginia, south of Cape Henry, and the shore currents move in a general north to south direction.[24] We may recognize four natural subdivisions of the coast: a first section from the headland to Cape Hatteras, a second between Capes Hatteras and Lookout, a third between Capes Lookout and Fear, and a fourth between Cape Fear and a point just west of Little River, beyond which the offshore bar seems to touch the mainland again. In the first section the inlets number but 2 in a distance of 113 miles, and the lagoon attains a great width with comparatively little filling. The abnormal width in parts of the first two sections is probably due to an exceptionally gentle slope of the sea-floor along the Cape Hatteras axis. In the second section of 72 miles, there are three inlets, giving an average spacing of 4 to 100 miles, and the lagoon becomes comparatively narrow toward Cape Lookout. In the third section the number of inlets increases to 9 in 100 miles, while the lagoons narrow still more and become much more filled with marsh deposits. At Cape Fear the lagoon broadens out considerably, but the width here is only seven and one-half miles as compared to twelve and one-half at Cape Lookout, or thirty miles at Cape Hatteras. In the fourth section there are eight inlets in 40 miles, which is equivalent to a spacing of 20 inlets to 100 miles; the bar is driven back nearly to the mainland, and the narrow lagoon is almost completely filled with marsh. Despite its complexities the Carolina case appears to meet the requirements of the theory."[25]

24. The basis for this statement on current direction is not given, although Prof. Arthur N. Strahler, who worked with Dr. Johnson for some years, has informed me he believes the current direction was inferred from the shape of the inlet mouths. It is interesting to note that such a direction is compatible with Abbe's theory; yet, as already mentioned in the section on Circulation Offshore, Johnson (1938) discussed the formation of the cuspate Carolina capes on the basis of geological relationships having no bearing on Abbe's hypothesis.

25. The Corps of Engineers (1948) gives the following up-to-date account of inlet distribution: "The prevalence of inlets increases to the southward along the coast. The latest information indicates that there is only 1 inlet open along the 100 miles of coast from the Virginia line to Cape Hatteras, 6 in the second hundred miles, 12 in the third hundred miles, and 6 between the Cape Fear River and the South Carolina line, a distance of 32 miles."

Continuing our quotations from Johnson, the physiographic feature known as the tidal delta that is so characteristic of the North Carolina inlets (Figure 25) is described. "... Débris brought by beach drifting or other longshore currents is seized by the inflowing or outflowing current at the inlet and transported into the lagoon or out to sea. Most of the débris is not carried far before being deposited in the quieter water of the larger waterbody to form a *tidal delta.* The typical tidal delta is wholly submerged and is double, one part facing landward and representing the result of deposition in the lagoon by incoming currents; the other part facing seaward and owing its construction to deposition in the sea by outflowing currents. Because the seaward part of the delta is exposed to the action of waves and longshore currents it is commonly stunted in its growth and margined by contours of simple curvature; only that portion in the lagoon is apt to acquire appreciable size and the lobate form of ordinary deltas."

From the above it is clear that the maintenance of a new inlet and its channel is often an engineering task in direct opposition to natural forces which, due to storms, are highly unpredictable. Estimates that are frequently made as a basis for evaluating the economic feasibility of an inlet project are thus subject to error. The experience with New Inlet in Dare County illustrates this. New Inlet was closed by a storm in 1922. An unsuccessful attempt was made to reopen it artificially in 1924; yet a storm accomplished the reopening in a couple of days in 1932.

According to the Corps of Engineers (1948), the usual combination causing the formation of a new inlet in the barrier beach off the broad North Carolina sounds begins with a sudden shifting of the waters from the landward to the seaward side of the sounds, caused by changes in wind direction during infrequent cyclonic storms of great intensity. The resulting high waters wash over low places in the bar and sometimes flow toward the ocean for a great many hours cutting a deep gorge. The past history of inlets indicates that the waters of Albemarle and Pamlico sounds will again carry out this pattern to form additional inlets. The past also indicates that such inlets will probably be filled at a later date by sand drifting along the shore.

One characteristic of past studies considering new or modified inlets is the tendency to assume that any biological effects will be beneficial. Increasing salinity near an inlet would probably better the clam production and possibly the yield of certain other fisheries products; however, harmful results are not inconceivable. Certainly the popular concept, that more inlets will mean increased migration of fishes into the sounds, is unfounded. The concept may be true or partly true; yet there may be some detrimental results. For example, if discharge of brackish water through an inlet attracts fish, the addition of inlets may so reduce this factor for any given inlet as to be less than the amount necessary to stimulate migration. Little or no in-

FIG. 25. Tidal delta on the inshore side of Ocracoke Inlet, showing as deep-shaded shoals, broken by wandering channels, represented by a lighter shade. Ocracoke Inlet, at the bottom of the picture, lies between Portsmouth Island and Ocracoke Island, and leads from the ocean into the Sound, above.

formation is available on such questions but to ignore them may cause great losses.

Nature of the Bottom

In the ocean north of Cape Hatteras the bottom is said to be rather sandy close to shore and more of a mud with rough areas due to shell accumulations, etc., at the greater depths offshore (Pearson, 1932). Somewhat the same conditions prevail south of the Cape except that rocks are scattered over the area, especially to the southward and offshore. Little is known as to the nature of these rocks to the south and the corals and coralline algae which, in part at least, build them. The specific locations of some of these scattered bottom reefs have been described by Radcliffe (1914) in a discussion of the

TABLE 9

A Summary by Areas of the Bottom Characteristics of North Carolina Sounds *

Locality	Area, acres	Av. depth of water, ft.	General character of bottom
Croatan and Roanoke Sounds	48,389	8 to 10 4 to 6	Sand.
Upper part of Pamlico Sound	45,757	10 to 12	Sand and mud.
Upper part of Pamlico Sound	45,157	1 to 5	Sand.
Upper part of Pamlico Sound	82,904	14	Sand and mud.
Eastern Pamlico Sound	60,626	1 to 10	Sand.
Middle Pamlico Sound	95,776	18 to 20	Mud.
Western Pamlico Sound	43,038	2 to 17	Sand and mud.
Eastern Pamlico Sound	61,834	2 to 12	Sand.
Middle Pamlico Sound	103,270	20	Mud.
Western Pamlico Sound	30,291	3 to 14	Sand and mud.
Eastern Pamlico Sound	76,570	1 to 20	Sand.
Middle Pamlico Sound	67,738	14 to 22	Sand.
Western Pamlico Sound	15,746	8 to 10	Sand and mud.
Southern Pamlico Sound	39,988	18 to 20	Mud.
Middle Pamlico Sound	45,413	16	Sand and mud.
Western Pamlico Sound	38,315	2 to 14	Sand and mud.
Southern Pamlico Sound	38,888	12 to 22	Sand and mud.
Middle Pamlico Sound	65,164	8 to 20	Sand and mud.
Western Pamlico Sound	50,639	2 to 20	Sand and mud.
Pamlico and Pungo Rivers	63,437	18	Mud.
Neuse River	50,299	23	Sand and mud.
Cedar Island Bay	28,615	18	Sand and mud.
Northern part of Core Sound	44,307	1 to 10	Sand and mud.
Southern part of Core Sound	38,907	1 to 15	Sand and mud.
Bogue Sound	25,929	2 to 5	Sand.
White Oak River	3,900	5	Mud.
New River	4,522	5	Mud.

* From Winslow (1889).

offshore fishing grounds. These and the less known rocks, so numerous south of Cape Hatteras, have already been mentioned as an obstacle to trawl fishing. Further studies of this bottom, such as are now in progress, may lead to the day when fishermen can work these areas, locating right over them when desired, circling the edges at will, or fishing well clear of them for still other purposes.

The bottoms in the sounds have been referred to repeatedly in published reports on oysters because the production of these shellfish is so dependent on a favorable firm substratum. Throughout, the bottom is either sand, mud, or a mixture of the two, and there is little or no actual rock.[26] Table 9 gives the area of different bottom compositions as determined by Winslow (1889). Winslow and other authors have reported the potential oyster-growing areas but changes due to depletion, shifting of sands, and silting make such accounts unreliable today.

Pollution

Pollution of North Carolina's marine waters is restricted to a few local situations mostly in the vicinity of towns and cities where toilet sewage, and in a few instances industrial sewage, is either untreated or inadequately handled. Much information relative to pollution sources is given in the study of "The Extent of Stream Pollution in North Carolina" by Stiemke (1947); however, as a summary of the marine waters most affected by pollution, reference is made to the areas which the State Board of Health has closed to the harvesting of oysters. As of April 12, 1949, the following eight areas, totaling about 27,000 acres, were on this restricted list:[27]

Core Sound at Atlantic	312 acres
Morehead City—Beaufort Area	3,950 acres
Oyster Creek at Bogue	107 acres
White Oak River at Swansboro	490 acres
New River at Marine Base	290 acres
Stump Sound at King Creek	122 acres
Wrightsville area	1,800 acres
Myrtle Sound	20,000 acres

Much of the sewage of these regions is toilet discharge, endangering human health. Among the dangers is the threat that typhoid fever will be spread by eating oysters contaminated by human fecal bacteria. Many of the above-mentioned areas are at the sites of military establishments where the situation should improve under postwar conditions; however, localities now under suspicion may more than offset the improved areas.

26. Oyster bars are often referred to as rocks though they are essentially accumulations of shells compacted to varying degrees over a firm substratum of the sandy consistency mentioned.
27. Exact descriptions of these localities are issued by the State Board of Health.

The total acreage thus restricted is relatively small; yet specific localities are affected considerably. The damage to the fisheries is not great. The condition does not ruin areas for fish life; furthermore, oysters grown in polluted waters can be transplanted elsewhere for purification before harvest. The addition of important nutrients as a result of pollution is probably small and of minor significance.

The subject of pollution would not be complete without mentioning pulp mill wastes in relation to the spawning and survival of anadromous fish, particularly shad. This has developed into an acute question in the lower Roanoke River. Strong accusations have been directed at the pulp mill activity and strong defense statements have been made in reply. The problem is being given some study and merits considerably more. It would be premature to discuss it further here, especially since, with the legal proceedings involved, one finds it impossible to obtain much of the pertinent information at this time.

Wind, Waves, and Weather

Little can be said here that is beyond the realm of common knowledge. The inland waters seldom present conditions too rough for reasonably able small craft, but offshore, particularly in the region of Cape Hatteras, conditions are frequently quite severe.[28] Many accounts and explanations of the latter are a bit fantastic, such as the theory of a consistently strong wind or current from the north bucking the opposing Gulf Stream flow from the south. The actual conditions are nothing more than one would expect in considering features already described in this chapter. A review of this might well start by mentioning the strong Florida Current (Figure 2) flowing northeastward just off the Capes. The non-wind counter currents that might buck this are ill defined, weak, and evidently quite irregular (see section on Circulation Offshore). Winds and wind currents that might buck it are also irregular but sometimes constitute strong opposing forces (Figures 4 and 26). Opposing currents of this sort are common off land prominences which in turn are often characterized by rough water. Off Hatteras this common condition is far more pronounced than usual and the severity is greatly augmented by the irregular shallows (Figure 7) which tend to turn long swells and waves into sharper ones and even into breakers. Add to all this the heavy shipping and fishing that passes or centers around this Cape and its reputation for wrecks is

28. The following quotation from the *Supplement to the U. S. Coast Pilot* (1945) describes expected results: "It has been found that with easterly winds, and particularly northeast winds, the Gulf Stream becomes very rough. A fresh northeast breeze causes as much sea in the Gulf Stream as is ordinarily produced by a moderate gale. Easterly winds appear to drive the warm surface waters of the Gulf Stream frequently many miles inshore of the average limits, and westerly winds appear to move the western limit of the Gulf Stream offshore.

readily understood. On the other hand, lulls between times of adverse weather, the milder conditions between the Capes, and the near-by harbors, such as Ocracoke, Beaufort, and lower Chesapeake Bay ports, are sufficient to enable a large trawler fleet to work this coastline during the winter, which is the most severe season (Figure 26). Perhaps, if greater strides are made with wave forecasting techniques that have been developed during the recent war, the area will be fished with far greater ease.

A miscellany of other conditions should be included in completing an account of the over-all hydrographic conditions. Air temperature has been referred to several times in discussions of water conditions. For a more detailed record than offered in Figure 14, Table 10 is presented, giving the monthly averages since 1875 for the central Hatteras station. Fog is another weather condition important in considerations relative to the water. The North Carolina coast is favored by the lack of this. At Cape Hatteras there are 10 days of dense fog per year (see U. S. Dept. Agriculture Yearbook, 1941). With the exception of the southern tip of Florida, no other coastal area in the United States has as little fog (there are 40 to 80 days of fog per year on Cape Cod). Data compiled by Dailey (1946) shows that most of the fog around Hatteras occurs during winter.

The subject of hurricanes or, more technically, tropical cyclones, demands what little consideration is possible here. Since one hears so much about hurricanes moving northward along the coast and since North Carolina's coastline is so prominent, there has been a tendency to think of this region as being especially subject to hurricanes. On looking at the numerous recorded hurricane courses on maps by Tannehill (1945) in his comprehensive discussion of these storms, it is clear that North Carolina is hit about as often as any other east coast area, any part of which may be struck by the highly varied courses. The disadvantage of this coastal prominence is that it may be struck by a storm directly off the sea, weakened only to the extent that such storms may die as they move northward and not subject to the loss in strength that inevitably results from an overland course. Also the nature of the offshore bar makes that area extremely vulnerable to any appreciable storm. If the reader will recall the comments on the instability of the offshore bar, given in the section on the Offshore Bar and Its Inlets, and, better yet, if he has been there, he may join with the writer in amazement that residents and dwellings have survived the full force of any great hurricane. That they have done so is clearly a matter of record, however, one example being the 1944 hurricane, the center of which passed over Hatteras with winds of about 100 miles an hour and tides 7.0 ft. above mean low tide (Sumner, 1944).

FIG. 26. Monthly and annual surface wind roses for Cape Hatteras showing, by the proportionate length of a given symbol, the percentage of winds of the indicated strengths and directions. Data from U. S. Weather Bureau (1941), *Airway Meteorological Atlas for the United States.*

TABLE 10

Monthly and Annual Air Temperature Averages for Hatteras, N. C.

1875-1946

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1875	44.9	43.7	52.6	53.7	64.7	72.9	78.9	77.2	71.1	62.1	55.4	52.0	60.8
1876	51.3	50.9	50.8	57.1	65.8	76.2	79.2	78.2	73.1	61.3	53.7	40.2	61.5
1877	43.6	45.8	51.2	55.2	60.7	74.9	78.5	78.3	73.3	65.5	58.2	50.7	61.3
1878	46.1	46.1	54.5	60.7	66.8	71.1	79.1	78.2	75.3	65.3	55.0	44.7	61.9
1879	41.6	41.8	46.9	56.1	64.7	72.2	77.5	76.4	70.6	68.0	55.4	56.3	60.6
1880	53.4	51.4	52.7	59.1	69.2	74.3	79.1	78.8	70.1	62.7	55.9	41.1	62.3
1881	39.7	41.8	48.0	52.8	67.6	74.5	78.6	78.0	78.7	70.6	59.9	52.1	61.9
1882	48.1	51.0	51.5	57.1	64.3	74.5	78.1	78.6	74.1	67.3	52.3	43.8	61.7
1883	42.8	48.2	47.1	56.3	64.8	75.6	79.6	77.0	73.2	64.9	56.1	49.3	61.2
1884	42.2	54.0	53.3	54.8	67.5	72.4	76.7	75.9	75.1	67.4	56.4	50.4	62.2
1885	47.9	41.2	44.4	58.3	66.3	73.0	78.2	78.0	72.1	64.1	54.7	47.5	60.5
1886	39.8	41.9	48.6	58.9	66.2	73.5	77.7	75.5	74.5	65.3	55.9	45.1	60.2
1887	44.7	51.3	49.4	57.0	69.1	72.4	78.9	76.5	70.9	65.1	54.2	47.9	61.4
1888	44.7	46.3	48.0	57.3	66.7	73.1	74.6	77.4	72.6	60.8	56.8	45.3	60.3
1889	47.6	43.6	47.1	56.4	68.4	73.5	77.8	76.2	71.0	60.8	57.6	54.6	61.2
1890	55.7	56.4	52.6	58.0	68.8	77.2	76.7	76.0	75.8	65.0	56.8	47.0	63.8
1891	47.1	53.2	49.0	58.9	66.3	75.2	76.2	78.6	74.4	62.3	53.5	52.8	62.3
1892	45.6	45.1	47.5	56.8	66.6	75.9	76.2	78.9	73.5	62.9	52.5	45.2	60.6
1893	36.5	47.6	48.0	59.2	65.7	73.3	78.3	76.9	74.0	65.1	55.7	49.9	60.8
1894	48.7	48.4	55.6	57.7	70.2	74.3	77.6	77.0	76.2	64.7	53.9	50.3	62.9
1895	45.9	35.9	50.2	58.9	65.7	74.2	76.8	78.1	76.6	62.3	57.4	48.4	60.1
1896	41.8	46.6	49.0	59.2	70.9	75.2	78.9	79.4	73.8	63.0	61.1	45.9	62.1
1897	42.9	47.6	52.9	57.1	66.0	74.4	78.9	78.1	73.8	66.3	57.7	50.7	62.2
1898	48.6	44.7	55.8	57.0	66.2	72.1	78.6	79.2	76.1	67.7	54.7	47.6	62.4
1899	48.0	41.8	52.7	55.2	66.7	76.4	78.1	78.5	74.8	67.1	57.5	48.3	62.1
1900	45.7	44.4	49.7	58.7	66.9	75.0	79.1	80.6	77.2	69.5	59.2	48.0	62.8
1901	45.4	39.4	53.4	52.5	65.5	74.5	78.9	79.5	75.4	65.3	50.0	46.2	60.5
1902	42.0	39.3	50.7	56.7	68.3	75.3	79.7	77.0	73.3	67.7	60.6	48.7	61.6
1903	45.7	49.7	58.2	60.3	67.7	73.4	79.7	79.5	72.9	63.9	51.8	42.8	62.1
1904	40.4	42.1	51.5	58.2	68.8	75.1	77.7	77.4	74.2	64.6	53.9	46.4	60.9
1905	41.7	38.5	53.9	59.0	71.3	74.5	78.9	77.9	75.6	66.5	56.7	49.3	62.0

1906	50.5	44.7	50.0	59.0	68.6	76.4	77.2	79.7	78.4	66.8	54.9	48.3	62.9
1907	49.5	43.0	54.4	52.9	65.2	71.5	78.7	77.8	76.7	62.0	54.8	49.2	61.3
1908	46.4	43.9	54.9	62.5	69.5	73.9	79.9	78.9	72.7	65.8	57.2	51.5	63.1
1909	50.7	52.5	52.2	61.8	68.3	76.1	76.8	77.3	72.9	63.2	58.9	43.9	62.8
1910	46.5	46.7	57.3	62.3	67.0	74.2	78.2	77.5	75.9	69.1	51.4	42.7	62.4
1911	48.2	47.8	50.2	57.4	68.0	75.8	79.0	79.6	76.0	67.2	55.6	51.8	63.0
1912	41.8	42.5	52.4	63.2	68.9	74.2	78.4	77.9	77.4	66.4	55.5	52.8	62.6
1913	56.2	48.8	58.0	60.8	69.0	73.6	78.8	77.6	73.0	65.6	54.4	49.8	63.8
1914	47.5	45.8	46.8	59.2	69.2	75.5	77.6	79.0	72.0	67.0	55.6	48.0	61.9
1915	48.1	47.8	45.2	59.2	68.3	71.6	77.8	79.9	77.1	68.4	57.3	44.8	62.1
1916	51.2	47.2	48.4	57.7	69.4	73.9	77.7	77.8	73.2	66.5	57.4	48.6	62.4
1917	47.8	44.0	51.2	59.2	64.6	73.9	78.4	78.8	71.4	63.2	51.4	40.3	60.4
1918	37.6	46.2	53.2	57.0	69.8	72.7	75.0	78.4	71.6	68.1	56.2	51.6	61.4
1919	47.8	45.8	52.6	58.4	69.0	72.8	77.3	78.6	74.0	73.0	56.6	45.8	62.6
1920	43.8	43.1	50.8	58.0	61.0	71.7	75.8	77.6	75.4	66.2	57.3	50.4	60.9
1921	47.8	48.6	60.5	62.4	65.0	73.8	77.9	76.6	77.2	65.6	60.8	50.1	63.9
1922	45.8	49.8	54.7	60.8	68.5	75.4	78.2	75.8	73.5	67.0	55.8	52.0	63.1
1923	48.4	43.9	53.3	59.1	67.6	75.8	77.0	78.5	74.8	63.2	54.0	53.8	62.4
1924	46.4	44.3	47.6	56.9	66.3	74.4	76.8	78.3	71.8	63.2	56.2	49.8	61.0
1925	46.6	52.2	53.6	61.0	67.3	76.9	78.6	78.0	77.6	64.6	55.4	47.9	63.3
1926	45.6	48.1	47.2	57.8	66.3	73.2	78.4	79.6	74.9	66.8	55.8	48.6	61.9
1927	44.5	54.4	52.6	57.3	69.2	71.6	77.0	76.2	74.4	68.2	59.0	49.6	62.8
1928	46.0	48.6	53.4	60.2	65.4	76.0	78.6	79.7	73.9	67.6	56.1	49.2	62.9
1929	50.4	45.2	56.6	63.0	69.6	75.1	78.4	77.4	74.6	65.2	58.4	50.1	63.7
1930	50.6	51.6	51.5	60.0	70.4	75.0	79.4	76.7	78.4	63.2	54.8	45.9	63.1
1931	46.0	46.9	47.6	58.0	61.7	72.7	78.6	78.0	77.2	67.2	61.4	56.2	62.6
1932	56.3	54.0	50.1	58.8	67.4	76.4	80.1	79.4	74.6	67.2	57.4	53.8	64.6
1933	53.4	50.4	52.6	61.2	72.4	75.1	76.4	79.8	79.2	68.4	55.0	53.3	64.8
1934	50.2	40.3	50.0	58.8	67.5	77.5	80.5	79.0	76.6	65.4	58.9	47.4	62.7
1935	46.8	48.2	57.6	57.8	67.1	76.0	77.1	78.2	73.4	65.6	59.1	42.4	62.4
1936	43.1	41.2	56.0	58.2	68.3	79.4	78.8	79.5	75.9	69.4	55.8	51.7	62.7
1937	59.4	45.8	50.0	59.6	67.6	76.7	78.7	79.5	73.2	63.8	54.8	46.0	62.9
1938	45.6	50.0	56.2	62.1	69.7	74.8	78.0	80.0	75.5	63.3	60.0	50.0	63.8
1939	50.3	53.4	55.9	61.4	66.9	76.8	78.0	79.6	76.2	68.8	53.3	48.5	64.1
1940	37.2	43.6	47.8	56.3	65.2	76.4	78.0	78.7	72.3	62.4	56.8	52.2	60.6
1941	45.0	41.2	45.9	59.2	66.5	74.3	79.2	77.2	76.6	70.6	58.6	51.8	62.2
1942	45.6	41.6	54.7	59.0	71.2	77.4	81.5	78.0	76.0	67.4	58.6	47.6	63.2
1943	47.0	46.8	50.7	57.4	69.8	79.2	78.4	78.4	72.4	63.5	54.4	45.7	62.0
1944	44.3	48.8	51.8	59.8	72.1	78.5	77.4	76.0	65.6	54.0	44.2	62.6	61.2
1945	42.7	46.4	57.0	63.2	67.4	71.0	79.4	77.2	78.3	65.8	59.2	44.8	62.7
1946	47.2	47.8	57.6	57.5	68.8	72.8	76.6	76.4	74.3				

Productivity

It now seems opportune to discuss, as best we can, the potential productivity of these North Carolina waters, reviewing where desirable hydrographic features of special significance to this subject.

With sunlight as their source of energy, the chlorophyll-bearing microscopic algae that are so abundant as drifters (plankton) in aquatic habitats synthesize inorganic ingredients into food. As a result they grow and multiply and thus photosynthesis provides the basic food supply of these areas just as it does through the growth of grass in pastures.

Attempts to compare this basic productivity for different types of environments indicate that coastal marine regions exceed cultivated land and other terrestrial associations. The comparisons may be stated in terms of photosynthetic efficiency which is the ratio of energy fixed by photosynthesis to the solar energy reaching the surface of the environment. In a discussion of plankton studies on Long Island Sound, Riley (1941) rates the mean efficiency of the sea at 0.31 per cent. For forests this photosynthetic efficiency is 0.16 per cent and for cultivated lands 0.13 per cent, according to figures quoted by Lindeman (1942) from an unpublished manuscript by G. E. Hutchinson. It is difficult to generalize on fresh waters because of the extreme variability between different lakes, ponds, rivers, etc.; however, many lakes and ponds that have been studied equal and even surpass marine waters in productivity per unit of area. Lindeman (1942) credits Lake Mendota with a photosynthetic efficiency of at least 0.27 per cent and possibly 0.40 per cent and reports only 0.10 per cent for senescent Cedar Bog Lake.

Certain characteristics help account for the comparatively high productivity of marine habitats. The microscopic size of the basic producers, the algae, offers a high surface-volume ratio for the utilization of radiant energy and the absorption of nutrients. The penetration of light to considerable depths results in photosynthetic activity over an appreciable vertical range, a feature only slightly approached on land even in forest regions. The characteristic minerals of sea water plus those contributed from land drainage provide a rich supply of important nutrients. (With the exception of the minerals of sea water, the above characteristics apply to many lakes, which explains why, with a favorable nutrient supply, they may equal or excel marine waters in production.)

From the marine fisheries standpoint it is a matter of record that relatively shallow waters, as in estuaries and over the continental shelf, are the great producers. Such waters are usually so located that they may benefit considerably from land-drained nutrients and in many places they are enriched by upwelling currents from the ocean depths. Also, as living things die and sink to the bottom in shallow water their contained nutrients are not drained from the region of photosynthesis.

The sounds of North Carolina comprise about 2,500 square miles of typically productive shallow waters, seldom as much as 20 feet deep. A complete range from sea water to fresh adds to the potentialities since vast areas meet the salinity requirements of almost any marine, brackish water, and migratory species. Correlated with the latitude is a mild seasonal temperature change which, if other things are equal, provides a longer growing season than is expected where it is colder. Rivers draining about 30,000 square miles, almost all within the Coastal Plain and Piedmont Plateau, flow into these sounds. This is small compared to the 67,505 square miles (Wells, Bailey and Henderson, 1929) draining into Chesapeake Bay with its surface area of 2,800 squares miles (Cowles, 1930), and it may be that the lesser Carolina fishery is partially the result of proportionate differences in nutrients contributed by drainage. On the other hand, too little is known to accept such a conclusion. The difference in harvest may not be correlated with differences in potential harvest. It may be that the barrier beach bordering the sounds creates a compensating reservoir effect holding important nutrients in more of a closed production system.

Offshore from the North Carolina barrier beach there are about 14,000 square miles of shallow water (to the 100-fathom curve which is the edge of the continental shelf). Because of the adjacent Florida Current of the Gulf Stream System, the temperature on this shelf has an unusually moderate seasonal change for this latitude. For this reason apparently, the region is an important winter retreat for migratory fish from the north, and perhaps from the south as well. In addition, this coast and its large adjacent sounds serve as the nursery area and center of dispersal for some species.

Some nutrients are inevitably added to these shelf waters from the rivers and sounds but the contributions from oceanic circulation are unknown. There are indications of counter-clockwise eddy currents over the shelf from the edge of the Gulf Stream System which, among other things, would tend to bring waters from off Chesapeake Bay. There is no known upwelling but biologically similar effects may be produced if the frictional stress of the Florida Current forces eddies of deep, nutrient-rich water into the coastal region.

With a figure for basic productivity it would be possible to estimate the total production of the 16,500 square miles of sounds and shallow oceanic waters of North Carolina. Riley (1944) states, "The best determinations for open oceanic waters average about 340 tons of carbon per km^2. per year [881 tons of carbon per square mile per year]. . . ." The same author (1941) says there is no major difference in productivity associated with latitude but that local conditions greatly modify productivity. Because of North Carolina's favorable conditions, it seems conservative to use the average of 881 tons, multiply it by the 16,500 square miles involved, and consider the resulting 14,536,500 tons as an estimate of the annual carbon production in North Carolina waters.[29]

The largest annual catch recorded for North Carolina is 224,457,000 pounds or 112,229 tons.[30] Using 10 per cent as the proportion of carbon in most living things, including fishes, this would represent 11,222 tons of carbon or .08 per cent of the calculated basic production.

This figure of .08 per cent depends on so many approximations that it serves only to indicate the general magnitude of the productivity relationship; however, my confidence in this is augmented by the fact that the following, somewhat different approach gives a figure of .06 per cent. This other procedure is as follows:

1. Radiant energy reaching the earth's surface at Washington, D. C. equals 341 g.cal./cm.^{2}/day (Hand, 1941) or 124,465 g.cal./cm.^{2}/year. Since the North Carolina coast is south of Washington and has approximately 2,800 hours of sunshine annually as compared to about 2,600 hours in Washington (from map data supplied by the U. S. Weather Bureau), this figure for radiant energy is probably a little low for the region being considered.

2. Riley (1941) rates the efficiency of net plant production in Long Island Sound at 0.31 per cent. At such an efficiency rating the net plant production from the above mentioned radiant energy would be 386 g.cal./cm.^{2}/year or 165×10^{15} for the estimated 16,500 sq. miles of North Carolina coastal waters. Since Long Island Sound is notably productive, the efficiency figure used may be high. Perhaps it helps offset errors created by using the radiation figure for Washington, D. C.

3. Using a figure of 1,000 g.cal./g. for the energy content of raw fish (as suggested in correspondence by Harden F. Taylor) the peak North Carolina catch of 224,457,000 lbs. would yield 102×10^{12} g.cal. which is .06 per cent[31] of the basic productivity of 165×10^{15} g.cal.

The losses expected at successive links in the food chain must be recognized

29. More precise estimates require, among other things, a greater knowledge of the details of circulation discussed above. For example, the extent to which currents hold produced organisms in the region or permit them to drain off may prove very critical.

30. The winter trawl fishery makes large catches offshore around Cape Hatteras and docks most of it in Virginia, whereupon it is listed in the Virginia, instead of the North Carolina records. Pearson (1932) studied this fishery in 1930-31 during months when it was more or less restricted to North Carolina's offshore waters and rated the yield at approximately 5,700,000 pounds. There are insufficient data to permit adding the proper share of the winter trawl catches to North Carolina's annual yield. Due to high prices, they represent a large economic factor; however, including them would not create an appreciable change in the poundage figures being used for these ecological discussions.

31. This percentage and the .08 per cent calculated above would both be slightly higher if an attempt were made to account for the carbon content and energy value of the menhaden involved, both of which are higher than average.

in considering the significance of these percentage figures. A predator is seldom able to assimilate more than 10 per cent of the over-all production of its food organisms (see Lindeman, 1942); so the losses through successive levels of the food chain are somewhat as follows:

The weight of all primary consumers is less than 10 per cent of the basic production. *Examples: oysters which feed on microscopic drifting plants and menhaden which feed largely on such plant plankton.*

The weight of all secondary consumers is less than 10 per cent of the weight of primary consumer's or less than 1 per cent of the basic production. *Example: mackerel which feed on small drifting crustacea which in turn feed on microscopic drifting plants.*

The weight of tertiary consumers is less than 10 per cent of the weight of secondary consumers or less than 0.1 per cent of the basic production. *Example: Bluefish which feed on small fish that are secondary and primary consumers.*

Obviously, other things being equal, a fishery should be more efficient if centered on species low in the food chain, as in agricultural practices where we eat primary producers such as wheat and primary consumers such as beef cattle. In this respect relatively high yields might be expected in North Carolina, for the fishery is characterized by species low on the food chain, such as menhaden which comprised over 80 per cent of the large 1939 catch; yet the harvest is more of the order to be expected at the tertiary consumer level. With menhaden, oysters, clams, shrimp, shad and many other low-level consumers abounding in North Carolina, there appears to be ample hydrographic and biological support for the hope that a considerably greater seafood production might be realized by improved management and resource-use techniques.

The present North Carolina harvest is not low by comparison with other fishery areas. From 1923 to 1945 the smallest annual catch was 86,214,000 pounds in 1932, which equaled 8.2 lbs./acre for these coastal waters, and the largest annual catch was the 1939 yield of 224,457,000 lbs., representing 21.3 lbs./acre. On Georges Bank, most important of the famous New England fishing areas, the annual yield from 1923 to 1945 ranged from 7 to 33 lbs./acre/year (Clarke, 1946); however, with fish like haddock and others high on their respective food chains dominating the catch, there is little reason to expect a high return. The range of 8-21 lbs./acre/year is also comparable to the commercial production in large lakes. Rounsefell (1946) reports a range from 29.72 pounds per acre for 10,000 acre lakes to 1.40 pounds per acre for 25,000,000 acre lakes. These lake figures exhibit a consistent negative correlation between lake size and yield per unit area which Rounsefell (1946) attributes to the relative amount of shoal shoreline waters. Marine habitats are usually characterized by vast areas with proportionately little shoreline, but North Carolina, with multiple estuaries and the offshore bar, has a better than average physiography in this respect.

In many situations, chiefly in freshwater habitats, the yield has been greatly increased by adding fertilizers. Yields of 400-600 lbs./acre/year have been obtained in the southeast by Swingle and Smith (1947) in ponds where fish such as bluegills, which are low on the food chain, dominate the catch. A spectacular increase was produced in certain marine Lochs in Scotland where flat fish grew at several times their normal rate after their habitats were fertilized (Gross, Raymont, Nutman and Gauld, 1946, and Raymont, 1947).

Fertilization warrants considerable attention in North Carolina, as elsewhere. It is not inconceivable that someday the mouths of the main rivers might be used as feeders to add fertilizing nutrients to the sounds with the offshore bar aiding by effectively impounding the derived benefits. There are, however, in addition to practical economic limitations, at least two fundamental points that detract from the prospects of improved yields by this means. Added nutrients provide their benefits by increasing basic production where it has been limited because of deficiencies; yet the present discussion has suggested that basic production has not been a limiting factor in the State's fisheries yield. Also fertilizers may stimulate the growth of undesired, instead of beneficial, plankton algae, not to mention the fact that some species may react unfavorably when excessive numbers of microorganisms are produced (see, for example, Loosanoff and Engle, 1946). Conveniently, there are in North Carolina many natural estuarine environments of varied sizes and types that might be used for progressive experimentation with fertilizers.

Summary Comments and Recommendations

This study is an attempt to assimilate, analyze, and describe all pertinent hydrographic information relative to North Carolina's marine fisheries as accumulated up to the year 1947. Since the coverage is broad and descriptive, this summary will of necessity be limited to selected items considered especially significant.

An offshore bar runs the length of the North Carolina coast separating inshore from oceanic waters. Where this bank, as it is called locally, projects seaward as the Cape Hatteras prominence, it encloses broad sounds to the west. To the south, where the bank lies closer to the mainland, the enclosed sounds are narrower and more in the nature of lagoons, with even the latter poorly developed southwest of Cape Fear.

From the Virginia line to Cape Fear this offshore bar is interrupted by about seventeen inlets connecting the ocean with the sounds. As controlled by strong natural forces, these inlets open and close, migrate with the shifting sands, and vary from shallow temporary washes to deeper more permanent openings. Apparently as a result of fill carried southward from the Virginia Capes headland, there are no inlets along the northern reaches of the bar. From the standpoint of exchange between sounds and ocean, the greatest inlets are in the central area, Ocracoke Inlet being the most prominent.

To create and maintain a new inlet or to deepen an existing one is to oppose strong natural forces. It can be done at any point if the engineering is adequate (which means proper financing) to withstand the extremes in adverse wind and currents. On the other hand, inadequate construction may mean money completely wasted as when New Inlet closed immediately after being artificially reopened in 1924. The public seems to class all proposals for new inlets as improvements for the fisheries as well as for navigation. This is an extremely hasty assumption. The increase in salinity in the sound side of a new or deepened inlet might increase clam production and possibly the yield of certain other forms, but the popular concept that more inlets will mean increased migrations into the sounds is unfounded. This may be true or partly so; yet there may be some detrimental results. For example, if the discharge of brackish water through an inlet attracts fish, the addition of inlets may so reduce this factor for any given inlet as to make it less than the amount necessary to stimulate migration. Studies should be made of the relation of inlets to the habitats and migrations of pertinent fisheries forms. Such studies should be both basic and practical, ranging from physiological studies of the influence of brackish water on fish behavior to before and after observations around new inlets created by nature. North Carolina affords natural models for the latter work, the greatest limitation being lack of data on past conditions.

The North Carolina sounds consist of about 2,500 square miles of typically productive shallow waters, seldom as much as 20 feet deep. The bottom areas are of sand, or mud, or a mixture of the two. A statement of the areas now capable of serving as oyster bars cannot be made but, in view of past history, it is assumed that with proper management vast areas, including some now depleted, can serve well in this respect.

Rivers draining about 30,000 square miles, almost all within the Coastal Plain and Piedmont Plateau, discharge into these sounds. Salinities range from fresh water at the river mouths to almost the full concentration of sea water at the inlets from the ocean. The tidal range is so small that, except at inlets, most changes in water level result primarily from wind-driven water. From the limited data available it appears that the temperature in these sounds generally approximates that of the overlying air, being slightly colder as a rule. There is very little freezing in mid-winter.

To the seaward of the offshore bar there are about 14,000 square miles of shallow water (to the 100-fathom curve which is the edge of the continental shelf). The adjacent Florida Current of the Gulf Stream System makes the temperature on this shelf comparatively warm the year around. The seasonal relationships of this warm area to the rest of the coast are as follows (for a comprehensive discussion of this see Parr, 1933):

During mid-summer rather uniform temperatures, usually above 78° F., prevail from southern Florida to Cape Hatteras. To the north of Hatteras there is a moderate gradient of decreasing temperatures but no temperature discontinuity or barrier exists short of the cold area around Nantucket and south of Cape Cod.

Later in the fall a temperature discontinuity appears, as coastal waters cool to the north and south of the general Hatteras region which maintains mid-winter temperatures of about 60° F. under the effects of the Florida Current.

Because of variations in such factors as the flow and course of the Florida Current, there are relatively great temperature fluctuations in the Hatteras area in winter.

Cape Hatteras has long been referred to as a temperature barrier to the distribution of marine forms, but these coastal temperature relationships suggest many distribution effects not brought to attention by the barrier concept. A non-migratory organism that requires warm water the year around might be missing along the coast from northern Florida to southern North Carolina and yet be present around Hatteras and offshore to the south of Hatteras. Other non-migrators that tolerate moderate winter cooling might have a coastal distribution as far north as Hatteras and little farther, whereas those requiring cooler water might be found only to the north of this cape. Continuing to deal in categories in order to elaborate on such general temperature effects, migratory species may be mentioned under four headings: (1) those which undertake northward migrations to cooler waters in summer and probably pass close to Cape Hatteras en route; (2) those requiring subtropical temperatures which might be found as far north as Hatteras in summer, though a cold summer upwelling off Daytona, Florida, may interrupt this; (3) those requiring warm waters to the extent that they retreat from the North Carolina sounds and from the coast to the south to a southern winter retreat or possibly to warm waters at the edge of the continental shelf including those in the Hatteras region; and (4) those requiring moderate winter temperatures, retreating from Middle Atlantic and North Carolina coastal points to winter around Hatteras.

The last is a comparatively well known category of great fisheries significance. It accounts for the prosperous winter trawl fishery for scup, flounders, croakers, sea bass, etc., which has developed off the Virginia and North Carolina capes in the last two decades. Also, the combined assets of the large shallow North Carolina sounds with a bordering area that remains warm through the winter may have an important bearing on the importance of these waters as a nursery habitat or center of dispersal for many fish populations. Referring to the North Carolina and more southern populations commonly thought to move farther south in winter, it is quite possible that some of these populations move into the Hatteras region and have as yet remained undiscovered or unrecognized. From experience fishermen occasionally speculate as to the great untouched offshore resources to be expected south of Hatteras in winter. The hydrographic data seem to support such speculation. The occurrence of uncharted rocks on the bottom in this area has discouraged exploration of such potentialities by privately owned trawlers; however, with the aid of modern detecting devices and sampling gear, it is a reasonable undertaking for a research organization, and is now being pursued by the Institute of Fisheries Research of the University of North Carolina.

The greatest annual fishery yield credited to all these North Carolina marine waters is less than one per cent of the estimated potential annual production of basic food. The food chains of many of the fishes harvested are so long and the loss in poundage at each food chain level is so great that this low percentage is readily understood. The North Carolina harvest compares favorably on an acre per acre basis with many other fishery areas including, for example, Georges Bank, but there is good reason to expect greater yields. One obvious suggestion is to look to fishes that feed low on the food chain, such as shad, menhaden, shrimps, oysters, and clams. Where these are not yielding up to expectations, the difficulties can often be discovered through basic research.

Probably the greatest gap in the story of the hydrography of North Carolina marine waters is with respect to chemical contributions and exchange. This involves the basic nutrients from which production must stem. A great deal should be done to trace the history of such nutrients to answer such questions as: what nutrients are contributed by river discharge, how are they utilized, are they lost with silt deposition, are nutrients contributed to the continental shelf area from oceanic circulation? The subject of pollution should be handled as well, especially with respect to fish that depend on good freshwater conditions for spawning up the river mouths.

Though some suggestions have been made, recommendations for future study can best be made as detailed programs are analyzed and planned. Certainly hydrography and quantitative ecology should be pursued intensively in future investigations. In the past we have been preoccupied with species studies, attempting to find basic difficulties from clues suggested by fisheries forms that are just the partial end points of production systems. A more basic approach has always seemed beyond our means both as to financing and as to the complexity of the problems involved. It is time to take a bold stand in both respects. If the discrepancy between basic production and yield suggested here is a reality, and this can be determined more definitely through further research, a far greater harvest is a very reasonable expectation.

BIBLIOGRAPHY

Abbe, Cleveland, Jr.

1895. Remarks on the cuspate capes of the Carolina coast. Proc. Boston Soc. Nat. Hist., Vol. 26, p. 489-497.

Beaven, G. F.

1946. Effect of Susquehanna River stream flow on Chesapeake Bay salinities and history of past oyster mortalities on Upper Bay bars. Third Ann. Rept. Maryland Bd. Nat. Resources, App. B, p. 123-133.

Bigelow, H. B.

1933. Studies of the waters on the continental shelf, Cape Cod to Chesapeake Bay. I. The cycle of temperature. Papers in Physical Oceanography and Meteorology of Mass. Inst. Tech. and Woods Hole Oceanog. Inst., Vol. 2, No. 4, p. 1-135.

Bigelow, H. B. and Mary Sears.

1935. Studies of the waters on the continental shelf, Cape Cod to Chesapeake Bay. II. Salinity. Papers in Physical Oceanography and Meteorology of Mass. Inst. Tech. and Woods Hole Oceanog. Inst., Vol. 4, No. 1, p. 1-94.

Böhnecke, G.

1938. Temperature, Salzgehalt und Dichte an der Oberfläche des Atlantischen Ozeans. Deutsche Atlantische Exped. *Meteor* 1925-1927, Wiss. Erg., Bd. 5, 2 Lief.

Brown, E. I.

1928. Inlets on sandy coasts. Proc. Amer. Soc. Civil Engineers. Vol. 54, Pt. 2, p. 1-32.

Church, P. E.

1932. Surface temperatures of the Gulf Stream and its bordering waters. Geographical Rev., Vol. 22, No. 2, p. 286-293.

Clarke, G. L.

1946. Dynamics of production in a marine area. Ecol. Monographs, Vol. 16, p. 321-335.

Corps of Engineers, U. S. Army

1935. Beach erosion at Kitty Hawk, Nags Head and Oregon Inlet, N. C. House Doc. No. 155, 74th Congress, 1st Session.

1948. North Carolina shore line, beach Erosion study. House Doc. No. 763, 80th Congress, 2nd Session.

Cowles, R. P.

1930. A biological study of the offshore waters of Chesapeake Bay. Bull. U. S. Bur. Fish., Vol. XLVI, p. 277-381 (Doc. 1091, 1930).

Dailey, R. B.
1946. Annual meteorological summary with comparative data, 1945, Hatteras, N. C., U. S. Weather Bur., mimeographed rept.
Daly, Reginald A.
1942. The Floor of the Ocean, New Light on Old Mysteries. Chapel Hill: The University of North Carolina Press.
Engels, W. L.
1942. Vertebrate fauna of North Carolina coastal islands. A study in the dynamics of animal distribution. 1. Ocracoke Island. Amer. Midland Naturalist, Vol. 28, No. 2, p. 273-304.
Gottschalk, L. C.
1945. Effects of soil erosion on navigation in upper Chesapeake Bay. Geographical Rev., Vol. 35, p. 219-238.
Grave, Caswell.
1904. Investigations for the promotion of the oyster industry of North Carolina. Rept. U. S. Fish Comm'r. for 1903 (1905), p. 247-341.
Green, C. K.
1944. Summer upwelling—northeast coast of Florida. Science, Vol. 100, No. 2607, p. 546-547.
Gross, F., J. E. G. Raymont, S. R. Nutman and D. T. Gauld.
1946. Application of fertilizers to an open sea loch. Nature, Vol. 158, p. 187.
Gutsell, J. S.
1931. Natural history of the bay scallop. Bull. U. S. Bur. Fish., Vol. XLVI, 1930 (1931), p. 569-632. (Doc. 1100, 1931).
Hachey, H. B.
1939. Temporary migrations of Gulf Stream water on the Atlantic seaboard. Jour. Fish. Res. Bd. Canada, Vol. 4, No. 5, p. 339-348.
Haight, F. J.
1942. Coastal currents along the Atlantic coast of the United States. U. S. Coast & Geodetic Surv. Spec. Pub. No. 230.
Hand, I. F.
1941. A summary of total solar and sky radiation measurements in the United States. Monthly Weather Rev., Vol. 69, No. 4, p. 95-125.
Harvey, H. W.
1945. Recent Advances in the Chemistry and Biology of Sea Water. London: Cambridge University Press.
Iselin, C. O'D.
1936. A study of the circulation of the western North Atlantic. Papers in Physical Oceanography and Meteorology of Mass. Inst. Tech., and Woods Hole Oceanog. Inst., Vol. 4, No. 4, p. 1-101.
1940. Preliminary report on long-period variations in the transport of the Gulf Stream system. Papers in Physical Oceanography and Meteorology of Mass. Inst. Tech., and Woods Hole Oceanog. Inst., Vol. 8, No. 1, p. 1-40.

Johnson, D. W.
1938. Shore Processes and Shoreline Development. New York: John Wiley & Sons, 1919, reprinted 1938.

Kincer, J. B.
1946. Our changing climate. Trans. Amer. Geophysical Union, Vol. 27, No. 3, p. 342-347.

Lamar, W. L.
1947. Chemical character of surface waters of North Carolina 1944-45. North Carolina Dept. Cons. and Develop., Div. of Water Resources and Engineering, Bull. 52, Vol. 1, p. 1-20.

Lindeman, R. L.
1942. The trophic-dynamic aspect of ecology. Ecology, Vol. 23, No. 4, p. 399-418.

Loosanoff, V. L., and J. B. Engle.
1947. Effect of different concentrations of microorganisms on the feeding of oysters (*O virginica*). Fishery Bull. U. S. Fish & Wildlife Serv., Vol. 51, Fishery Bull. 42, p. 30-57.

MacCarthy, G. R.
1931. Coastal sands of the eastern United States. Amer. Jour. Sci., 5th Series, Vol. 22, No. 127, p. 35-50.

Martin, R. J. (editor).
1933. Climatic summary of the States. Section 96. Central and Southeastern North Carolina. Section 97. Northeastern North Carolina. U. S. Weather Bureau, Washington.

Nelson, T. C.
1928. Report of the Department of Biology of the New Jersey Ag. Exp. Sta., year ending June 30, 1927, p. 77-83.
1931. Studies of the movements and of the distribution of oyster larvae in natural waters of New Jersey. Rept. Dept. Biol. of the N. J. Ag. Exp. Sta., year ending June 30, 1930, Bull. 552, p. 5-24.

North Carolina Fisheries Commission Board.
1923. Report of special committee on inlets which investigated the proposal to construct certain additional inlets on the North Carolina coast. Raleigh.

Parr, A. E.
1933. A geographic-ecological analysis of the seasonal changes in temperature conditions in shallow water along the Atlantic coast of the United States. Bull. Bingham Oceanog. Coll., Vol. 4, Art. 3, p. 1-90.

Pearson, J. C.
1932. Winter trawl fishery off the Virginia and North Carolina coast. U. S. Bur. Fish. Investigational Rept. No. 10.

Radcliffe, Lewis.
1914. The offshore fishing grounds of North Carolina. U. S. Bur. Fish. Economic Circular No. 8.

Rathbun, Richard.

1887. Ocean temperatures of the eastern coast of the United States, from observations made at twenty-four lighthouses and lightships. *In:* Fisheries and Fishery Industries of the United States, by G. Brown Goode and associates, Sec. III, App., p. 155-239.

Raymont, J. E. G.

1947. A fish farming experiment in Scottish sea lochs. Jour. Marine Res., Vol. 6, No. 3, p. 219-227.

Riley, G. A.

1941. Plankton studies, III, Long Island Sound. Bull. Bingham Oceanog. Coll., Vol. 7, Art. 3, p. 1-93.

1944. The carbon metabolism and photosynthetic efficiency of the earth as a whole. Amer. Scientist, Vol. 32, No. 2, p. 129-134.

Rounsefell, G. A.

1946. Fish production in lakes as a guide for estimating production in proposed reservoirs. Copeia, 1946, No. 1, p. 29-40.

Rude, G. T.

1922. Shore changes at Cape Hatteras. Annals Assoc. Amer. Geographers, Vol. 12, p. 87-95.

Stewart, J. Q.

1945. Coasts, Waves and Weather for Navigators. Boston: Ginn & Co.

Stiemke, R. E.

1947. The extent of stream pollution in North Carolina. N. C. State College Record, Vol. 46, No. 6, p. 1-69.

Sumner, H. C.

1944. The North Atlantic hurricane of September 8-16, 1944. U. S. Weather Bureau, mimeographed rept., Marine Section.

Sverdrup, H. U., M. W. Johnson and R. H. Fleming.

1942. The Oceans. New York: Prentice-Hall, Inc.

Swingle, H. S., and E. V. Smith.

1947. Management of farm fish ponds. Bull. Agric. Exp. Sta. Alabama Polytechnic Inst., No. 254.

Tannehill, I. R.

1945. Hurricanes, their nature and history, particularly those of the West Indies and the southern coasts of the United States. Princeton: Princeton University Press.

U. S. Coast & Geodetic Survey.

1936. U. S. Coast Pilot, Atlantic Coast, Section D, Cape Henry to Key West, 4th ed., Serial No. 582.

1945. Density of Sea Water at Coast and Geodetic Survey Tide Stations, Atlantic and Gulf Coasts. DW-1 revised 1945.

1945. Supplement to United States Coast Pilot, Atlantic Coast, Section D, Cape Henry to Key West, 4th (1936) edition.

1946. Tide tables, Atlantic Ocean, 1947. Serial No. 678.

U. S. Coast & Geodetic Survey, continued
1946. Current tables, Atlantic Coast North America for the year 1947. Serial No. 683.

U. S. Department of Agriculture (numerous authors).
1941. Climate and Man. Yearbook of Agriculture. House Doc. No. 27, 77th Congress, 1st Session.

U. S. Geological Survey.
Surface water supply of the United States [separate paper for each year involved]. U. S. Geological Survey Water-Supply Papers.

U. S. Weather Bureau.
1941. Airway meteorological atlas for the United States. U. S. Weather Bureau, W. B. No. 1314.

Wells, R. C., R. K. Bailey and E. P. Henderson.
1929. Salinity of the water of Chesapeake Bay. U. S. Geol. Surv., Professional Paper 154-C, p. 105-152.

Winslow, Francis.
1886. Report on the waters of North Carolina with reference to their possibilities for oyster culture, together with the results obtained by the surveys directed by the resolution of the General Assembly, ratified March 11, 1885. Raleigh: North Carolina State Printer and Binder.
1889. Report on the sounds and estuaries of North Carolina with reference to oyster culture. U. S. Coast & Geod. Surv., Bull. No. 10, p. 52-136.

PART II

BIOLOGY AND NATURAL HISTORY OF THE ECONOMIC SPECIES

BY

William A. Ellison, Jr., Eugene W. Roelofs, Alphonse F. Chestnut, Carter Broad, John C. Pearson, Robert E. Coker, Harold J. Humm, and Francesca LaMonte, with an Introduction by Harden F. Taylor

CONTENTS

INTRODUCTION

BY Harden F. Taylor
Executive Director of the Survey

The purpose of Part II of this Survey is to assemble and summarize the present knowledge of the natural history of the several economic species of fish and shellfish and also game fishes in North Carolina waters, and to focus attention on the large unknown area where further research is needed. In carrying out this purpose, the broad subject has been subdivided and assigned in its parts to biologists who are considered qualified to deal with them.

In addition to the detailed treatment of the fisheries by species, the ecology and dynamics of the flora and fauna of the region as a whole ought also to be considered at length, but in the absence of sufficient exact knowledge to make such a treatment worth while, we can here mention only a few generalizations and must leave the rest to future research.

The lay of the land (and water) of the coastal region of North Carolina, as dealt with in detail in Part I of this Survey, predetermines the kind and amount of living things to be found there.

The outer banks enclose the mouths of the rivers to form sounds; the input of the rivers into these sounds varies greatly in quantity, turbidity, and chemical content with rainfall and run-off from the land, and varies also in temperature with the inland weather and the seasons. The sounds themselves are shallow with much surface in proportion to volume, and can change in temperature much and quickly. Their salinity or saltiness is governed by the back-flow of sea water through the inlets as affected by tide and the direction and velocity of wind. Moreover, precipitation into and evaporation from the sounds affect both salinity and temperature of the water. The overall effect of these and other variables is to provide not constant but highly variable conditions in both time and place in the sounds to which animals and plants must accommodate themselves one way or another. Attached forms such as seaweeds, grasses, and mollusks must be able to endure a wide variety of conditions if they are to survive; swimming forms can either endure these conditions or migrate; some of them, such as crabs and flounders, are sufficiently tolerant of salinity and temperature to remain in the sounds the year round; most of the others migrate seasonally into the sounds in summer and out again to sea in winter, with the result that the fisheries of the State are mostly seasonal and highly variable.

At sea the waters are controlled by oceanic conditions. North Carolina lies between the sub-tropical Florida–Caribbean region with the Gulf Stream close to shore, and the colder northern sub-arctic region where the Gulf Stream is far out to sea, with its great, stable year-round fisheries; with Cape Hatteras apparently a natural dividing point between these regions, the State marks the northern limit of one and the southern limit of the other, and its assortment of fishes is of an in-between composition. North Carolina does not seem to have any dominant species which it can call its own; it has some shrimp, spanish mackerel, speckled trout, bluefish, and mullet, but (if production is any indication), less than are found farther south; and some croaker, gray trout, striped bass, and oysters, but less of them than Chesapeake Bay; it has, however, perhaps a greater variety of fishes than any other Atlantic state, and fortunately those it does have are mainly the choice or deluxe varieties and these mostly the invertebrates, oysters, shrimp, crabs, scallops, and clams.

When the migrant fishes, young and adult, leave the sounds, their destinations at sea are mostly unknown. No doubt some of them go south; some probably proceed to the deeper continental shelf, there to feed or hibernate until their next return. In recent years a new winter trawl fishery has been established offshore from the Virginia Capes to a little south of Cape Hatteras, as a result of the discovery of the winter quarters of some of the species which inhabit the sounds in summer; further exploration may reveal similar opportunities farther south of Hatteras. Some fishes such as the menhaden and spanish mackerel perform long coastwise migrations from the north to the Florida region, making North Carolina a port of call on their way. The strategy of the North Carolina fishermen is to know intimately the movements of the various fishes so as to find and catch them when and where they are present.

In addition to the variability caused by migrations, most if not all fishes seem to be subject to cycles of abundance and scarcity. These cycles are of irregular occurrence and duration and, in the present state of fishery science, are not predictable. In part, no doubt, local fluctuations in abundance are caused by migrations or geographic shifts in the centers of population of freely-moving species, but in another part the actual total population of each species itself varies, sometimes widely. As examples, annual alewife production in the twenty-two statistical canvasses made since 1887, has varied in North Carolina from 5 to 17 million pounds, bluefish from 323,000 to over 2 million, croakers from 286,000 to nearly 10 million, etc. In the case of each species, good periods are followed by lean periods, and vice versa, so that it seems reasonable to believe that those species which are now at a low point in production or abundance may be expected to increase in the future.

Long-term geographic shifts in the population of fishes from one region to another are well known to the fishing industry. The weakfish or gray trout was absent from northern New England waters from before 1800 to 1838, then became abundant in the late 1800's, reaching a peak from 1901 to 1904; it declined rapidly after 1904, and was again practically absent from these waters by 1909. Bluefish were absent from New England waters during the period 1764 to 1810, but since that time they have supported a continuous but fluctuating fishery. The centers of abundance of the North Carolina species, gray and spotted trout, bluefish, and croakers, seem to have shifted, so that their relative abundance in the State and in the neighboring States has changed much from time to time. Notwithstanding the fluctuations in abundance of many or all the species, the total production of the food fishes as a whole in North Carolina shows no consistent trend, upward or downward.

Changes in the abundance of the several species are thus undoubtedly the result of natural factors even though fishing may also have some effect. Heavy fishing may reduce a population, but the fishery arrests itself automatically as it becomes unprofitable and is discontinued or much diminished long before any species is totally "fished out."

While in most cases a decline in production is followed by an increase, there are certain instances where changed conditions may prevent subsequent increases. This seems true of the shad in nearly all of the Atlantic coast streams. Obstructions, pollution, sedimentation, and soil erosion have made many of the rivers unsuitable for shad spawning and survival of young. This problem is discussed in greater detail in the sections dealing with the species.

The relationship between legislation and fluctuations in abundance is interesting and important. Restrictive laws are generally made when a fishery is declining or when it has reached a low point in the usual cycle; and when subsequently the species increases in abundance, the restrictive measures are given credit for having produced the increase. The same chain of events has occurred in the case of artificial propagation, although recent research has cast serious doubt on the ability of fish plantings to increase the population of sea or coastal fishes to a measurable degree or even to sustain it where it naturally tends to decline. Considerable research needs to be done to determine whether the fish need the protection they are now given, and whether the inconveniences of restrictive measures to the fishermen are justifiable from an economic or biological viewpoint.

It is indicated in Part III of this Survey that economic improvement in the fishing communities is not to be expected from advance in prices, but it must come from the production and sale of more fish and from increased efficiency and lower cost. Is the State capable of producing substantially more fish than it now does? Statistics of commercial production are not a reliable indicator of abundance, since fishermen catch only the kinds and amounts of fish that they can dispose of to best advantage and the number of fishermen is also determined by the total magnitude of the economic opportunity. In the statistics of North Carolina (if menhaden is excluded) there appears to be no drift upward or downward in the total quantity or real value of food fish or in the number of fishermen engaged in catching them. If there is any tendency toward smaller individual sizes of finfish (an indicator of heavy drain on the supply), no one seems to have observed it. No systematic studies have been made on the catch per unit of effort, but there is no talk here, either, of any change, and none has occurred, so far as we know.[1] The only measure we have of the amount of effort is in the statistics of production units (numbers of boats, nets and other gear) reported in the Government canvasses.

While most of the potential increases of the State depend on the spontaneous bounty of nature, the oyster can be increased in abundance at will by the now well developed art of cultivation, since the State has an abundance of natural bottom in water of suitable quality and condition. Perhaps the clam and scallop, two of the State's choice species, may also be artificially cultivated or assisted.

If we can reason from analogy with the other fishing regions of the country, North Carolina could well produce much more fish generally than it now does if the market demanded it, if the fishermen should take full advantage of their opportunities, and if legislation were designed to encourage them to do so. The New England, Gulf of Mexico, Pacific coast, and Alaska regions have all fished more aggressively and produced more total fish as the human population has increased, and as improved technical processes and better marketing have stimulated demand. The Middle Atlantic and Chesapeake regions failed to increase their yields of food fish over the years because of special conditions (shad and oysters) and only the Great Lakes seem to have reached the limit of their productivity (Part III, Appendix, Tables 48, 49, and 50). The percentage composition of the total by species has continually changed in all the regions as it has in North Carolina. There are no obvious signs of shortage in the known fisheries of North Carolina, and there are large expanses of offshore waters not yet explored.

Up to now, the quantitative science of fisheries production has concerned itself almost wholly with particular species separately, and has tacitly assumed that the whole is the sum of the parts in the sense that if each species of a regional fishery could be "managed," conserved, or increased, one by

1. As Dr. Roelofs points out in his Summary and Recommendations concerning the finfishes, the North Carolina fishermen believe that the last few years have witnessed a decrease in the abundance of finfish, but we have no quantitative data as a support for this belief at this time.

one, the total would or could be correspondingly enhanced. Little attention has been paid to this or any other regional fishery as a community of many rivaling, competing, predatory, and mutually destructive species wherein the rise of one is inseparably associated with the decline of others so that the whole behaves as a body and in a manner entirely different from that of any of the parts. Each species in its early stages of life drifts helplessly as eggs, then as larvae; as such it is consumed by anything that feeds on drifting life and itself consumes other drifters; as it grows it continues to devour other species smaller than itself, is devoured by others larger, and until it is consumed it is in severe competition with many other rivals. Nearly all the destruction of all species occurs in the earliest stages of life, i.e., infant mortality is by far the greatest mortality of every species and is the part of marine life about which we know practically nothing quantitatively.[2] The science of marine biology, up to now, has concerned itself mainly with the exceptional survivors, the adults which have already escaped most of the hazards of existence, have outgrown most of their enemies, and are in least danger from them. We know very little in detail about the food of fishes or the quantitative relation between the amount of food consumed and the amount of growth, and what we do know is mainly derived from examination of adult stomachs.

It appears that until we know far more than we now do about the dynamics of fishery production as a whole, especially at the level where most of the discriminate and indiscriminate destruction occurs, "fishery management" by public regulation is little more than vain presumption arising from rivalries and jealousies among fishermen and sportsmen, and designed principally to assuage them.

2. For extensive information concerning the food relationships of, and struggle for existence among, the plankton or small drifters, see throughout and especially p. 97-112 of Bigelow's classic work (1928) cited in Mr. Ellison's bibliography of the menhaden.

THE MENHADEN

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CONTENTS

GENERAL AND HISTORICAL

POSITION AND MAGNITUDE OF THE MENHADEN FISHERY

The menhaden is a member of the important family Clupeidae, which includes the shad, herring, alewives, and the hickory shad of the Atlantic and the pilchard of the West Coast. Not being considered an edible fish, it is rarely recognized and in fact scarcely known by name among the general public. It has, however, given the United States one of its great fisheries and is fished for in more states and over a wider range than any other important fish in the territorial waters of the United States.

As a food fish, the menhaden has never been popular, and may never be, because of its unesthetic quality, although it is perhaps unequalled by any other known food in intrinsic nutritive value at so low cost. From the earliest colonial times it has provided bait for other fish and industrial commodities in the form of oil, fertilizer, or animal food. During the middle of the nineteenth century considerable quantities were salted for export to the West Indies and for home consumption. A little later (1873-75) small menhaden were canned as "American sardines" or "shadines," but the superiority of the small herring of Maine caused this practice to be abandoned. The principal value of the fish even in those days was derived from its use as fertilizer, animal food in limited amounts, oil, and bait. Large quantities of the fish were used by the fishermen out of New England ports for bait and a substantial trade was developed in supplying these fishermen.

During World War II menhaden was canned in fairly large quantities, but most of it was put up for export and little was consumed in this country.

The roe of menhaden has had some acceptance as a food item, and if marketed in a suitable package and properly labeled, it might offer considerable possibilities, coming as it does when other fish roe in large quantities is unavailable.

In the United States, as a source of marine animal oil, the menhaden is at present pre-eminent. Marine animal oils fall into two classes: (1) body oils from the whole animal or as by-product from offal; and (2) liver and visceral oils for vitamins. The former are used for industrial purposes, such as making soap, paint, and linoleum, and the latter for pharmaceutical preparations.

In 1947 the menhaden accounted for over half the production of oil and meal made from the body and waste of marine animals processed in this country. With the decline of the pilchard fishery on the West Coast for the past three years, it has had no close rival in the United States and Alaska in this respect. For the year 1947, 8,473,371 gallons of oil valued at $11,425,497 were produced from menhaden alone. Pilchard supplied 2,103,965 gallons valued at $2,677,453. Nine other species supplied 5,323,106 gallons valued at $6,004, 244. As a source of oil from all marine animals, the menhaden ranks high, its oil being exceeded in value only by the medicinal oils from those marine animals producing viscera and liver oil of high vitamin content. The fishes from which the medicinal oils come are the shark, halibut, tuna, swordfish, ling cod, and jewfish for the high potency oils, and the common cod, rosefish, burbot, skate, sole, etc., for lower potencies but larger volumes. Among these fishes no single species approaches menhaden in the dollar value of oil produced (see Tables 1 and 2). The total value of all oils produced from all marine animals in the United States in 1947, including a small amount from whales, was $31,750,662. Of this amount slightly over 35 per cent came from menhaden.

The largest landings of menhaden in the history of the fishery were recorded in 1948 when over one billion pounds were processed. From this amount of fish, 104,058 tons of dry scrap and meal, valued at $11,560,914, and 8,763,939 gallons of oil, valued at $10,132,179, were produced, with a combined money value of $21,693,093. Although the year 1948 saw the greatest amount of fish ever landed, the dollar value was slightly less than that of 1947, which amounted to $22,336,212. The decrease is attributed to a decrease in yield of oil.

Table 1 gives for 1947 the value of marine animal oil produced from whole fish and waste, and Table 2 gives the value of marine oil produced from viscera and liver.[1]

TABLE 1

Production of Marine Animal Oils from Whole Fish and Waste, 1947

Species	Gallons	Value
Menhaden	8,473,371	$11,425,497
Pilchard	2,103,965	2,677,453
Nine others	5,323,106	6,004,244
Total	15,900,442	$20,107,194

TABLE 2

Production of Marine Animal Oils from Liver and Viscera, 1947

Species	Gallons	Value
Shark	490,940	$ 6,634,050
Cod	260,377	556,546
Tuna	43,305	1,373,609
Miscellaneous (9)	37,888	3,079,263
Total	832,510	$11,643,468

The principal uses of menhaden oil are for the manufacture of cutting oils, paint, linoleum, etc. For a time efforts were made to market menhaden oil on the basis of its vitamin content, but its value is so low as compared to the oils of other fish easily obtained that there is little likelihood that menhaden oil will ever be used for this purpose.

Meal made from menhaden is highly rated as an animal food and, particularly during the past few years, has fetched a high price. It is about equal in total dollar value to that of the oil produced. In 1947 the total meal made in the United States from all sources of marine animals, including that manufactured from cod, haddock, rosefish, salmon, pilchard, and menhaden, was 371,616,000 pounds valued at $22,353,488. Of this amount, menhaden supplied 197,204,000 pounds, or 53 per cent, the value of which was $10,883,852, or 48 per cent of the total. Because of its greater value as fish meal for animal feeding during recent years, little or no menhaden is manufactured into fertilizer.

HISTORY OF THE MENHADEN FISHERY

Of the important fisheries of the Atlantic coast, the menhaden industry is the youngest with the exception of the rose- or redfish industry, which was started in the early 1930's in New England. The fish has been known from colonial days when the Indian chief Squanto, friend of the white man, taught the early Pilgrims to fertilize their crops with it. John Lawson, colonial ex-

1. All statistics of menhaden herein are from U. S. Fish & Wildlife Service.

plorer of North Carolina, records the use of "fatbacks" as a food of the early colonists.

It was not until the first half of the nineteenth century that serious effort was made to separate the oil from the flesh, and even as late as 1879, Professor Goode urged the use of the dried fish scrap as a food for domestic farm animals, citing such use by European farmers and by the farmers of New England. As late as 1864 the pressed scrap was thrown overboard in Maine or given to farmers at the price of hauling it away.

Formerly the fish were taken incidentally with other fish or sought after in relatively small amounts to be used as fertilizer. They had no other recognized value; their use as whole fish fertilizer was a doubtful practice, for although prolific crops resulted for a season or two, the oil from the fish so "burnt" the land that it was untillable for years to come. Until the early part of the nineteenth century, however, menhaden was used solely as a raw whole fish fertilizer.

There are many claimants for the honor of having started the menhaden industry, but the evidence seems to indicate that two men, Barker and Tallman, who in 1811 set up two small iron pots at Black Point Wharf, Portsmouth, Rhode Island, were first (Goode & Clark, 1887). Their process was simple. First, the menhaden, covered with water, were boiled in the iron pots until the breakdown of the fleshy tissues released the oil. The boiled mass was then poured into containers and weighted by rocks placed on boards laid over the solid mass. When the oil floated to the top of the water, it was skimmed off and barreled for shipment to the New York market. Two pots were added in 1814. Gales in 1815 destroyed the apparatus, and business was not resumed until 1818. In 1824 a cooker replaced the pots. This cooker was a wooden tank 5½ feet high, 6 feet wide, and 8 feet long. A furnace was located at one end, from which a copper flue ran through the box. The "factory" was built on skids and hauled from place to place by two oxen. According to the early report, it was hauled from the shore to the farm a mile away, and, after the oil was recovered, the water and scrap were broadcast to add fertility to the soil.

The first factory to use live steam was built by John Tallman in 1841, also at Portsmouth, R. I. This installation consisted of eight wooden tanks holding 60 barrels of fish each and a flue boiler. In 1842 the business expanded and branched, and Tallman and Lambert built a plant at the mouth of the Merrimac River, Mass. Shortly thereafter Daniel Wells built a factory, modeled after Tallman's, on Shelter Island, near Greenport, New York. About this time, Charles Tuthill, of Greenport, invented a method for expressing the oil from the cooked fish. The next twenty-five years saw a great expansion in the menhaden industry, and by 1866 plants had been established along the Atlantic coast from Maine to Portsmouth Island, North Carolina.

The early history of the menhaden industry is given briefly by Earll (1887). Early efforts to establish the menhaden industry in North Carolina were inspired by Northern soldiers who had sojourned in the State during the Civil War. Their glowing accounts of the abundance of menhaden in the waters of North Carolina encouraged Northern capitalists to invest in the fishery. Capital, and men experienced in the capturing and processing of menhaden, were brought to the State to initiate the program. In spite of the experience and background of the promoters, the establishment of menhaden factories in North Carolina had rugged going, and at one time, even as late as 1880, it was doubted that the menhaden industry could ever be developed here.

This early fishery was limited almost entirely to the sound waters, Core and Pamlico sounds and a part of Bogue Sound being the principal fishing grounds, with the exception of one fishery that was established on the Cape Fear River.

Some effort was made to fish outside the inlets, but the unpredictable storms and the narrow circuitous inlets with their strong tidal currents discouraged any extensive effort in this direction. The shoal waters of the sound, the periodic scarcity of fish, and the poor yield of oil conspired to defeat all the early efforts.

The first processing plant was established on Harpers (Harkers?) Island in Core Sound in 1865. The first year, this plant was equipped with kettles and hand presses and was dependent upon gill nets for its fish supply. Later a boiler was installed and purse and haul seines were introduced for the capture of the fish. In 1873 operations were discontinued on the Island and the equipment was moved to Cape Lookout, which was considered a more favorable location. The plant was never erected at the new site and the project was abandoned with a total loss of capital of about $3,000.

In 1866 the Excelsior Oil and Guano Company established a plant at Portsmouth Island, near Ocracoke Inlet. This plant was financed by Northern capital and was probably "modernly" equipped. It was an ambitious undertaking, backed by $50,000 capital. Purse seines were employed and Northern fishermen skilled in their use and acquainted with the behavior of the fish were imported for the operation of the seines. After three years the project was completely abandoned with the loss of the original $50,000 capital and $25,000 more. The reasons given for the abandonment of this project were (1) the scarcity of fish; (2) the limited range of operation due to the hot weather. The boats could fish no further than 25 miles from the plant and land fish in condition to process; (3) "outside" fishing was found impracticable because of the shoalness of the inlets and the frequency of sudden storms; the shifting channels prevented entrance into the sounds and fishing boats caught outside were in a hazardous predicament; (4) the fish in the sounds, upon which the fisheries principally depended, were found to be very poor in yield of oil.

In spite of the adverse conditions experienced by others, a factory was built in 1870 at Oregon Inlet by the Church Brothers of Rhode Island. During the first season they employed a steamer for the operations, but in the second year they abandoned the steamer operation and attempted to carry on the fishery by small sailing vessels. At the end of two seasons the operations were suspended because of the strong current which kept the vessels from passing freely into and out of the sound. The record shows that the Church Brothers engaged in activity with a Mr. Etheridge of Roanoke Island, but does not indicate whether it was in the prosecution of the menhaden fishery or some other fishery activity.

In 1871 a factory was established at the mouth of the Cape Fear by the Navassa Oil and Guano Company. This venture lasted two years and then it was closed at a $10,000 loss because of the poor oil yield and the small amount of fish taken. In 1879 Captain I. Kain of Roanoke Island, having convinced himself by experiment that a menhaden plant could be made successful, established a plant on Roanoke Island. During his first year of operation, his venture failed because the fish did not enter the sound. What happened after the first year is not known, although a commentator writing in 1880 indicated that Captain Kain did continue for that year.

From this unpromising and discouraging beginning, the menhaden industry in North Carolina has grown to one of large proportions and now takes an important place in the economic life of the seaboard region of the State. In 1948, 198,270,000 pounds of menhaden were processed in eight plants. The value of the produce from these fish was $3,901,605. During this year North Carolina produced slightly more than 19 per cent of the quantity captured on the Atlantic and Gulf coasts, and the dollar value was nearly 18 per cent of the total value of these fish on the Atlantic and Gulf coasts.

For the nine-year period 1940-48, North Carolina produced 1,179,279,980 pounds of menhaden valued at $17,996,700. The quantity landed represented 17.28 per cent of the total of menhaden on the Atlantic and Gulf coasts, and the dollar value represented 16.6 per cent of the total money value.

Menhaden, like all other products of the sea, has shown a remarkable increase in value during the last ten years. This has no doubt come about by reason of the serious shortage of animal proteins and oils and, of course, by inflation or general rise of all prices. The last three years [2] have been very favorably affected by the decline of competition from the pilchard industry on the West Coast. Even before these inflationary conditions arose, the menhaden had been the object of one of the most important and generally profitable fisheries of North Carolina. In the country at large it has always

2. This chapter on the menhaden was written in the spring of 1949.

been recognized, since it became an organized fishery, as one of the most important sources of animal food and marine animal oils, and the world demand for fish meal seems to be insatiable. It appears likely to maintain its relative position both in the State and in the nation.

Table 3 gives the total quantities and values of the national landings and of the landings of North Carolina:

TABLE 3

Annual Landings of Menhaden for the Atlantic and Gulf Coasts and for North Carolina for the Period 1940-1948

	North Carolina		Atlantic and Gulf Coasts		N.C. Percentage	
Year	Pounds	Value	Pounds	Value	Pounds Per cent	Value Per cent
1940	129,741,480	$ 898,728	634,589,000	$ 3,999,482	20.45	22.47
1941	122,390,240	1,560,067	775,087,000	7,080,588	15.79	22.03
1942	86,202,870	1,147,728	482,644,000	6,642,928	17.86	17,28
1943	116,557,220	1,633,196	615,554,000	8,717,635	18.94	18.73
1944	116,928,400	1,517,201	685,980,000	8,749,826	17.05	17.34
1945	142,209,510	1,865,819	759,074,000	11,202,127	18.74	16.66
1946	139,531,520	2,816,014	916,013,000	17,716,625	15.23	15.90
1947	127,448,740	2,656,342	948,156,000	22,336,212	13.44	11.89
1948	198,270,000	3,901,605	1,007,889,000	21,693,093	19.67	17.99
Total	1,179,279,980	$17,996,700	6,824,986,000	$108,138,516	17.28	16.64

In spite of this contribution to the economics of the fishing industry, and hence to the general economy of those seaboard states where it constitutes an important fishery, it has never been the object of serious investigation. Neither the Federal Government nor the states have undertaken a study of the habits of the fish, its migrations, or its potentials. Since most such studies on other fishes in recent years have been directed towards conservation measures, it would appear that little will be done so far as the menhaden is concerned until either the cry is raised that the stock is being depleted or that the menhaden fishery is threatening the life of some other fishery.

NAMES AND CLASSIFICATIONS

SPECIES AND THEIR SCIENTIFIC NAMES

There are seven American species of the menhaden genus *Brevoortia.* Two of these are South American forms, *B. pectinata* and *B. aurea;* three species occur in the Atlantic Ocean, *B. tyrannus, B. smithi* and *B. brevicaudata;* two appear in the Gulf of Mexico, *B. patronus* and *B. gunteri.* There is no intermingling by those species, which are separated geographically, and the range for each, while over broad areas, is strictly limited to given boundaries. For instance, the South American species never appear in the northern waters, the Gulf species never leave the Gulf, and the three Atlantic species remain in the Atlantic limited in their southern range by the east coast of Florida. Hildebrand (1919) ascribed to *B. aureus* a range as far north as Beaufort but later (1941) corrected this error by naming as *smithi* the species formerly identified as *aureus.*

B. patronus, closely related to *B. tyrannus* of the Atlantic, ranges from Tampa, Florida, to Brazos Santiago, Texas. *B. gunteri* ranges from Grand Isle, Louisiana, to the mouth of the Rio Grande. *B. smithi* ranges from Indian River City, Florida, to Beaufort, North Carolina, while *B. brevicaudata* is known only locally at Noank, Connecticut. *B. tyrannus* ranges from Florida to Nova Scotia.

While specifically different, *tyrannus* of the Atlantic and *patronus* of the Gulf are closely paired as are *smithi* of the Atlantic and *gunteri* of the Gulf. The ranges of these two pairs are believed by Hildebrand (1948) to have been at one time continuous but were made discontinuous when the last water passage across Florida between the Atlantic and the Gulf was closed. Passage around the peninsula is prevented by unsuitable conditions, and no menhaden of any species are found in the waters of southern Florida. Before this isolation of the two pairs occurred, *tyrannus* and *patronus* were probably identical, as were *smithi* and *gunteri:* Local conditions seem to have produced species differentiation (Hildebrand, 1948).

Of the Atlantic species, *B. tyrannus* only is of commercial significance; *brevicaudata* appears only at Noank, Connecticut; and *smithi,* according to Hildebrand, is not known to school. There are apparently exceptions to this conclusion of Hildebrand, for Harrison (1931) reports that while they are seldom seen in large schools, considerable quantities of the species were taken in the Beaufort area in 1929.

Of the five North Amercan species, *tyrannus* is the most important commercially, over 73 per cent of the 1948 catch of 1,007,888,840 pounds being taken in the waters of North Carolina, Virginia, Delaware, New Jersey, and New York and consisting of *B. tyrannus.* A part of the South Carolina and Florida catch also consisted of *B. tyrannus,* but the lumped figures do not permit of a breakdown. Except where otherwise noted, from this point on, the present study is concerned only with the species of greatest industrial importance, *B. tyrannus.*

COMMON NAMES

Brevoortia tyrannus probably has more common names than any other fish; and although it is universally known as the *menhaden,* the local names remain familiar and almost affectionate appellations. Perhaps regional and sectional pride has something to do with this resistance to change, for the names are strictly regional; and when there is an encroachment of a foreign name, it can usually be traced to the presence of outsiders in a local fishery. For instance, *menhaden* is not the common name of the fish south of Rhode Island; yet we find it common in Florida. The fishery in Florida was developed late by Northern shad fishermen. The same is true in Maine, where the common name is *pogy;* yet an equally acceptable name is *menhaden,* introduced there by Rhode Island fishermen who carried their local names. The name *menhaden* is endemic to southeastern New England and the fish is recognized there by this name only.

In Maine and Massachusetts *pogy* and *menhaden* are the most common names. Southern Massachusetts and Rhode Island favor *menhaden* almost exclusively. Fishermen of Connecticut lean to *bony-fish,* as do those of certain sections of Long Island. Fishermen of the New York City vicinity and along the New Jersey coast know the fish as *mossbunker* or *bunker.* In Maryland and Virginia it is known as *alewife,* probably a corruption of *allizes,* a colonial name used in common with *shadd,* another name for menhaden that has held through the centuries and which is still used in some places (Goode, 1879, 1884). In North Carolina the fish is known as *fatback* and *shadd,* both of colonial origin (Lawson, 1709).

Each of the names is derived from some physical characteristic, resemblance to other fish or functional use. *Bony-fish* and *hardhead* refer to the heavy bony head. The names *bug-fish* and *bug-head,* common in Virginia, allude to the parasite, *Oleucira praegustator,* which is generally present in the mouths of menhaden in the south. *Menhaden* and *pogie,* from *poghaden,* are Indian names meaning fertilizer; and *shadd* is an Indian name from the Indians of Virginia. *Fatback,* common in North Carolina, refers to the smooth plump back of the fish when it is in a well-nourished condition. The southern New York and New Jersey *mossbunker* is a name given by the early Dutch settlers who saw in the fish characteristics which recalled to their minds a fish native to their homeland, the *marshbanker.*[3]

Other names for the menhaden are: *porgie, yellow tail, yellow-tail shad, shiner, herring, greentail, hard-head shad, old wife, chebog, bughead,* and *bunkers.*

NATURAL HISTORY

DISTRIBUTION AND MIGRATIONS

Menhaden are seasonal migrants north of Virginia, appearing along the New Jersey coastline and northward only after the spring warming of the ocean. In the Chesapeake region, according to Hildebrand and Schroeder

3. The "scad," or horsemackerel, *Trachurus lacuta,* which visits the shores of north Europe in immense schools swimming near the surface.

(1928), they are sometimes found in winter by trawlers in deep waters. From Wimble Shoals to the South Carolina line and in Florida waters, menhaden are year-round inhabitants and are present in North Carolina in sufficient abundance to support a fishery ten months of the year. February and March are normally shut-down and overhaul periods in North Carolina plants, although there is some evidence to indicate that fish are present in sufficient amount off the North Carolina coast to be landed in commercial quantities. Large schools have been reported in February as far north as Wimble Shoals.

The weather, however, during February and March is so uncertain that it would make for a costly discontinuous plant operation and would also make fishing for menhaden by purse seines a hazardous occupation. The result is that there are no definitive data to indicate the abundance of fish off the coast of North Carolina during February and March. There is little information concerning the presence of fish off the South Carolina and Georgia coasts, but it is known that in Florida they are present the year around.

Along the Virginia coast and northward to Maine, menhaden make their first appearance after the ocean water has warmed up to a temperature of around 50° F. The first of the fish to arrive are only a few scattered individuals. These are the vanguard of the main invasion which does not appear until the water has reached the temperature in excess of 50° F. The fish first appear along the coast as follows: The Chesapeake Bay region, March and April; the New Jersey, New York, and southern New England region, April and May; Cape Ann, in Massachusetts Bay, middle May; and the Maine coast, the latter part of May and in June (if they appear at all). The fish disappear from these regions in reverse order, beginning their departure from the Maine coast the latter part of September and completely disappearing by the middle of October. By the middle of November the fish have all left the Massachusetts Bay region. Along the southern New England coast some strays remain until late November and December, but very few fish are found after October. The same is true of the New York and New Jersey coasts.

In North Carolina the migration pattern is an interesting one. The spring fishery usually starts in May, although sometimes in April. This fishery depends principally upon individuals which run from 6 to 8 inches in length and which are believed locally to come up from Florida. Usually these fish strike shoreward about the latitude of Fernandina, moving north and paralleling the coast, supplying a good fishery at Mayport, Florida. For the past four years, however, they have scarcely touched Mayport, and snapper fishermen working 30 miles out have reported great schools moving north. In these recent years they have struck first off the South Carolina coast about Georgetown and are called in North Carolina the "Georgetown-flats" fish.

These fish support the fishery in North Carolina until August, when they disappear.

About October 15 a run of fish appears in North Carolina from the north and is joined by fish from the southern sounds and estuaries. These fish run from 10 to 12 inches in length and are known locally as "Chesapeake Bay" fish, "holy jumpers" or "forerunners." They contribute to the fishery about a month and are followed about November 10 by the so-called "Delaware" fish, which measure from 13 to 16 inches. These fish, in turn, are succeeded about Thanksgiving by 16-to-20-inch fish recognized as the "Boston Bay" or the "Amagansett" fish. All of the fish appearing from October 15 to November are following a north-south migration route. In former years both the "Delaware" and the "Boston Bay" fish were taken at Southport, but for the past fifteen years they have rarely appeared south of New River Inlet, at about which point they make a southeasterly course for the open ocean.

In December there comes a run of small fish which, according to the fishermen and plant operators, "just come." Their source or destination is not known. The average size of this fish is the smallest of all those taken in the fishery. The schools are of mixed sizes, which is unusual, and fish from 2 to 10 inches appear in the same haul. Further, a boatload shows the greatest admixture of menhaden and food fish that is found at any time of the year.

It is a moot question what causes the migration of menhaden; but the generally accepted theory, which is the oldest one, is that they appear along the coastline when the temperature of the water has reached 50° F. and that they leave when the temperature falls below this. Their appearance in the Gulf of Maine and their westerly progress from south to north in the Gulf closely parallels the warming of the waters to 50° F. Off the North Carolina and Florida coasts, where menhaden are year-round inhabitants, the average monthly surface temperature is 50° F. or above. Directly to the north and south of North Carolina it falls below this in mid-winter. Fish appear in the greatest abundance only after the water has warmed above 50° F. It is generally believed that the fish, departing from a given region, make for the deeper waters nearest to that region where the desired temperature is to be found; but there is "fishermen" evidence to indicate that long coastwise migrations to the north in the spring and to the south in the winter are the rule. Smith (1896), describes the route of departure from the Massachusetts Bay region as around Cape Cod and along the shoreline to the eastern end of Long Island and thence to sea. Fishermen are reported to have followed menhaden from the Long Island coast to Delaware; and at Beaufort, North Carolina, it is commonly accepted as a fact that the schools which leave the Delaware coast in the fall are continuously fished down the coast to this area. This question will not be settled until tagging experiments are undertaken.

Such an investigation would present relatively little difficulty if advantage were taken of the recent developments in abdominal tagging and magnetic recovery of the tags.

Although the menhaden makes its annual appearance along the entire Atlantic coast, the routes of migration, local appearance, and abundance are variable. In some cases the fish have been known to abandon completely waters that they had hitherto visited in great numbers. In other cases the abundance shows the fluctuation in population that is common to all the sea fishes. Fowler (1906) says that menhaden were present on the New Jersey coast along Cape May in goodly numbers but not in the abundance of former years.

Mr. William Gaskins of the Wallace Fisheries, Morehead City, North Carolina, has told the writer that the Mayport fishery on the Florida coast has been a virtual failure for four successive years. The fish which have ordinarily supplied this fishery did not strike into the coast at the usual points but passed by many miles at sea moving to the north. Mr. Gaskins also reports that a fall fishery off Beaufort, North Carolina, was supplied with fish which first made their appearance at Wrightsville Beach, North Carolina, and moved north until they encountered schools of southbound fish which they joined and reversed their northward movement. This fishery was productive in the Beaufort–Morehead City area until about 1925, but since that time none of these northbound fall fish have appeared. Above, in a discussion of the so-called "Boston Bay" and "Delaware" fish, it has already been pointed out that these fish now forsake the coast about New River Inlet and move to the open ocean. Eighteen years ago, this fall run of fish supported an active fishery at Southport which is no longer existent.

Mr. George Wallace of the Wallace Fisheries, Morehead City, North Carolina, says that prior to fifteen years ago the appearance of the spring run of menhaden in large quantities could be regularly depended upon to strike in abundance in April. These fish have not made an appearance in any numbers since 1933.

The classic example of the abandonment of a fishing ground is that off the coast of Maine. The menhaden fishery was first established in Maine about the middle of the nineteenth century and prospered greatly for a number of years, although at times the fish failed to appear in as great abundance as usual. Over the years, however, they did come in sufficient numbers to justify continuous plant maintenance and operation, but in 1904 they completely disappeared, and, according to Bigelow and Welsh (1925), the appearance of menhaden north of Cape Cod between 1904 and 1921 was an extremely rare event. Within the last year or two they have showed signs of returning, and recently there is considerable talk of reviving the menhaden fisheries of Maine. Bigelow and Welsh (1925) describe in a very interesting manner the fluctuations of the menhaden in the Gulf of Maine, and it is worth while to quote the following:

> Perhaps the most interesting aspect of the occurrence of the menhaden in the Gulf of Maine is that it fluctuates tremendously in abundance from year to year, periods of great plenty alternating with periods of scarcity or entire absence from our waters. Thus 1845 was a "big year," while in 1847 pogies were very scarce. Then for some years prior to 1875 they were tremendously abundant off the coasts of Massachusetts and Maine every summer, and a considerable menhaden fishery grew up on the Maine coast. Since then the local stock has undergone the most violent fluctuations imaginable, of which abundant testimony is to be found in the files of the Bureau of Fisheries. Thus very few menhaden were taken in the Gulf during the cold summer of 1877 until September and October when they were reported as about as abundant as normal. Practically none appeared north of Cape Cod in the year 1879, as striking an abandonment of a considerable area by a fish previously abundant there, perhaps, as has taken place within recent times.

The following is a summary taken from Bigelow and Welsh (1925) showing the years of abundance and scarcity:

1845	Abundant	1890	Plentiful
1847	Scarce	1892	Fish disappeared
1875	Abundant	1894	Abundant
1877	Very scarce until September and October, when they became abundant	1895–97	Scarce
		1898	Abundant
		1902	Scarce
1879–85	Extremely scarce	1903	Abundant
1886	Abundant	1904–21	Extremely rare north of Cape Cod
1888	Plentiful	1922	In great abundance in southwest Massachusetts Bay
1889	Plentiful		

These fluctuations are no doubt controlled by biological factors such as temperature and food. It seems to be the consensus that the primary factor is temperature, particularly where complete abandonment or severe diminution in numbers is concerned. Other conditions, however, are known to affect the local movements of menhaden. It is a common occurrence for inept or greedy fishermen to break up schools, causing them to sound or to run to open sea.

Natural enemies also affect the local movements of menhaden. Friedlaender relates in September, 1882, that very large bodies of menhaden appeared along the Long Island coast between Fire Island and Rockaway Inlet. He attributes the presence of this mass of fish in this area to the abundance of sharks which had driven them in.

Smith (1896) cites two interesting cases where bluefish apparently affected the migration of menhaden, one case in Long Island Sound and another off the North Carolina coast. He reports that menhaden were held in Gardiner and Neapeague bays several weeks beyond their usual date of departure by remarkable quantities of bluefish which were present in the ocean. He relates that about October 21 the bluefish disappeared and that "the departure of the menhaden rapidly ensued." By the middle of November the menhaden had largely withdrawn from Chesapeake Bay, and all schools were moving south. On November 16 the "J. W. Hawkins" observed fish swimming rapidly northward. Twenty miles farther south a large school of bluefish was encountered. For a week the northward migration of menhaden and bluefish was observed. It is assumed that the northbound bluefish intercepted the southbound menhaden causing them to reverse their direction.

BREEDING HABITS

EGGS AND SPAWNING. In spite of the appearance of the menhaden every year along the entire Atlantic coast from Florida to Maine, their breeding habits were not well understood until comparatively recently. Various theories were advanced from time to time, which had the menhaden spawning from the headwaters of tributaries to the Gulf Stream, on the shoals off Georges Banks, and all the way to the Florida Keys, where it is now known the Atlantic menhaden never appear. Even now, knowledge concerning the spawning of the menhaden south of the Chesapeake Bay region is confused or nonexistent.

For certain sections of the coast, however, the time, period, and conditions of spawning have been well worked out. In general, it may be stated that menhaden spawn all along the Atlantic coast from Florida to Maine, the time of spawning varying with the latitude. Menhaden spawn in the Gulf of Maine in the summer and probably in late spring. In the Vineyard Sound area they spawn in the summer as early as June and through October (Kuntz and Radcliffe, 1917). In Long Island waters the season extends from late May to October (Perlmutter, 1939). Westman and Bidwell (1948) say that spawning begins in Raritan Bay and lower New York Bay in April, and increases to a maximum in June. In the Chesapeake Bay area Hildebrand and Schroeder (1928) find that spawning occurs in the fall. Hardcastle (1946) concludes that spawning off North Carolina occurs in late winter and in the vicinity of the Gulf Stream. He found fully ripe ova in December but reports that ripe specimens are seldom seen, that when the fish approach maturity, they disappear, and when seen again, are spent. Reporting on the observations of local fishermen, he says that in late winter great schools are occasionally seen in the Gulf Stream area churning the water and making it white with spawn. South of North Carolina no definitive data have been disclosed as to the time of spawning. Hildebrand and Schroeder, on the basis of larvae varying in size from 27 mm. in January to 46 mm. in May, concluded that menhaden spawned in the Chesapeake in the fall of the year.

The most extensive and complete investigation on the spawning of menhaden has been done in Long Island waters by Perlmutter.

He places the spawning time from May to October with the height in May. The season is prolonged and spawning apparently very prolific. Perlmutter found that the eggs of the menhaden represented a large proportion of the total egg catch of all species collected in 1938. Perlmutter established a wide latitude in both temperature and salinity conditions. He found spawning freely taking place between 55° and 80° F., and a salinity from 84 to 100 per cent sea water. Since the incubation period is short (Bigelow and Welsh, 1925), there must be a high tolerance to temperature and salinities or a great mortality must result. Since Perlmutter found both larvae and eggs under the reported conditions, it may be concluded that the tolerance is high.

According to Bigelow and Welsh (1925) sexual maturity is attained in the season following the third winter. The sexes are not distinguishable by external characteristics (Hildebrand and Schroeder, 1928). In one specimen reported (Goode, 1884), 150,000 eggs were found. Hardcastle (unpublished manuscript) has found over 41 per cent of the mature and immature males to be infested with a gonadal parasite, *Eimeria brevoortia*. In some cases 100 per cent of the mature males have the parasite. Hardcastle does not indicate whether or not sterility results.

EMBRYOLOGY. The eggs are buoyant, highly transparent and 1.4 to 1.6 mm. in diameter. The perivitelline space is very large, resembling the shad and European pilchard eggs. The yolk sphere is approximately 0.9 mm. in diameter and contains a transparent oil globule 0.12 to 0.14 mm. in diameter. The egg membrane is thin and horny (Kuntz and Radcliffe, 1917).

Welsh found by experiment that the incubation period does not exceed 48 hours (Bigelow and Welsh, 1925). The newly hatched larvae are approximately 4.5 mm. long and slender with yolk sac attached. The pigmentation is less than before hatching, and small black chromatophores appear on dorsal aspect of the body and on ventral aspect posterior to vent.

Four days after hatching, the larva is 5.7 mm. in length. In the 9 mm. fish the dorsal and ventral fins begin to differentiate and the posterior gut has become distinctly convoluted. At 23 mm. all fins are well differentiated, but the body is still slender, and at 33 mm. scales appear. The fish remains slender. At 41 mm. most of the characteristics of the adult have appeared. The body proportion has been acquired and the shoulder blotch is distinct (Kuntz and Radcliffe, 1917; Bigelow and Welsh, 1925).

In the young larval and fry stages the menhaden are very similar to the herring and almost indistinguishable, but according to Bigelow and Welsh (1925), the differentiation of appendages and similarity to the adult occurs at a much smaller stage in the menhaden, a menhaden of 20 mm. length in this respect being far more advanced than a herring at 35 mm.

THE YOUNG OF MENHADEN. Very little work has been done on the young of the menhaden, although its rate of growth for the Gulf of Maine seems to have been reliably and adequately worked out by Bigelow and Welsh (1925). They found that menhaden that were spawned in the summer attained a length of 2¼ to 3¼ inches (6-8 cm.) the first winter and averaged slightly more than 6¼ inches (16 cm.) the second winter, while those spawned in the fall grew to 1¼ inches (3 cm.) the first winter and 5 inches (13 cm.) the second. Between these extremes there are all gradations depending upon the exact time of spawning. Hildebrand and Schroeder (1928), writing of the Chesapeake area, give slightly different values. They rate the first-year-old fish at 5⅛ inches and the second-year-old fish at 8½ inches.

The young fish apparently have a very high tolerance of salinity and temperature, seemingly enjoying an environment that varies from slightly brackish water to one with the salinity of sea water. They are found forty-five miles up the Hudson River (Westman and Bidwell, 1948) and at the same time in Long Island Sound. Their tolerance of temperature is apparently greater than that of the adult. Bean (1903) found that adult menhaden could not survive in an aquarium if the water dropped below 50° F. On the other hand, Kendall (1910) reports on observations by Edwards in which young menhaden 2 to 6 inches long survived without harmful effects a temperature of 31.5° F. They swam on their sides at 30° F. and died only "when it became much colder and snowed."

FOOD AND FEEDING

FOOD. Before 1894 it was generally believed by laymen and scientists that menhaden subsisted on mud and silt, although as early as 1879 the engineer on a menhaden steamer observed and pointed out that menhaden "feed on floating crustaceans" (Goode, 1879). In 1894 Peck published the findings of observations made by him the previous year at Woods Hole, Massachusetts. The work of Peck is important for it positively identified the food of the menhaden and established the menhaden as one of the prime converters of basic food.

Peck's investigations were complete and thorough. He examined the stomach contents of the fish and, by means of the devices available at the time, explored the waters in which the menhaden fed. He also estimated the speed at which the fish moved through the water, calculated the volume of water strained, and examined and described the gill mechanism by means of which they were able to filter out the microscopic plants and animals which serve as their food.

He found that the food of the menhaden consisted, not of bottom mud and silt as had been supposed for thirty years, but of small microscopic plants and animals which lived in the upper few feet of the waters in which the menhaden lived during its annual inshore migrations.

The menhaden is an indiscriminate and non-selective feeder, whose dietary consists of whatever of suitable size the waters in a given locality and at a given time afford. A close parallel, both as to quality and quantity, was found between the stomach contents of the menhaden and the contents of nets towed in the waters from which the fish were taken. Although the diet varied from place to place and from time to time (night or day), the food consisted of small annelids, sometimes ½ inch long, rotifers, small crustacea, amphipods, schizopod shrimp, ostrocods, peridinia, diatoms, foraminifera, and several larval forms. Ordinarily diatoms and small crustacea predominated as would be expected, since they are the most plentiful members of the microscopic pelagic life. In this respect the menhaden is different from most of the fish in the sea. Its catholic and non-discriminating taste distinguishes the menhaden as strongly exceptional, if indeed not unique, among the fishes of the sea. Most fishes exercise a certain selectivity in eating, changing their diet from season to season and from place to place. Among the pelagic feeders, the mackerel and the herring, the latter a close relative of the menhaden, are strongly selective, the herring often disappearing from waters in which its desired food is not present. Cheng (1941) compares the herring to the menhaden in this respect, pointing out that the herring, "unlike the menhaden, selects its food by individual acts of capture"; and Lebour (1920) has demonstrated the highly selective feeding habits of fishes.

MECHANISM OF OBTAINING FOOD. The menhaden strains these microscopic and near-microscopic plants and animals from the sea water by means of a very efficient sieve located in its mouth and throat. The gills of the menhaden are equipped with a set of comb-like, long, slender gill-rakers, lying parallel and very close together, each raker itself being a comb of still finer teeth. The entire mouth cavity is coated with mucus. As the fish swims through the water, his mouth open and opercula distended, the water, laden with microscopic plants and animals, passes through this fine sieve. The animals and plants become entangled, are coated with mucus, and then are swallowed or forced down the throat into the stomach. This straining device is as efficient as any devised by man. Bigelow (1928) aptly compares the filtering mechanism of the menhaden with similar apparatuses of other fish, ". . . nor is any other local species possessed of a filtering apparatus comparable to that of the menhaden for fineness and efficiency."

The menhaden feeds by swimming rapidly through the water with mouth agape, literally funneling the water through its mouth and forcing it through its pectinated or comb-like gills. Schroeder (in Hildebrand and Schroeder, 1928) in his field notes recorded aboard the "Fish Hawk" graphically describes the feeding habits of the menhaden as follows:

The fish swam swiftly in circles, like the dust driven by a whirlwind; then suddenly formed in a straight line, continually rising and falling at various depths. Each time they rose their mouths were wide open, but it was not possible to see whether or not their mouths were open when they swam downward. The fish near the shore seldom "broke water," but those observed in the open swam in compact schools, causing ripples at the surface; at times hundreds of them swiftly darted a few inches out of the water, causing a noise that could be heard easily at a distance of 300 feet. One large school was seen to divide into two parts. Some schools swam against the tide and then suddenly turned back with the tide. No general direction seemed to be maintained.

Enormous quantities of water, considering the size of this fish, are filtered daily. Peck (1894), basing his calculations on the speed of the feeding menhaden and the area of its mouth opening, figured that the menhaden forced water through its gills at the rate of 6.8 gallons a minute containing about 3.4 cubic centimeters of organic filtrate. Peck points out that his figures are estimates, that the menhaden does not feed continuously, that all the water may not pass through the gills at the rate the fish swims and that many small organisms may escape. He feels, however, that his estimates are reasonable. According to these estimates, a menhaden could filter nearly a barrel of water an hour and extract about 24 cubic inches or nearly a pint of food of the richest sort. Unfortunately, no quantitative work has been done on this subject, and at best the figures remain estimates.

How much of the time a menhaden feeds is not known, although Peck's observations indicate that it feeds at some time both night and day. That it is a voracious feeder or an efficient converter must be admitted, for it appears off the coast in an emaciated condition, and in a very short time it is fat and well nourished. It has the richest fare at its disposal that can be found in nature at sea or on land and, according to Bigelow (1928), subsists entirely and for life on this fare: "Outside the littoral zone the menhaden is the only important Gulf of Maine fish that continues throughout life to subsist chiefly on diatoms and peridinians with the most minute crustacea and other animals.

"The menhaden has no rival among the fishes of the Gulf of Maine in its utilization of this pelagic vegetable pasture." In writing this Bigelow compares the menhaden with other eaters of the pelagic flora, such as the herring and mackerel. What is true in the Gulf of Maine must be true along the entire Atlantic seaboard, and we find the menhaden seeking those inshore waters which are made up of oceanic waters and the rich outpourings of rivers and estuaries. It is no wonder that the menhaden is one of the richest sources of oil of all sea forms. It has no equal on our Atlantic coast and has only the pilchard sardine as a close rival in Europe and the anchovy on the Pacific coast.

The relationship of the type of food to the oil production of menhaden has received no attention from scientists. It is a fact recognized by all fish curers and herring fishermen that the food of the herring directly affects the quality and quantity of the oil. If the herring has been feeding heavily on copepods and euphausiids (tiny crustaceans), they will be found in prime condition for curing and salting. If, on the other hand, the diet has consisted chiefly of pteropods (small mollusks), the fish is watery and the curing poor. Norwegian fishermen recognize this fact and often "pen" the fish until they are cleansed (Kyle, 1926). The quality, as well as the quantity, of the food of the menhaden may readily account for poor oil yield during a season and period where in previous years it was good.

The food of the small menhaden appears to be identical in character with that of the adult, although the very small menhaden possesses teeth (Hildebrand, 1948), the significance of which is not known.

ENEMIES

Menhaden is the prey to virtually all of those carnivorous fishes which inhabit the same waters as the menhaden. In New England it is eaten by the whiting, codfish, pollock, dogfish, shark, tuna, whale, and even the flounder. In the more southern waters it is eaten by the pompano, cavally, bonito, and bayonet-fish. Along the entire coast wherever they are found in common with menhaden, the striped bass, swordfish, weakfish, or sea trout, and dolphin destroy and consume them. They are attacked and eaten in rivers, particularly southern rivers, by gar-fish and catfish.

Of the enemies, the whales, dolphin, shark, tuna, bluefish, and weakfish are the most destructive. As many as one hundred individuals have been taken from the stomach of one large shark, and Dr. Goode says that the whales and dolphins consume them by the hogshead. From the air, predatory sea birds attack the schools, and it is not unusual to see gulls riding the schools and enjoying a feast.

The quantities in which they are eaten or destroyed by their natural enemies is prodigious. Dr. Goode estimates that the number of menhaden annually destroyed by natural enemies amounts to a million million of millions, or put differently, 1,000 times the number taken by man in 1948, let us say, when the greatest capture on record was made.

Of all the enemies, bluefish are the worst and the most savage foe. Not only do they devour great numbers but after gorging themselves they continue to kill and destroy, often driving menhaden into the surf, by which they are thrown on the beach in windrows, sometimes to a depth of two feet or more, where their decaying bodies foul the shore and air for weeks. On occasions when this stranding of menhaden has occurred near inhabited beaches or towns, it has been necessary to have them removed as a health menace. There are reports from Hatteras, North Carolina, to the coast of Massachusetts which graphically describe this wanton destruction.

Bluefish are frequently governed in their migrations by the presence and movements of the menhaden schools, and conversely, menhaden disappear as quickly as possible with the arrival of bluefish. Bigelow and Welsh (1925) say that they may actually drive menhaden from their customary grounds.

EFFECT OF THE MENHADEN FISHERY ON OTHER FISH

Periodically the menhaden industry becomes the object of controversy. No fishery of modern times has been attacked by so many, over such a wide area, so violently, and from so many angles. The agitation centers around the presumed destruction of commercial food fish and sports fish, the interference with the normal routes of spawning migration of all fish, the ruination of sports fishing grounds. The testimony and arguments on both sides are sometimes bitter and violent and ordinarily are characterized by the absence of exact data on which to base them. Until 1894 no recorded observations had ever been made; and since that time none has been made which has come to the attention of this writer.

In 1894 the U. S. Fish Commission put observers on two boats which operated the full season from the Maine coast to Cape Lookout, North Carolina. A total of 946 productive seine hauls were made, and the catch recorded. In all, 60 species of fish were taken. The surface swimmers predominated, and of these (excluding menhaden) bluefish, alewives, shad, butterfish, and mackerel were the most prominent. Some bottom dwellers such as skate, cod, pollock, hake, and haddock were taken in shoal water.

Altogether a total of 28,060,505 fish were taken among which there were 27,965,755 menhaden and 93,893 fish commonly considered food fish. Of these food fish 86,000 were alewives, which are also used for oil and fertilizer; and 6,990 more prized and high priced food fish. Of these latter there were 2,274 bluefish, 1,816 shad, 800 butterfish, 631 common mackerel, 150 spanish mackerel, 3 cero, 35 bonito, and 500 squeteague. Of the demersal fish, or bottom dwellers, there were 1 cod, 1 pollock, 33 haddock, 40 hake, and 30 whiting (Smith, 1896).

These figures have been challenged, but it is presumed that the investigators were competent and the ability and integrity of the author of the report are beyond question. It is surprising, however, considering the range of the two vessels that so few species are represented in the catch. It is also surprising to find that so few of the natural predators of the menhaden such as sharks (388), bluefish, and squeteague were taken, although it should be borne in mind that the predators are not necessarily mixed intimately among the individuals of the fish schools. If, however, the figures are taken as reliable, they would mean that at this rate, in a banner year such as 1948 when 1,504,311,700 menhaden were landed, a total of food fish of approximately 375,000 of other fish were caught with the menhaden, that is, if alewives, which are not esteemed as a food fish and which are frequently reduced for their oil and meal or sold as bait, are not included. Of this 375,000 total, about 120,000 would be bluefish, 47,000 shad, and the remainder butterfish, common mackerel, squeteague, spanish mackerel, bonito, cero, etc. Since a good many of the food fish, probably most of them, are eaten by the crew, carried home or sold as food fish, there seems little to be alarmed about.

BIBLIOGRAPHY

Bean, Tarleton H.
1903. The Food and Game Fishes of New York. Notes on their common names, distribution, habits and mode of capture. Albany: J. Lyon & Co., 1903, p. 251-460, 2 pls. New York State Forest Fish & Game Comm'n.

Bigelow, Henry B.
1928. Plankton of the offshore waters of the Gulf of Maine. Bull. U. S. Bur. Fish., Vol. XL, Pt. II, 1924 (1928), p. 1-509, 134 figs., extensive bibliog.

Bigelow, Henry B., and William W. Welsh.
1925. Fishes of the Gulf of Maine. Bull. U. S. Bur. Fish., Vol. XL, Pt. I, 1924 (1925), 567 p., 278 figs., extensive bibliog.

Cheng, C.
1941. Ecological relations between the herring and plankton off the northeast coast of England. Hull University College; Hull Bulletins of Marine Ecology. Vol. 1, No. 5, Sept. 1941, p. 239-254.

Earll, R. Edward.
1887. North Carolina and its fisheries in 1880. *In* Goode and associates (1884-87) (which see below), Sec. II, Pt. XII, p. 475-497.

Fowler, Henry W.
1906. The Fishes of New Jersey. Ann. Rept. New Jersey State Museum, Pt. II, 1905 (1906), p. 35-477, 103 pls.

Friedlaender, Oscar O.
1883. Notes on the menhaden fishery. Bull. U. S. Fish Comm., Vol. II, 1882 (1883), p. 252.

Goode, G. Brown.
1879. The natural and economical history of the American menhaden. U. S. Comm. of Fish and Fisheries, Pt. V, Rept. of the Comm'r. for 1877 (1879). Appendix A, xii + 529 p., 31 pls.

1884. Food fishes of the United States. *In* Goode and associates (1884-87) (which see below), Sec. I, Pt. III, p. 163-682 (menhaden p. 569-577).

Goode, G. Brown (and a staff of associates).
1884-87. The Fisheries and Fishery Industries of the United States. V

Sections (7 volumes), Sec. I, Text and Plates, 1884; Secs. II, III, IV and V, (Vols. I and II and Plates), 1887, U. S. Comm. of Fish and Fisheries.

Goode, G. Brown, and A. Howard Clark.

1887. The menhaden fishery. *In* Goode and associates (1884-87) (which see above), Sec. V, Vol. I, text, Pt. V, p. 327-415.

Hardcastle, Aaron Bascom.

(1946) The Genus *Eimeria* with special reference to the species parasitic on marine fish. Unpublished ms. in Library, Duke University Marine Station, Beaufort, N. C.

Harrison, Roger W.

1931. The menhaden industry. U. S. Bur. Fish., Investigational Rept. No. 1, Vol. I, 1931, 113 p.

Hildebrand, Samuel F.

1919. Two species of menhaden occurring on the coast of North Carolina. Rept. U. S. Comm'r. Fish. for 1918 (1920), Appendix VI, 8 p., 2 figs., 1 pl.

1941. An annotated list of salt and brackish water fishes, with a new name for a menhaden, found in North Carolina since the publication of The Fishes of North Carolina, by Hugh M. Smith in 1907. Copeia, 1941, No. 4, p. 220-232.

1948. A review of the American menhaden. Smithsonian Inst., Misc. Coll., Vol. 107, Mar. 22, 1948, No. 18, 39 p. Pub. 3913.

Hildebrand, Samuel F., and William C. Schroeder.

1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish., Vol. XLIII, Pt. I, 1927 (1928), 366 p., 211 figs., glossary, extensive bibliog.

Kendall, W. C.

1910. Effects of the menhaden and mackerel fisheries upon the fish supply. [Proc. Fourth Int'l Fish. Cong. Washington, 1908]. Bull. U. S. Bur. Fish., Vol. XXVIII, Pt. 1, 1908 (1910), p. 279-293.

Kuntz, Albert, and Lewis Radcliffe.

1917. Notes on the embryology and larval development of twelve teleostean fishes. Bull. U. S. Bur. Fish., Vol. XXXV, 1915-1916 (1918), p. 87-134, 126 figs.

Kyle, Harry M.

1926. The Biology of Fishes. New York: The Macmillan Company, 1926, xvi + 396 p., illus., pls.

Lawson, John.

1709. History of North Carolina, by John Lawson, Gentleman (being a reprint of the copy now in the North Carolina State Library, Raleigh. Presented by President James Madison in the year 1813). Charlotte Observer Printing House, 1903.

Lebour, Marie V.

1920. The food of young fish. No. III (1919), Jour. Mar. Biol. Ass'n. of the United Kingdom, n.s. Vol. XII, No. 2, July, 1920, p. 261-324.

Peck, James I.

1894. On the food of the menhaden. Bull. U. S. Fish Comm., Vol. XIII, 1893 (1894), p. 113-126, 8 pls.

Perlmutter, Alfred.

1939. A biological survey of the salt waters of Long Island, State of New York. Dept. of Conservation, Part II, Supplemental to Twenty-eighth annual report, 1938 (1939), 17 p.

Smith, Hugh M.

1896. Notes on an investigation of the menhaden fishery in 1894, with special reference to the food-fishes taken. Bull. U. S. Fish Comm., Vol. XV, 1895 (1896), p. 285-302.

Westman, James R., and Milton H. Bidwell.

1948. Waste disposal and fisheries of the salt waters adjacent to the Greater New York metropolitan area. New York State Dept. of Conservation, mimeograph report, Freeport, N. Y., Dec. 1948.

THE EDIBLE FINFISHES OF NORTH CAROLINA

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CONTENTS

ALEWIVES

Pomolobus species

The alewife fisheries along the Atlantic coast are supported by two species: the "true" alewife, "branch herring," or "goggle-eye" (*Pomolobus pseudo-harengus*), and the "blueback," "glut herring," or "school herring" (*P. aestivalis*). These two species have overlapping ranges, the former being taken from Nova Scotia to the Carolinas, and the latter also from the Bay of Fundy, but mainly from Chesapeake Bay to Florida. The North Carolina fishery therefore includes both species, but the school herring is the more important. Although the fishermen recognize the different species (the goggle-eye is known as the forerunner of the shad) no distinction is made in the commercial catch.

The principal Atlantic coast alewife fisheries are found in Chesapeake Bay and North Carolina's Albemarle Sound region. Smaller fisheries exist in New England and Florida. Only a small portion of the fish harvested are eaten fresh, the bulk being salted or otherwise cured. Some of the roe is canned. By-products from the fishery include scrap for fertilizer, oil, and pearl essence from the scales.

Nearly all the alewives caught in the State are taken from the Albemarle

Sound region, and particularly the Chowan River. Other rivers discharging into the sound also yield small quantities, as do the Pamlico and Neuse rivers. None are marketed south of Carteret County. Alewives are taken in pound nets, haul seines, and gill nets. The season is a relatively short one, occurring in late March, April, and early May.

The alewife is anadromous, i.e., it lives in salt water but migrates into fresh-water rivers and streams for the purpose of spawning. The time of its spawning migration in a given locality is regular from year to year. In the Albemarle Sound region, the first run usually occurs in late March or the first half of April. A number of Albemarle Sound fishermen say that the largest runs "almost always start on the Monday following Easter Sunday." The goggle-eye usually arrives three or four weeks ahead of the school herring; the latter arrive with the shad. The goggle-eye also spawns farther upstream than does the school herring.

The alewife has a high reproductive capacity. The average number of eggs produced per female is given by Smith (1907) as 100,000. The adhesive eggs cling to sticks, stones, pilings, and other available material; fishermen report large numbers of eggs sticking to the pound nets. The length of time required for hatching depends on water temperature; two to six days is considered the range of the period of incubation. The young are very active and feed on other small fish, mosquito larvae, small crustaceans, insects, etc.

Insofar as is known, the adult alewife, like all members of the herring family, is a plankton feeder. The alewife, young and old, in turn serves as food for other predatory fishes which occupy the same waters. Predators in fresh water include the striped bass and white perch. Its salt-water enemies undoubtedly include the bluefish, spanish mackerel, and many others.

The young alewives spend their first summer in the fresh water, growing to a length of two to four inches by fall, at which time the water temperature drops and the young fish move downstream and into the warmer salt water. After three or four years the fish have attained adult size, are sexually mature, and ascend the rivers to spawn.

Little is known of the alewife during its stay in salt water. What happens to the adult fish after spawning is also a mystery. It is evident that they return to the ocean, since no adults are found in the rivers or sounds after completion of the spawning season. The commercial catch consists almost entirely of three- and four-year-old fish. It is not definitely known whether the four-year-old fish also spawned as three-year-olds, or whether these fish did not mature until their fourth year and are spawning for the first time.

The North Carolina alewife fishery has declined during the last 40 to 50 years. During the period 1890 to 1900 the annual production of the State was between 15 and 20 million pounds (about one-third of U. S. production). This decline is not so severe as that experienced in New England, where a number of dams and obstructions have been placed in the rivers. However, since 1900 the annual take has fluctuated considerably with a low of about 6 million pounds in 1937 and a high of nearly 15 million pounds in 1934. Such fluctuations are most probably the result of differences in abundance rather than in economic factors. The price of alewives remains nearly constant (one cent per pound) regardless of peak or lean years. Merriman (1941) has shown that in the case of the striped bass, abundance depends to a large extent on the survival rate of the young in various years; the survival rate in turn depends on conditions of temperature, wind, water flow, predation, and food for the young. Production and survival of a large number of young are then represented in the fishery in succeeding years in proportion to the age of the fish composing the commercial catch. Fluctuations in alewife production, therefore, are believed to result largely from biological and climatic factors.

SHAD

Alosa sapidissima (Wilson)

The shad, a member of the herring family, was until 1935 the most important food fish of North Carolina in terms of value. It was an important species along the entire Atlantic coast since it supported a commercial fishery in every state. The spring spawning runs were known in every suitable river from the St. Johns River in Florida to the St. Lawrence. Since the great decline in the fishery, beginning shortly before the turn of the century, the shad runs in a number of streams are of historic interest only. Several factors are involved in the collapse of the fishery; these will be discussed later.

The shad, like the alewife, is anadromous, living in salt water but ascending coastal streams to spawn. The earliest shad runs occur in Florida, beginning in November or December. These are followed, in succession, by runs in the streams in Georgia, South Carolina, North Carolina, and up the coast, the most northerly runs occurring in late May. In Albemarle Sound, North Carolina's most important shad fishing locality, the earliest shad may appear in February, but the peak of the run occurs in late March or early April. The runs along the entire coast take place when the water temperature in the rivers reaches 50° to 55° F.

It was formerly thought that the spawning migration originated from the ocean south of Florida, where all shad were believed to spend the winter. As the huge mass moved northward, groups split off to return to the streams of their birth along the coast. This theory is no longer entertained. Although the life of the shad in salt water is still not known, it is believed that the fish move offshore more or less opposite their native streams, and return to their respective sections of the coast or even to their native streams for spawning.

The shad runs are usually composed of several cycles spaced at intervals of a few days. The earliest runs consist largely of males (bucks) whereas the females (roe-shad) arrive in the later runs. The roe-shad are larger, weighing on the average at least a pound more than the bucks. The eggs are deposited over the stream bottom, sandy or pebbly shallows being selected when available. On the average, 25,000 to 30,000 eggs are produced per female, although large individuals may produce as many as 150,000. The eggs fall to the river bottom, where they remain until hatching. Many eggs, therefore, may not be fertilized, may be covered by mud or silt, and may be eaten by bottom-feeding animals.

The eggs hatch in from three to ten days; the exact time depends upon water temperature. The young feed on plankton which they obtain by means of numerous long gill-rakers, and grow rapidly during the summer. They remain in fresh water until, with the advent of cold weather in the fall, they move downstream and into the sea. By fall, they have reached an average length of three to five inches. Young individuals of seven to nine inches are not uncommon in some areas. Little is known of the growth rate of the shad after they leave the streams. They mature and first spawn at about the same age as the alewife, i.e., three or four years.

Upon completion of spawning, the adults begin their return to the sea. These fish are in poor condition because they take little or no food during the spawning migration. However, according to Atkins (in Bigelow and Welsh, 1925) they begin feeding again before reaching salt water, and so recover somewhat before going out to sea.

North Carolina is favorably situated geographically, with respect to shad, in that the shad runs occur here early in the season while the price is high. When the later large runs of the Chesapeake and other northern waters reach their peak, the price of shad drops as much as 50 per cent or more, because of the larger supply. But by this time, the bulk of the North Carolina supply has been marketed.

The history of the shad decline in North Carolina parallels that of the entire Atlantic coast. Shad were once so abundant as to be sold for fertilizer but the runs became smaller during the period 1800-1850. The earliest available records for the whole coast are for 1880, when 17 million pounds were taken. Stevenson (1899), however, gives records for the Greenfield seine fishery in Albemarle Sound from 1852 to 1896. These records show years of abundance and scarcity throughout the period, with a general increase from 1852 to 1874, a rapid decrease from 1875 to 1878, followed by a gradual increase to 1896, a year in which 50 million pounds were taken from the rivers of the Atlantic coast. It is not known whether the Greenfield records reflect accurately the picture of the entire coast, but they very likely follow the general trends in the coastal fishery. Total production dropped to 26 million pounds in 1908, and the 1940 catch was only about 12 million pounds.

North Carolina's production dropped from about nine million pounds in 1897 to less than one million in 1940. In fact, the annual production since 1930 has averaged less than a million pounds. North Carolina has produced from 8 to 15 per cent of the total U. S. catch.

Much has been said and written regarding the causes of the decline in the shad fishery. Overfishing, pollution, and dams are generally considered the three important factors involved. At first, it was thought that overfishing was chiefly responsible; therefore about 1880 a large-scale program of artificial propagation was initiated in an attempt to restore the shad population. Early indications were that the planting of small shad was accomplishing its purpose (a gradual increase in supply of adults from 1880 to 1896) but improvements in fishing methods and greater fishing intensity were not considered in accounting for such increases. Then after 1896, while planting was continued, the shad decreased at a rapid rate. Artificial propagation did little, if any, demonstrable good; at least it could not maintain the supply.

The effect of overfishing, or even the possibility of overfishing, is not completely understood. Huntsman (1944) summarizes one of the current attitudes toward overfishing (of fish in general) as follows:

> Frequently the possibility is advanced that overfishing has resulted in under-replacement of the stock through decrease in the numbers of spawning fish. Since most species have a high reproductive capacity, this does not readily occur. Exclusion of anadromous fish from their spawning grounds by impassable dams definitely prevents replacement of the stock. Conceivably, overfishing might prevent full replacement of stock, but it is desirable to have carefully documented experiments to establish the need for restriction of the fishery to assure replacement. Leaving out of account such forms as the amphibious walrus of the Atlantic and fur seal of the Pacific, which are particularly vulnerable on their breeding grounds, we have as yet been unable to learn of a clear, documented case of under-replacement through overfishing for this continent. Information on this would be welcomed. It is proposed to undertake somewhat precise experiments to determine in particular cases how many spawners are required for replacement of the stock, so that the full surplus may be taken for human use if desired.

It is also difficult to place the full responsibility for the shad decline on overfishing, in the light of the Greenfield fishery data referred to above. This fishery, as were most other fisheries, was inoperative for four years during the Civil War, 1862-1865 inclusive. If the breeding stock previously had been maintained at too low a level, this four-year period should have provided ample time to increase the stock. Yet the annual production for the five-year period following the war was only 14 per cent higher than the five-year prewar period (41,746 fish as compared with 36,609). The take for the next five-year (1871-1875) period was about the same, but the following five years witnessed a drop to 17,185 fish annually. Production since that time has never approached the period 1857-1861. Although this does not prove the impossibility of overfishing, it does show that controlled fishing may not provide the remedy desired, since if complete cessation of a fishery for a four-year period gave little benefit, controlled fishing could do no more.

The Hudson River fishery is an interesting one and should be followed closely. The shad made a surprising come-back in the Hudson in 1936, and since that time only a portion of the available shad have been taken. Production since then has been maintained at a high level, although there were indications of a decline in 1947. This fishery should be observed carefully in the future to ascertain whether limited fishing will insure a continuous high yield.

The effects of pollution and construction of dams are much more easily demonstrated and evaluated. Many streams have been ruined for shad by industrial and municipal pollution and by the erection of obstructions of various kinds. Clearing of land has resulted in erosion and silting, rendering streams unsuitable for shad spawning. Shad formerly ascended many rivers to their head waters. Stevenson (1899) reports shad fisheries in the early days on the Neuse River above Raleigh, but there are very few rivers today where the shad can reach the head waters. In other words, shad and civilization are not compatible, and it is doubtful that the shad can ever be restored to the status of colonial days, in spite of the attempts to do so by well-meaning conservationists.

In North Carolina, the upper waters of the Cape Fear, Neuse, and Pamlico-Tar rivers formerly contained important shad fisheries, but today most of the state's production comes from Croatan, Roanoke, and Albemarle sounds. A few shad are still taken from the lower regions of the rivers mentioned above but none from the head waters. The gear used in the shad fisheries is comprised chiefly of gill nets, pound nets, and seines.

THE MULLETS

Mugil species

Two species of mullet are caught and marketed under this name in North Carolina, namely, the striped or jumping mullet (*Mugil cephalus*) and the white or silverside mullet (*M. curema*). A number of other species are known, most of them being found in tropical waters of the world, but the two named above form the mullet fishery of northern waters. The jumping mullet is more abundant than the silverside in North Carolina. The former also has a more northern range, extending into the Gulf of Maine, whereas the latter is not found north of Cape Cod (Bigelow and Welsh, 1925). The local species are also found on the Pacific coast and both coasts of South America.

Some studies have been made on the biology of the mullet in North Carolina waters. Adult and young fish are found dispersed in the sounds during the summer. In the fall the fish congregate in schools and move to the inlets and apparently wait for weather conditions favorable to their moving out. Early fall runs (August and September) contain small fish less than a year old. These are followed by the year-old fish, and later in the fall (October and November) the adults school up and move to the inlets. These fish carry spawn, indicating that this is a spawning migration. The fish move out of the inlets in November and December, usually on a northerly wind (according to old-timers) and spawn in the ocean. Spawning is believed to occur in the vicinity of the inlets because within two or three weeks, young mullet are found entering the inlets. After spawning, the schools break up and some of the adult fish also begin moving into the inlets. Both the young and the old fish apparently move in and out of the inlets with the weather during the winter, and finally move into the sound in the spring.

The fall spawning migrations described above are reported from North Carolina by Smith (1907), from Florida by Hildebrand and Schroeder (1928), and from Texas by Gunter (1945). All are similar in outline but differ slightly regarding dates and extent of the spawning season.

Little is known of the growth rate of the mullet. Nichols and Breder (1926) report that the young, after the first summer's growth, have reached an average length of about two and one-half inches (standard length, measured from tip of snout to the end of spinal column). The adults may reach a length of two and one-half feet, although the average size of mullet taken commercially is less than eighteen inches. Nichols and Breder state that mullet may spawn at an age of two years.

The food of the mullet consists of a wide variety of plants and animals. Dr. Coker reports, in Smith (1907), finding amphipods, annelids, shrimp, and bivalve mullusk shells in fish examined at Beaufort, North Carolina, during June and July. However, Nichols and Breder allude to a progressive proportionate lengthening of the intestine as the fish ages, and suggest that such a change may be correlated with a change in diet from one of plankton to one containing a high percentage of higher marine plants. It is obvious, therefore, that the mullet is omnivorous and perhaps takes its food largely on the basis of availability without exercising a great degree of selection.

The mullet fishery is a seasonal one, usually of short duration. Most of the mullet are taken in seines during the period of the fall mass migration. The average annual production in North Carolina is over three million pounds. The handling and disposal of such a quantity in a space of a few weeks becomes a definite problem. The price is usually low because of the flooded market. About 95 per cent of the mullet are sold fresh; the rest are either brine-cured, salted, or filleted and packaged. A small amount of mullet roe is dried and salted. Technological studies aimed toward developing other products should be undertaken in order to spread the marketing of these species over a longer period. Development of other products might also increase the value of the fish marketed fresh by preventing gluts or overloads.

SPANISH MACKEREL

Scomberomorus maculatus (Mitchill)

Spanish mackerel is the most important member of the mackerel family in the commercial fisheries of North Carolina. It is also a highly prized sport or game fish. It is a smaller fish than its close relative, the kingfish or cero, and it is more abundant in North Carolina waters. The spanish mackerel is found along the Atlantic coast from Massachusetts to Brazil and also in the Gulf of Mexico. It attains a size of nine to ten pounds, although Smith (1907) reports a 25-pound fish from Chesapeake Bay.

The spanish mackerel is a migratory species and travels in schools. In the spring, it migrates northward from its winter habitat in the southern waters. Its winter habitat is not definitely known although Longley and Hildebrand (1941) report that the species is abundant in the vicinity of Key West, Florida, from November to April, the months when they are absent from northern waters. The size of the wintering area is unknown, but the spanish mackerel is taken in commercial quantities all around the coast of Florida, both Atlantic and Gulf, between these months of the winter period.

A migration from the winter grounds to the Gulf and one up the Atlantic coast coincide, starting in March and April. Gunter (1945) reports that spanish mackerel appear off the Texas coast in March. They spend the summer in the Gulf and begin to leave in September; they become scarce by November although a few individuals may be taken during the winter. The largest catches are made in August. The Atlantic coast migration also begins in late March and April and passes through North Carolina waters in May and early June, the latter month producing the larger catches. They do not reach New York waters until July, according to Bigelow and Welsh (1925). Very few fish are taken during the summer in North Carolina, but the southern migration in September and October supports a fall fishery. The fish have grown in the northern waters during the summer, and are larger on their return trip. The smallness of the fall catches is attributed to general adverse and unstable weather conditions during this season, but occasionally a break in the weather will permit large catches.

Spanish mackerel are believed to spawn along the entire Atlantic coast, although the principal spawning area is Chesapeake Bay. The fish, as they begin the spring migration, are ready to spawn, but all the eggs in an individual female do not ripen simultaneously, indicating that not all eggs are discharged at one time but rather are discharged at intervals as the migration proceeds. The spawning season, therefore, extends for several weeks, during which several hundred thousand eggs may be deposited. The eggs float on the surface and hatch in a relatively short time. Smith (1907) reports the hatching period to be 25 hours in water of 77°-78° F. Ryder (1882) took eggs at New Point Comfort, Virginia, and reports their hatching in 24 hours, but the water temperature is not given. The latter author observed the young actively feeding on the fourth day although the nature of the food was not determined. He reports further that teeth are developed by the end of the first week of life. The early development of teeth indicates that their carnivorous feeding habits develop very early. The adult spanish mackerel is among the most voracious feeders; it follows schools of smaller fish, apparently without regard to species.

Goode (Sec. I, Text, 1884) states that the spanish mackerel was known in New England as early as 1673, when it was clearly described and referred to as the speckled hound-fish. No further mention of this species is made until Mitchill (1815) described and named it. Goode further reports that the species was not taken commercially until 1845 in New England and somewhat later in the southern waters. He records a catch of several thousand pounds landed at Wilmington, North Carolina, in 1879, which could not be sold to local dealers because there was no market for it (the dealers believed the fish to be the horse mackerel, *Orcynus*), and the entire catch was thrown away. In the next few years the true value of the spanish mackerel was realized and the North Carolina fishery developed rapidly.

This species supports its largest fishery in Florida, where the annual take is several times that of the other Atlantic states combined. The catch in North Carolina recorded by the Federal Government since 1889 shows wide fluctuations. The production in 1889 was 63,000 pounds; it increased to about 350,000 pounds annually during the period 1897-1908, then slowly decreased to a low of 48,000 pounds in 1934. In 1936, 433,000 pounds were taken. Production since then has varied from 141,000 pounds to 507,000 pounds, the latter figure representing the 1945 catch. An indication that such fluctuations may be rather limited in area is given by Smith (1907) who reports that, during a peak in North Carolina's production, the spanish mackerel "is especially abundant in the Gulf of Mexico, about the Florida Keys, and on the coast of the Carolinas; and was once very numerous in Chesapeake Bay, but is now much less abundant than it was 25 years ago." This species seems to be subject to wide fluctuations in local abundance, but such changes do not necessarily embrace its entire range.

This fish undoubtedly occurs off the entire coast of North Carolina, but few are taken commercially south of Carteret County. Over 50 per cent of the State's production is landed in Carteret County, with Dare, Pamlico, Hyde, and Beaufort counties taking the remainder. They are taken by troll lines, hand lines, and pound nets.

BLUEFISH

Pomatomus saltatrix (Linnaeus)

The bluefish is found along the entire Atlantic coast of the United States from the Gulf of Maine southward, including the Gulf of Mexico. It is not restricted to our coast, however. According to Goode (Sec. 1, Text, 1884), it is also found in waters of Australia, Malay Archipelago, Cape of Good Hope, Brazil, Madagascar, Syria, Canary Islands, and in the Mediterranean. It apparently does not occur along the Atlantic coast of Europe, nor in Bermuda or the West Indies waters, but it occurs in commercial quantities off Uruguay and Argentina, from which it has been imported to the United States. The species is migratory, and its abundance in a given area is sporadic.

It is also known to disappear from certain waters for protracted periods. Such was the case in New England during the period 1764-1810 when no bluefish were taken. According to Goode (*loc. cit.,* 1884), bluefish were common in New England in 1672 and were abundant in Nantucket waters from 1659 to 1763. They did not appear in 1764 and were entirely absent from New England waters until 1810, when small numbers returned to New York and southern New England. They were abundant in these waters by 1825. According to Bigelow and Welsh (1925), they did not return to Cape Cod and northern Massachusetts until 1837 or 1838. From 1850 to the late 1860's they were abundant at Gloucester. Their numbers then began decreasing, and since 1889 the species has remained scarce.

The history of this species in North Carolina waters is not clear. Smith (1907) quotes Lawson (1709) as saying that they appeared in the fall in great schools on the coast and were taken by the Hatteras Indians. However, Goode (*loc. cit.,* 1884) quotes R. E. Earll as saying that the bluefish was first known in the Hatteras area in 1842, that it reached a peak between 1870 and 1876, and that from 1877 to 1880, they were much less abundant and of smaller size. Their history between 1709 and 1842, therefore, is unknown, but this account does bear out their erratic movements and fluctuations in abundance.

Very little is known of the spawning of the bluefish. It is generally agreed that they spawn offshore in early summer. A few fish in "ripe" condition have been taken in early June, but spawning fish have not been observed. However, young fish about three inches in length enter the sounds in June and July. This fact substantiates the belief in the early-summer spawning period. The young, as well as the adults, travel in schools of a particular size group. The larger fish remain in the deeper waters while the smaller ones enter the shallower coastal and sound waters. The growth rate and age at maturity are not known. The only available information is that the young reach a length of four to five inches during the first summer. The bluefish grows to a maximum size of less than 30 pounds; in fact, fish weighing over 15 pounds are rare along the United States coast.

The feeding habits are well known. Studies of the bluefish contain many references to its voracity. It has been alluded to as an animated chopping-machine, the business of which is to cut to pieces as many fish as possible in a given space of time. Reports of the bluefish leaving blood and partially eaten fish in their wake are plentiful. Various estimates of the number of fish destroyed by an individual bluefish have been made, and on the basis of such estimates, some authors have calculated the total number of fish destroyed by these killers. Such figures for one section of the coast run as large as several hundred billion. Perhaps such figures should not be taken too seriously since they have only doubtful basis on fact. From all reports, the bluefish feeds on almost any fish smaller than itself, and if its prey is too large to be swallowed, the bluefish merely eats part of it, leaving the remainder.

Bluefish are taken along the entire North Carolina coast, chiefly in offshore waters. Some are taken in Pamlico Sound. The counties landing the greatest catches are Carteret, Dare, Pamlico, Brunswick, and Hyde. Bluefish are taken in long haul seines, run-around gill nets, and stake gill nets. They are taken chiefly in early spring (March and April), although some may be taken during the summer. These summer inhabitants are generally small, one to three pounds; the larger fish are believed to move farther north or to stay in deeper water. In the fall, October to December, they become more abundant as the southern migration takes place. It is not known whether the entire coastal stock winters in the south or moves offshore more or less opposite the summer grounds. The increase in North Carolina waters in the fall, as well as the winter fishery in Florida, tends to favor the theory of a north-south migration rather than the inshore-offshore movement.

The bluefish is a highly desirable food fish, is generally in demand, and therefore brings a good price. The commercial production in North Carolina is variable, having been as high as two million pounds and as low as less than a half million pounds annually. The bluefish is an important game species, and it has been estimated that the number taken by sport fishermen in some places may equal or surpass the commercial catch.

Since the species is pelagic (living near the surface in the open ocean) and spawning occurs offshore, where the waters are not fished, it seems doubtful that fishing exerts an appreciable influence on the total population, and so no restrictions on fishing seem advisable. Periods of abundance and scarcity will undoubtedly occur, much as they have occurred in the past.

STRIPED BASS

Roccus saxatilis (Walbaum)

The striped bass (also known as "rock" or "rockfish") is found along the Atlantic coast from the Gulf of St. Lawrence southward. Jordan and Evermann (1896-1900) report it on the western coast of Florida (Gulf of Mexico), Bean (1884) records it from Mississippi, and Gowanloch (1933) mentions it in "Fishes and Fishing in Louisiana." However, Merriman (1941) states that although it occurs from Florida to the Gulf of St. Lawrence, it is most common from North Carolina to Massachusetts. In 1945, of a total commercial production of 5,624,000 pounds, 65 per cent was produced in the Chesapeake states. It was introduced (135 fish in 1879 and 300 in 1882) on the Pacific coast and supports a commercial fishery there which yielded 250,000 pounds in 1945.

This fish appears to be a coastal form, for it is rarely taken more than a few miles offshore. The species is anadromous, living in salt water but spawning in fresh water, and it is therefore taken in both inside and outside waters. It is sought by both commercial and sport fishermen. One of the most notable sport fisheries occurs each spring in the Roanoke River at Weldon, North Carolina, over a hundred miles inland from the river's mouth.

An investigation of the striped bass was undertaken by the Connecticut State Board of Fisheries and Game in 1936. Since the species is migratory, it soon became evident that the investigation should be extended over an area larger than a single state. This extension was made possible by the financial support of the American Wildlife Institute and the United States Bureau of Fisheries. The investigation was concluded in 1938 and reported on by Merriman (1941). Much of the information given in this review is taken from Merriman's study, and in all the references to Merriman below, his 1941 paper is to be understood.

The striped bass spawns all along the Atlantic coast in the spring, the exact time depending on latitude and water temperature. According to Smith (1907) spawning in North Carolina occurs in late April and early May. The spawning activities are well known to fishermen who have witnessed the "rock-fights," in which a single large female and a number of smaller males rise to the surface and vigorously splash about, creating a commotion which can be heard for several hundred feet. Whether these fights are part of the actual spawning act or merely a form of courting is not known.

The sex ratio of spawning striped bass is estimated to be 10 to 50 males for each female. Merriman took a sample of 127 fish at Weldon in the spring of 1938, and found only six of them to be females. Spawning males are considerably smaller than females. Worth (1903) states that the males weigh from one to three pounds whereas the females weigh from four to fifty pounds. This size difference is due to the difference in age at which the two sexes reach maturity. Most males are sexually mature at the end of two years growth, while females require at least four years, at the end of which time only about 25 per cent are mature. Merriman estimated that at the end of the fifth year of life, 75 per cent of the females are sexually mature, the remaining 25 per cent requiring six or seven years. The majority of the spawning males at Weldon are two-year-olds, with smaller numbers of three- and four-year olds; females, however, are all over four years old, accounting for their larger size.

The number of eggs produced per female varies greatly with the size of the fish. Worth (1903) reports egg counts from 11,000 to 1,215,000 but does not include data on size or weight. Merriman found a 4½-pound female containing 265,000 eggs. Bigelow and Welsh (1925) report a 12-pound fish which produced 1,280,000 and estimate that a 75-pound fish would produce 10,000,000 eggs. The eggs are semi-buoyant and are therefore carried downstream during the development period. The time required for hatching, dependent on water temperature, is from 30 to 74 hours. Considering the current of the Roanoke River, Merriman believes that many of the eggs produced in the vicinity of Weldon, North Carolina, may reach Albemarle Sound before hatching.

The young fish apparently remain in fresh or brackish water for two summers, for young-of-the-year and yearly fish are rarely taken in outer coastal waters. Young bass feed on small invertebrates such as fresh-water shrimp, insects, and worms (Townes, 1937; Hildebrand and Schroeder, 1928; and Merriman, 1941). The older and larger bass are known to feed largely on other species of fish, such as menhaden, alewives, shad, silver-sides (*Menidia*), killifish (*Fundulus*), and shiners (*Notropis*). Other species of fish and crustacea are also taken in lesser quantities.

The rate of growth of the striped bass has been studied by Merriman. Measurements were made of fish ranging from one month to nine years of age. There is some evidence of varying growth rates in different localities along the coast. In 1937, for example, the two- and three-year-old fish from Massachusetts were larger than the Connecticut bass of the same age. The average lengths (from tip of nose to fork of tail) of striped bass at successive years of age are given by Merriman as follows:

	AVERAGE LENGTH	
Age	Centimeters	Inches
1	12.5	4.92
2	23.5	9.25
3	36.5	14.37
4	45.0	17.72
5	53.0	20.87
6	61.0	24.02
7	68.5	26.97
8	75.0	29.53
9	82.0	32.28

The growth of the striped bass, as found by subtractions in the above table, was 4.92 inches during the first year, 4.33 inches the second, and 5.12 inches the third year. The growth rate then decreases, being 3.35, 3.15, 3.15, 2.95 and 2.56 inches during the fourth to eighth years respectively.

Unusually large striped bass are taken occasionally. Smith (1907) reports fish weighing 125 pounds taken at Edenton, North Carolina, in 1891, and states further that striped bass weighing 60 to 75 pounds are (or were) not uncommon. Apparently these larger fish are no longer as common as in the past, for Merriman states that "bass above 60 pounds are now decidedly rare."

An interesting feature in the life history of this species which was not commonly known prior to Merriman's study is the annual mass migration to the north in the spring and to the south in the fall. These migrations were demonstrated by tagging a large number of fish at various points along the Atlantic coast.

The spring migration is believed to start from Chesapeake Bay and the size of the migrating group increases as the fish from more northerly points join it. When the migrating mass reaches Long Island, Connecticut, and Rhode Island waters, large groups split off to spend the summer in these waters, so that the body of fish dwindles as it moves farther north. The northern limit of the migration apparently is determined by the size of the migrating mass. During years when the population is small, the northern limit seems to be Cape Cod, but in years of large populations, such as 1936 and 1937, striped bass were common as far north as New Hampshire and Maine. During those years, bass were taken in commercial quantities in Cape Cod where normally the annual migration is not large enough to support a fishery.

In the fall, the migration reverses, starting with those individuals which spent the summer in the most northerly waters, gaining numbers as it is augmented by the fish from Long Island and southern New England, and then decreasing as groups split off to spend the winter in different localities.

There are indications that the migrations are greatly influenced by water temperature. The striped bass tolerate a wide range of temperature, as shown by their distribution described earlier; yet Merriman found that "the times when the first striped bass of the year were taken—in April 1936, 1937, and 1938—and the times that the last ones of the year were caught—in November, 1936 and 1937—in the Niantic River, Connecticut, were always when the temperature of the water was approximately the same, 6.0° to 7.5° C. (42.8° to 45.5° F.)."

Not all striped bass take part in the annual migration; some individuals remain in each of the southern localities during the summer and conversely some remain in the northern waters during the winter. Whether such individuals are part of a continuous resident population or are detached from the migrating mass is not definitely known.

The age and sex composition of the migrating fish is interesting in that the group spending the early summer in New England waters contains 90 per cent females, most of which are two or three years old. This condition is explained by the fact that the migration coincides with the spawning season. As pointed out earlier, females do not spawn until the end of their fourth year while males mature at the end of the second year. Since fish of both sexes remain in fresh or brackish water for two years, the only fish which are available for the migration are females too young to spawn (the 2- and 3-year olds). However, the migration also includes some larger females which are of spawning age but do not contain eggs. This fact suggests that females do not spawn every year.

There is a second and less numerous migration in early summer, after the spawning season. This migration is composed of individuals and small groups of larger females which have spawned and are moving north for the summer. The movements of these larger females is reflected in the fishing records of New England, where catches prior to June consist of smaller fish and the catches during the summer and fall contain a greater percentage of the larger size fish—more than can be accounted for by the growth of the earlier and smaller migrants.

Information regarding the migratory habits of the male striped bass is needed. According to the literature, the sex ratio on the spawning grounds is 10 to 50 males per female, and the summer populations in the north, resulting from migrations described above, are 90 per cent females. A large number of males are therefore unaccounted for during the summer, except by Merriman's statement that the "strikingly abnormal sex ratio does not exist in waters farther south." If the second migration (females which have spawned) is large enough to influence materially the northern catch, there should be 10 to 50 times as many males to distribute themselves along the coast, and there should be some southern localities where the summer population is predominantly male. Future studies on this species may clear up this phase of the life history.

The migrations described above involve only a part of the coastal population of striped bass. Although it is found from Florida to Nova Scotia, only those fish from Chesapeake Bay to Cape Cod normally participate in the migration described. It is believed, on the basis of tagging experiments, that the Albemarle Sound population contributes very little to the northern migration and that very few of the south-bound migrants reach North Carolina in the fall or winter. The Nova Scotia population also seems to be a separate group and contributes very little to the New England population. On the basis of observations made by Parr (1933), Merriman suggests that a cold water barrier at Cape Cod normally limits the northern spring migration and that a warm water barrier at Cape Hatteras marks the southern extent of the normal fall migration.

We find no mention in the literature of migrations of striped bass in the regions north and south of the area covered by Merriman. It remains to be determined, then, whether the North Carolina population is a resident one or whether it represents the northern limit of a migration from more southern waters. If in North Carolina there is a resident and more-or-less static population, not moving to or coming from other coastal states, the management of the species would be simplified. At present the minimum legal size in North Carolina for commercial purposes is 12 inches. Such a fish is two years old and, if a female, is two years younger than spawning age. The females are thus available to commercial use for two years before spawning. If, therefore, the North Carolina fishermen could be reasonably certain that the fish were not moving into "foreign" waters to be caught, they might welcome legislation to protect the species until they attain spawning age and a considerably larger size. Since the third year is the year of greatest growth, it might be advisable, in any case, to allow the fish to reach the larger size before harvesting. On the other hand, the additional food, including young herring and shad consumed by the striped bass thus protected, might be of more value than the increment of growth of the bass. The production of striped bass in North Carolina, as in other states along the coast and as with other species, has had its ups and downs. These fluctuations are believed to be closely associated with survival of the young of various year-classes. In 1934, for example, an exceptionally large crop of young was produced in Chesapeake Bay (Merriman, 1941) which were caught in 1936 and 1937 along the coast north to Cape Cod. These years saw all previous catch records broken by wide margins. These same years in North Carolina, however, witnessed no such increase. This fact provides additional evidence that the two populations are separate and distinct, and that conditions favorable to the survival of young are not general but rather occur in specific localities. There is no record of a local decline in North Carolina such as is reported in more northern waters during the latter part of the nineteenth century. The average annual catch from 1887 to 1945 is 550,000 pounds, and in only one year (1902) has the catch varied by more than 50 per cent of this amount. In 1902, 1,175,000 pounds was reported. Although there have been good years and poor years, there has been no appreciable upward or downward trend in the last 60 years.

Most of the striped bass in North Carolina are taken in Croatan Sound and the eastern end of Albemarle Sound. In 1938, Dare County landed over 50 per cent of the State's catch, with other counties along Albemarle Sound producing the rest. These fish also ascend Pamlico and Neuse rivers, but the commercial catch in them is negligible. A few are taken in the Cape Fear River area.

Future studies on the striped bass in North Carolina should include a determination of the extent of migration of the population, since the nature of such migrations may well be considered a basis for more effective management of the fishery. Because the species is anadromous, like the shad and alewife, it is necessary to keep streams free from obstructions and pollution if the continued utilization of this fishery is desired.

GRAY TROUT

Cynoscion regalis (Bloch & Schneider)

The gray trout, also known as gray weakfish and squeteague, is found along the Atlantic coast from southern New England to Florida, although it is of commercial importance only from North Carolina northward. It was formerly believed to inhabit waters of the Gulf States, but Ginsburg (1929) found the Gulf trout to be a distinct species, *C. arenarius*. The gray trout is ordinarily taken in North Carolina from March to December; the exact length of the season depends upon the date of beginning and the severity of the winter. The gray trout is among those fishes which are considered "good-eating" and therefore commands a good price. The states reporting the largest catches are New Jersey, Virginia, and North Carolina.

An interesting note regarding the distribution of this species is found in the report of Bigelow and Welsh (1925) on the fishes of the Gulf of Maine. Trout were plentiful in Massachusetts Bay in the middle and latter part of the eighteenth century, but disappeared before 1800. The disappearance was apparently so complete that a single specimen taken in 1838 at Provincetown was sent to Boston for identification. By 1867 they were reappearing in southern Massachusetts and became abundant in 1870, but were not reported north of Cape Cod until 1884. They then became very abundant, and reached a peak in 1901-1904. The 1906 population was somewhat smaller and rapid annual decreases took place; the 1910 Massachusetts Bay catch was 17 pounds. By 1917 they had again disappeared from these northern waters.

The gray trout is believed to spawn at sea. This conclusion is reached on the basis of a study of the movements of adult fish and distribution of the very young fish by Hildebrand and Cable (1934). They report that the adults move inshore in early spring as the water temperature rises (March and April), but in May they move offshore, to return after spawning. The large trout increase in abundance through June, July and August. Very young fish appear in coastal waters from late May to the middle of August; this period coincides with the absence of the large adults. This evidence seems sufficient to place the spawning at sea during the period May to August. The spawning period therefore is an extended one, although the peak of spawning activity occurs in May and June. No adults containing roe in a "ripe" condition have been found in inshore waters.

Many young fish move into the shallow inside waters as soon as they are able to swim, although young are also taken during the summer in shallow offshore water. They remain in the sounds and estuaries all summer and fall, and apparently stay during the winter as well except for short periods of severe cold. The young may therefore move in and out several times during the winter. The adults, however, move out to sea with the first cold weather and do not return until spring.

The food of the very young trout has not been studied, but from the time they reach one and one-half to two inches, Welsh and Breder (1923) state that the young feed largely on small crustacea such as copepods, isopods, amphipods, shrimp, and crabs. Worms and smaller fish are taken. Smith (1907) and Nichols and Breder (1926) list menhaden as the principal food of the gray trout, although other fish and shrimp are also important food items. The young trout grow rapidly; they reach an average size of about seven inches by the end of the first year. They spawn for the first time when three years old, according to Higgins and Pearson (1927).

The gray trout is a migratory species; adult fish spend the summer in the north and the winters in the south. This seems particularly true in the Chesapeake Bay to Cape Cod section of the coast. But as in the case of the striped bass, the extent of migrations in waters south of Chesapeake Bay is not known.

The chief North Carolina fishery is in Pamlico Sound and tributary waters; Carteret, Dare, and Pamlico counties account for nearly the entire catch. Trout are taken from inside waters throughout the year, except for periods of cold weather when they move "outside." They are taken by offshore trawlers during these winter periods.

Smith (1907) lists the gray trout as much less abundant than the spotted trout, but data obtained by the Federal Government since 1930 show the annual catch of gray trout in North Carolina to be nearly five times that of the spotted trout—(five million pounds annually as compared with a little over one million. See this Survey, Part III, Table 91, Appendix).

Some concern has been expressed in years past regarding the destruction of young gray trout by the summer pound-net and haul-seine operations in North Carolina. Higgins and Pearson (1927) made a thorough investigation, reported on the tremendous destruction of small trout, and recommended a closed season on pound netting in Pamlico Sound from the end of the shad season until August 1 in order to preserve the gray trout fishery. This recommendation was never carried out, but the gray trout fishery did not decrease. What the effect of a closed summer season would have been is of course unknown. However, during recent years very few pound nets have been fished in Pamlico Sound after the shad season, but there is no evidence of an increase in gray trout resulting from the much-reduced pound netting.

SPECKLED TROUT

Cynoscion nebulosus (Cuvier & Valenciennes)

Also known as spotted or speckled weakfish or squeteague, the speckled trout has a wider distribution than the gray trout; it is found from New York to Texas. Since it is commercially important only in the southern part of its range (Virginia, southward) it is frequently referred to as the southern weakfish, squeteague, or trout. Both species are therefore important in North Carolina, where they are usually called trout, the names weakfish and squeteague being more common to the north. Like its close relative, it is a fish of superior flavor, and commands a good price. It is of particular importance in North Carolina because it is taken during the entire year in shallow water and therefore supports some fishery in the slack season during the sojourn of other fish in deeper offshore waters in the winter months.

The spawning of this species is not well known. Hildebrand and Cable (1934) found larvae (very young fish) under one-fourth inch both offshore and in estuaries and conclude that spotted trout probably spawn in both the inside and the outside waters. The North Carolina spawning season coincides with that of the gray trout, May to August. Pearson (1929) reports that this species in Texas spawns largely in the coastal bays and lagoons from March to October.

Growth and food of the spotted trout have been studied little. Hildebrand and Cable (1934), on the basis of measurements of the young, found that its growth rate parallels that of the gray trout, reaching 6.75 inches in seven to eight months. Nichols and Breder (1926) show the growth to be as follows: first winter, 4.5 inches; second winter, 9.0 inches; third winter, 12.2 inches; fourth winter, 14.2 inches; fifth winter, 15.75 inches; and sixth winter, nearly 17 inches. Regarding feeding habits, Smith (1907) states, "It swims in schools, and preys on all kinds of small fishes, and is itself eaten by bluefish, drum and northern squeteague" (i.e., by gray trout).

Adult and young spotted trout now are found in the sounds and mouths of rivers throughout the year. However, they apparently did not occur in the Beaufort region in the earlier part of this century; Coker reports (in Smith, 1907) that the winter fishery is a recent development and that the presence of schools of trout in the winter "presents something new and unexplained." Trout were known to frequent other shallow waters in winter in earlier years, however. Records of finding "numb" trout (fish which become numb, rise to the surface almost motionless and are easily captured) during extremely cold periods are found in the literature (Lawson, 1709, cited by Smith, 1907; and Goode, 1884, Sec. I, Text). It seems, therefore, that long-term fluctuations in distribution take place in at least certain localities.

Production of spotted trout in North Carolina amounts to about a million pounds annually. There have been high and low years, but there has been no significant trend in the fishery since 1925.

SPOT

Leiostomus xanthurus (Lacépède)

The spot, which derives its name from the round spot on its shoulder, is found from Massachusetts to Texas. North Carolina, Virginia, and New Jersey are the largest spot-producing states. The spot is not so large a fish as are many other commercial species, but it is highly regarded as a food fish. It is of much more importance in North Carolina than it was fifty to sixty years ago. In fact, Smith (1907) states that there was no special fishery for spot, but that they were taken incidentally in seines, gill nets, and pound nets. Before 1900, the annual North Carolina production was less than a half a million pounds, but since the middle 1930's the annual catch has been in the neighborhood of five million pounds. The spot now supports a special fishery, particularly in October and November, when other fish are scarce.

The life history of the spot has been studied by Hildebrand and Schroeder (1928) and Hildebrand and Cable (1930). However, some phases of the life history are still unknown, or are known only on the basis of circumstantial evidence.

The spawning and development of the eggs have not been observed. It is known, however, that adult fish leave the sounds in the fall (October and November) and that the females carry eggs presumably ready for discharge. Larval fish (under one-half inch in length) have been collected in shallow waters along the coast from November to May. It is evident, therefore, that the fish spawn offshore, and, judging by abundance of larvae, it is believed that the principal spawning period is during December and January, with some spawning in November and February.

The rate of growth and average size of the spot vary throughout its range. Pearson (1929) states that spot are not taken commercially in Texas because they do not attain sufficiently large size, seldom reaching ten inches. Hildebrand and Cable (1930) report that the average size of the spot taken commercially in the Beaufort, North Carolina, region is somewhat smaller than at Norfolk, Virginia. Croakers and weakfish (trout) also reach a larger size in the northern part of their range. At Beaufort, the young fish grow rapidly during the summer, reaching a length of four to five inches by fall. At the age of one year they have reached five to seven and one-half inches, the larger ones having attained the size of the smaller ones from the previous year-class. From this point on, it is difficult to follow the growth because the year-classes are intermingled and the fish tend to school by size-groups rather than age-groups. In New Jersey, Welsh and Breder (1923) report that spot reach a length of three to four inches in their first year, indicating a somewhat slower growth in the northern waters. In Texas, Pearson (1929) reports the first year's growth as very similar to that in North Carolina. The difference in the average adult size referred to above is due to the fact that in Texas, few fish over two years of age are taken, whereas in North Carolina the commercial catch is made up largely of fish not less than three years old.

The age of first spawning is estimated to be two years. Hildebrand and Schroeder (1928) found no fish under eight inches in October which were ready to spawn, while Pearson (1929) found spot in Texas in spawning condition at six and one-half to seven inches. These fish, however, were approaching two years of age. The maximum age of spot has not been determined because of the difficulty involved in "reading" the scales after two years of age.

The spot is a bottom feeder. The small fish feed largely on plankton. As the fish grows, somewhat larger forms are taken. The food of the adult includes crustaceans, principally amphipods and ostracods, and also minute mollusks, annelid worms, fish, and vegetable debris (Welsh and Breder, 1923; and Hildebrand and Schroeder, 1928). Large amounts of sand are also found in stomachs, sometimes constituting fifty per cent of the stomach contents. Whether the sand is taken intentionally or incidentally is unknown.

Some spot are taken in Pamlico Sound during the summer in haul seines, but the chief fishery occurs in the fall (October and November) when the fish are migrating in schools from the inside waters to the offshore waters. The fishery operates both inside and outside the inlets along the entire coast from Ocracoke southward. Carteret County leads in production, but the aggregate from the southern counties, New Hanover, Pender, Onslow, and Brunswick, amounts to about a third of the State's production.

CROAKER

Micropogon undulatus (Linnaeus)

The croaker is known from Massachusetts to Texas. The largest croaker fishery is located in the Chesapeake Bay states, Virginia and Maryland, where the croaker may be designated as the principal food fish. There it leads all other food fish both in quantity and in value. The 1944 figures show a harvest of 38 million pounds, valued at $2,017,732. Although the North Carolina yield is considerably less, the croaker nevertheless occupies an important place in the State's fisheries.

The life history of the croaker has been studied in more detail than that of many of our other marine food fishes. It has received attention in recent years throughout its entire range.

The croaker was formerly reported by Smith (1907) to spawn in the sounds and estuaries, but more recently it has been shown by Hildebrand and Cable (1930) and Wallace (1941) that spawning occurs offshore. The spawning season is rather extended, covering a period of from five to nine months. In Chesapeake Bay, Wallace found sexually mature fish migrating to the ocean from July to November, with the males tending to migrate before the females. Welsh and Breder (1923) found males with running milt off Atlantic City, New Jersey, in July, but ripe females were not found until September. However, Hildebrand and Cable (1930) found young croakers, less than one-half inch in length and obviously recently hatched, during nine months of the year—September to May—in the Beaufort area. Pearson (1929) found larval croakers in Texas waters from October to February.

The age of the spawning fish varies from one locality to another. Pearson (1929) reports that croakers in Texas spawn at the end of the second year, while Wallace (1941) states that less than half of the Chesapeake Bay males and none of the females were sexually mature at the end of two years. It has been suggested by Hildebrand and Cable (1930) that individuals of the same species may mature earlier in the warmer climates.

The number of eggs produced per female has not been adequately determined. A single specimen, measuring 15.5 inches, taken by Hildebrand and Schroeder (1928) contained 180,000 eggs. However, fish of this size are seldom taken in North Carolina waters and the average reproductive capacity would therefore seem to be considerably less.

The eggs of the croaker have not been taken by any of the workers. However, Hildebrand and Cable (1930) found larvae about one-eighth inch long off the shores of the outer banks at Beaufort. These small fish are not capable of active swimming, but are carried about by water currents. Since there are no definite inshore currents in this region, except during flood tides, it seems probable that the eggs are deposited or hatched comparatively close to shore. Wallace (1941) is able to explain the occurrence of larval croakers in Chesapeake Bay, perhaps over 100 miles from the spawning area, by the presence of a definite current of ocean water moving along the bottom through a deep channel up into the Bay. No such currents are known in the Beaufort and Pamlico Sound regions, and it therefore seems that the eggs are deposited in the outside water, but not far from the shore.

Those young croakers which are not carried in by the tide move into the shallow inside waters soon after they become capable of swimming. They stay inside all summer and grow rather rapidly; they reach an average length of five and one-half to six inches by October. The adult fish also move into the sounds during the summer where they are taken commercially as well as by hook-and-line sport fishermen. During the colder winter months, the fish move out of the sounds into the ocean, but apparently stay closer to shore than the older fish.

In recent years, the fishery has been extended to the winter months and offshore with the use of large trawlers. This winter fishery has been of importance to the fishermen because the winter season was previously a slack period. But other fish being scarce, the croaker commands a fair price on the winter market and thus tides the fishermen over the formerly lean season. The smaller operators also find croakers coming into shallow waters during warm spells in the winter.

The croaker, both young and adult, is primarily a bottom feeder. The chief items of food reported by Hildebrand and Schroeder (1928) are small crustacea, annelids and mollusks, in the order named. Fish are occasionally found in croaker stomachs, although the principal food forms are those which have no direct commercial value.

As was previously pointed out, the chief croaker fishery is located in the Chesapeake Bay region. Not only are more croakers taken in Chesapeake Bay than in North Carolina, but the northern croakers are also considerably larger than those taken locally. The average size of croakers marketed in North Carolina is seven to ten inches; these are considered "pin-heads" in Chesapeake Bay.

The annual production of croakers in North Carolina has varied from 300,000 pounds in the 1880-1890 period to a high of nearly ten million pounds in 1937. Since 1937, the production has declined to about four million pounds in 1945. The records since 1888 show at least three distinct peaks of abundance, each succeeding one being larger than the previous one. One peak in 1902 shows a production of about two million pounds, followed by a decline to 387,000 pounds in 1918. Another peak occurred in 1928-1929, with 7.7 million pounds in 1929. This peak was followed by a decline to 4.3 million pounds in 1934. A peak also occurred in 1936-1937, this time to nearly ten million pounds. This species, like many others, is subject to wide fluctuations in abundance. The present slump may therefore be expected to be followed by an increase in production.

MINOR COMMERCIAL SPECIES

KING WHITING (SEA MULLET)—*Menticirrhus* SPECIES

As in the case of the jumping mullet, the sea mullet taken commercially in North Carolina includes at least two species, *M. americanus* and *M. saxatilis*. Other names for these fish are kingfish, sea-mink and hake. Sea mullet is the most common name used in North Carolina.[1] They are found from Chesapeake Bay to Texas. They are bottom feeders; their chief food are mollusks and crustaceans.

The sea mullet brings a good price at times, but is subject to rapid price fluctuations. The production varies from year to year, probably as a result of economic influences as well as fluctuations in abundance. Although the total catch and value of the sea mullet is not as high as that of many other species, the fishery nevertheless is important in that it is operated in shallow offshore waters.

HOGFISH—*Orthopristis chrysopterus* (LINNAEUS)

Also known as pigfish, this species is one of the most common food fishes of the North Carolina coast. It is found everywhere in the sounds and shallow offshore waters and is present throughout the year. At certain seasons and in some localities it is about the only fish available. It takes a hook readily and the number taken by sports fishing may equal or exceed the commercial catch. The meat has a good flavor, although it is claimed that hogfish from some areas are better than others. Variation in flavor may be due to difference in diet since the hogfish, much like the mullet, feeds on a variety of things.

Most of the catch is sold fresh, but small quantities are salted for local consumption.

HARVESTFISH—*Peprilus alepidotus* (LINNAEUS)

The harvestfish is a small pan fish and is considered an excellent food fish. It is taken during the summer from the bays and sounds, the Pamlico Sound area producing the bulk of the State's catch. It apparently is much more abundant now than forty years ago, when Smith (1907) reported that it had not often been recorded from North Carolina, although it was not considered rare. Average production since 1923 has been in excess of a half a million pounds annually. Little is known about the biology of this species.

BUTTERFISH—*Poronotus tricanthus* (PECK)

The butterfish resembles the harvestfish in appearance, but it is not as deep bodied and it has smaller dorsal and anal fins. It is found from Massachusetts to North Carolina, and in North Carolina is taken in most of the sounds, Pamlico Sound leading in production.

The butterfish, like the harvestfish, is a small but excellent food fish. Production is limited and variable. It is present in the sounds from spring to fall, often traveling in large schools. Its winter habitat is not known. It is believed

1. The "sea mullets" are not mullets at all; they are more properly called kingfishes. They are members of the noise-making or drum family (Sciaenidae) along with the croakers, spot, red and black drums, silver perch and sea trout or weakfishes.

to spawn in June and July in the bays and sounds, and is more abundant in Chesapeake Bay and northward than in North Carolina.

WHITE PERCH—*Morone americana* (GMELIN)

The white perch, closely related to the sea bass family, is considered by many the finest of all food fishes. It therefore commands a good price on the market and, being a game fish, is also sought by anglers. It will take a variety of baits, including artificial lures.

The white perch is at home in shallow fresh, brackish, and salt water. It is found from South Carolina to the maritime provinces of Canada. The Currituck-Albemarle Sound region yields most of North Carolina's production, which varies from 150,000 to nearly a million pounds annually.

In habits, this fish resembles its relative, the striped bass. It feeds largely on fish, shrimp and other animals. Spawning occurs in early April in North Carolina, three to six days being required for hatching of the eggs. Nichols and Breder (1926) report that about 40,000 eggs per female are deposited; the eggs are heavy and sticky, and cling together in masses on the bottom or attach to any object with which they come in contact.

Fishing for this species should be encouraged, for it is an extremely popular pan fish and is always in demand.

BLACKFISH—*Centropristes striatus* (LINNAEUS)

More commonly known in North Carolina as the sea bass, the blackfish lives on bottoms, many of which are non-trawlable, around wrecks and coral beds and feeds voraciously on fish, squid, crabs, and other animals. It takes a hook readily and is caught in commercial quantities by hand lines.

The blackfish grows to a size of six pounds but the average weight is not over two to three pounds. Spawning takes place in the spring off the North Carolina coast; the eggs rise to the surface and hatch in about five days in water of 60° F. The young are common along the shore and in the inlets, gathering around jetties and wharves.

The blackfish fishery at present is not large. The population of this fish could perhaps support an increased fishery. The chief obstacle is that the coral reefs which are the centers of concentration of blackfish are located some distance offshore, and for the most part North Carolina fishermen do not have boats which can operate safely in the outside waters day after day because of uncertain weather conditions. In some northern waters, these fish are taken in traps or pots.

FLOUNDERS—*Paralichthys* SPECIES

There are a number of different kinds of flounders on the Atlantic and Gulf coasts, each kind or species having a rather definite distribution. North

Carolina waters contain several species although the commercial catch is made up largely of the summer or southern flounder, *Paralichthys dentatus.*

Although the flounder is not one of the leading species in the State in total production, it is important to the fishermen because it is a year-around fishery and fills the gap in fishing created by the seaward migration of other fish in winter.

The flounder is a bottom feeder and is found in the harbors and sounds. The fish move out of the inlets during the winter and are taken by offshore trawlers. Spawning is believed to occur in the ocean, perhaps not far offshore, since larvae are found close to shore in greater numbers than in the inside waters.

CARP—*Cyprinus caprio* (LINNAEUS)

The prolific fast-growing carp was introduced into North Carolina in 1879, according to Smith (1907), and quickly became established in the waters of the State. For many years, from the 1870's to the 1890's, the carp was the subject of great interest and was extensively investigated, cultured, and transplanted to many parts of the United States by the U. S. Fish Commission. For an exhaustive review of the carp, see Cole, 1905. It has a low value as a food fish, the meat having an inferior flavor and texture, but it has been successfully used as food for other fish being propagated in hatcheries. There is, therefore, little demand for fresh carp and the price is low. The carp fishery in North Carolina is variable, but on the average is worth less than $20,000 annually.

SUMMARY AND RECOMMENDATIONS

The present knowledge of the natural history of the commercially important finfish of the State is only of a general nature. We know, for example, something about where and when certain fish spawn. In most cases, spawning has not been observed but ripe females have been taken. The location of ripe fish in relation to inside or outside waters and the appearance of the larval stages at given times and locations indicate the approximate times and places for spawning. In the case of the jumping mullet, for example, we can say only that it is believed to spawn during November and December, in the ocean—not far off shore. This statement is made on the basis of the observed fact that mature fish pass through the inlets to the ocean in October and November, and that, about two weeks later, larval mullet are taken in the vicinity of the inlets. Information on other species is of a similar nature. The type of bottom, the temperature and depth of water in which most species spawn are not known.

Little is known regarding the life of most species while they are in the ocean. Where do they spend the winter? What do they feed on? How fast do they grow? And what is the natural mortality?

In the sounds, more observations have been made, and knowledge of the life histories in these waters is further advanced, although still inadequate. Interspecies food relationships—a most important factor in fisheries management—are known on the basis of examination of stomach contents of very few fish, and these mostly adult.

Magnitudes of population and fishing mortality cannot be determined on the basis of the present inadequate records of catch and effort, and no data are available for estimating trends in average size or age composition of the commercial catch.[2] We do not have the information on which to determine whether or not the present fishing intensity and commercial catch represent a wise utilization of the finfish resources.

The following recommendations are made for future study of the finfish in North Carolina waters:

MIGRATIONS. More observations should be made of the movements of fish after they leave the inside waters in the fall. Do they move south or do they spend the winter off the North Carolina coast, and if so, where? Knowledge of location of the winter grounds may open up new possibilities for the industry. Limited trawling operations in the Cape Lookout area during early 1949 produced some fair catches of croakers, spot, flounder, trout, and sea mullet. We must know more about the extent of the winter population. Are more fish to be found in deeper waters? Present trawling is commonly limited to about 20 fathoms. Are the fish located in other areas of trawlable bottoms? Answers to these questions should be sought.

FOOD OF FISHES. Studies should be made of the food and feeding habits of the commercially important species at various stages of growth. To what extent is each utilized as food by other fishes? How many young shad and alewives are eaten by striped bass, and how many shrimp by gray trout? Is it wise economy, on any reasonable assumption as to what the food conversion factor is,[3] to protect the predatory species; or would it be advantageous to promote the exploitation of them as indirect protection of those species in the food chain which are closer to the basic production? Detailed food and growth studies should clarify these interspecies relationships.

ABUNDANCE. It is desirable to know more about the quantity of fish available to the industry and what fluctuations in abundance occur. We have for certain years records of the catch, but as indication of the effort used in

2. The best indication of an over-fished population is a decrease in catch per unit effort. Lacking catch per unit effort data, the size and age composition of the catch may be used as criteria. A population which is being over-fished will yield smaller and younger fish.

3. The usual assumption is that it takes 10 pounds of food to produce a pound of fish—although this figure is only an estimate and undoubtedly varies considerably according to species and individuals.

the industry in this region we have only the numbers of operating units (i.e., boats and the different kinds of gear) without any data on the extent to which they are used. The catch of all fish, food and non-food, per fisherman in North Carolina has increased during the 50 years to 1940 (see Part III, Table 24), but the menhaden industry is wholly, or at least in large part, responsible for this increase. Fishermen believe that the last few years have witnessed a decrease in other finfish. Such may be the case, inasmuch as the State's Commercial Fisheries Division reports a 33 per cent decrease in production during the 1946-1948 biennium, as compared with the 1944-1946 biennium. It is not definitely known whether this decrease is the result of weather conditions, decreased effort, or decrease in available fish. This situation points to a need for a statistical study of production such as can only be made by obtaining better records of fishing effort and production.

Are such fluctuations in production the result of changes in abundance of fish, or other factors? Are fluctuations in abundance due to natural or man-made factors, or both? In addition to the well known fluctuations of species are there also fluctuations of the whole fisheries of the region collectively? What, if anything, can be done to insure a continuous and adequate supply of fish? Or should we fish intensively while prices are high and let the population, if decreased, be restored while prices are low?—i.e., to what extent should we substitute efforts of deliberate control for the natural self-regulatory forces of supply and demand? These are questions which apply to the fundamental philosophy of fisheries management and should be considered with the economic interests of the industry in mind.

FISHING METHODS. Perhaps this is not a strictly biological problem. But we should try to develop more efficient methods of finding and catching fish. The industry has made few advances in fishing methods since the development of the otter trawl; we are either setting or dragging nets, hoping that fish will be caught. Could we use the reactions of fish to light, sounds, odors, or chemicals in attracting them to nets or other enclosures? In order to answer this, we must first know how fish react to these various stimuli. Such a study might also throw light on diurnal and seasonal migrations.

BIBLIOGRAPHY

Bean, Tarleton H.
1884. On the occurrence of the striped bass in the lower Mississippi Valley. Proc. U. S. Nat. Mus., Vol. 7, 1884, p. 242-244.

Bigelow, Henry B., and William W. Welsh.
1925. Fishes of the Gulf of Maine. Bull. U. S. Bur. Fish., Vol. XL, Pt. I, 1924 (1925), 567 p., 278 figs., extensive bibliog. (Doc. 965, 1925).

Cobb, John N.

1906. Investigations relative to the shad fisheries of North Carolina. N. C. Geol. Surv., Economic Paper No. 12, 1906.

Cole, Leon J.

1905. The German carp in the United States. Rept. U. S. Bur. Fish., 1904 (1905), p. 523-641, 3 pls., extensive bibliog. (Doc. 592, 1905).

Earll, R. Edward.

1887. North Carolina and its fisheries in 1880. *In* Goode and associates (1884-87) (which see below), Sec. II, Pt. XII, p. 475-497.

Eigenmann, Carl H.

1901. Investigations into the history of the young squeteague. Bull. U. S. Fish. Com., Vol. XXI, 1901 (1902), p. 45-51 (Doc. 477, 1901).

Ginsburg, Isaac.

1929. Review of weakfishes (*Cynoscion*) of the Atlantic and Gulf coasts of the United States, with a description of a new species. Bull. U. S. Bur. Fish., Vol. XLV, 1929 (1930), p. 71-85 (Doc. 1058, 1929).

1931. On the difference in the habitat and size of *Cynoscion arenarius* and *C. nothus*. Copeia, 1931, No. 3, p. 144.

Goode, G. Brown (and a staff of associates).

1884-87. The Fisheries and Fishery Industries of the United States. V Sections (7 volumes), Sec. I, Text and Plates, 1884; Secs. II, III, IV, and V (Vols. I and II and Plates), 1887, U. S. Comm. of Fish & Fisheries.

Gowanloch, J. N.

1933. Fishes and fishing in Louisiana. State of Louisiana, Dept. Cons., Bull. No. 23, 1933, p. 208-213.

Gudger, E. W.

1913. Natural history notes on some Beaufort, N. C., fishes, 1912. Proc. Biol. Soc. Washington, Vol. XXVI, 1913, p. 97-110.

Gunter, Gordon.

1945. Studies on the marine fishes of Texas. Pubs. Inst. of Mar. Sci., Vol. I, No. 1, 1945, 190 p.

Higgins, Elmer, and John C. Pearson.

1927. Examination of the summer fisheries of Pamlico and Core Sounds, N. C., with special reference to the destruction of undersized fish and the protection of the gray trout, *Cynoscion regalis* (Bloch and Schneider). Rept. U. S. Comm'r. Fish. for 1927 (1928), Appendix II, p. 29-65 (Doc. 1019, 1927).

Hildebrand, Samuel F., and Louella E. Cable.

1930. Development and life history of fourteen teleostean fishes at Beaufort, N. C. Bull. U. S. Bur. Fish., Vol. XLVI, 1930 (1931), p. 383-488, 101 figs. (Doc. 1093, 1930).

1934. Reproduction and development of whitings or kingfishes, drums, spot, croaker, and weakfishes or sea trouts, family *Sciaenidae*, of the Atlantic coast of the United States. Bull. U. S. Bur. Fish., Vol. XLVIII, 1940 (Bull. 16, 1934), p. 41-117.

1938. Further notes on the development and life history of some teleosts at Beaufort, N. C. Bull. U. S. Bur. Fish., Vol. XLVIII, 1940 (Bull. No. 24, 1938), p. 505-642.

Hildebrand, Samuel F., and William C. Schroeder.

1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish., Vol. XLIII, Pt. I, 1927 (1928), 366 p., 211 figs. (Doc. 1024, 1928).

Huntsman, A. G.

1944. Fishery depletion. Science, Vol. 99, No. 2583, 1944, p. 534-535.

Jordan, David Starr, and Barton Warren Evermann.

1896-1900. The fishes of North and Middle America. Bull. U. S. Nat. Mus. No. 47, Pts. I-IV, (1896-1900), 3313 p., 392 plates.

Longley, W. H., [edited and completed by Samuel F. Hildebrand].

1941. Systematic catalogue of the fishes of Tortugas, Florida. Carnegie Institution of Washington. Papers from Tortugas Laboratory, Vol. XXXIV, Pub. 535, 1941, 331 p., 33 photos., plates.

Merriman, Daniel.

1941. Studies on the striped bass (*Roccus saxatilis*) of the Atlantic coast. U. S. Fish & Wildlife Service, Fish. Bull. Vol. 50 (Bull. 35, 1941), 77 p., 23 tables, 36 figs., extensive bibliog.

Mitchill, S. L.

1815. The fisheries of New York, described and arranged. Transactions, Literary and Philosophical Society of New York, 1815, Vol. I, p. 355-492, pls. I-VI. New York.

Nichols, J. T., and Charles M. Breder.

1926. Marine fishes of New York and southern New England. Zoologica: Scientific contributions of the New York Zoological Society, Vol. IX, No. 1, 1926, p. 1-192.

Parr, A. E.

1933. A geographic-ecological analysis of the seasonal changes in temperature conditions in shallow water along the Atlantic coast of the United States. Bull. Bingham Oceanog. Coll., Vol. IV, No. 3, 1933, p. 1-90.

Pearson, John C.

1929. Natural history and conservation of the redfish and other commercial sciaenids on the Texas coast. Bull. U. S. Bur. Fish., Vol. XLIV, 1928 (1929), p. 129-214, 44 figs. (Doc. 1046, 1929).

1938. The life history of the striped bass, or rockfish, *Roccus saxatilis* (Walbaum). Bull. U. S. Bur. Fish., Vol. XLVIII (Bull. 28, 1938), p. 825-851, 26 figs., extensive bibliog.

Pratt, Joseph Hyde (compiler).

1906. Report of Committee appointed by Governor R. B. Glenn to investigate the fishing industries in North Carolina. N. C. Geol. Surv., Economic Paper No. 13, 1906, 75 p.

Ryder, John A.
1882. Development of the spanish mackerel (*Cybium maculatum*). Bull. U. S. Fish Comm., Vol. I, 1881 (1882), p. 135-172, 4 plates.

Smith, Hugh M.
1907. The Fishes of North Carolina. N. C. Geol. & Econ. Surv., Vol. II, 1907, 453 p.

Stevenson, Charles H.
1899. The shad fisheries of the Atlantic coast of the United States. Rept. Comm'r. U. S. Fish., 1898 (1899), p. 101-269.

Townes, H. K., Jr.
1937. Studies on the food organisms of fish. A biological survey of the Hudson River watershed. State of N. Y. Conserv. Dept., Biol. Survey No. XI, Supplemental to 26th Ann. Rept., 1936, p. 217-230.

Truitt, R. V., and V. D. Vladykov.
1937. Striped bass investigations in the Chesapeake Bay. Trans. Am. Fish. Soc., Vol. 66, 1936 (1937), p. 225-226.

Vladykov, V. D., and D. H. Wallace.
1938. Is the striped bass (*Roccus lineatus*) of Chesapeake Bay a migratory fish? Trans. Am. Fish. Soc. 1937, Vol. 67, 1938, p. 67-86.

Wallace, David H.
1941. Sexual development of the croaker *Micropogon undulatus,* and distribution of the early stages in Chesapeake Bay. Trans. Am. Fish. Soc., Vol. 70, 1940 (1941), p. 475-482.

Welsh, William W., and C. M. Breder, Jr.
1923. Contributions to the life histories of Sciaenidae of the eastern United States coast. Bull. U. S. Bur. Fish., Vol. XXXIX, 1923-24 (1924), p. 141-201, 60 figs. (Doc. 945, 1923).

Worth, S. G.
1882. The artificial propagation of the striped bass (*Roccus lineatus*) on Albemarle Sound. Bull. U. S. Fish Comm., Vol. I, 1881 (1882), p. 174-177.
1883. A poor season for shad hatching in North Carolina. Bull. U. S. Fish Comm., Vol. II, 1882 (1883), p. 54.
1903. Striped bass hatching in North Carolina. Trans. Amer. Fish. Soc., Vol. 32, 1902 (1903), p. 98-102.

Yarrow, H. C.
1874. Notes on the shad as observed at Beaufort Harbor, North Carolina, and vicinity. Rept. U. S. Comm. Fish and Fish., Part II, 1872-3 (1874), p. 452-456.
1877. Notes on the natural history of Fort Macon, North Carolina, and vicinity. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXIX, No. 3, 1877, p. 203-218.

THE OYSTER AND OTHER MOLLUSKS IN NORTH CAROLINA

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CONTENTS

THE OYSTER

Ostrea virginica (Gmelin)

INTRODUCTION

Our native eastern oyster is one of nearly a hundred different species of oyster found throughout the world. It is distributed from the Gulf of St. Lawrence to Mexico and is the only species of commercial importance on the Atlantic and Gulf coasts. In 1940, according to Federal statistics, the harvest from these coasts amounted to 78.4 million pounds valued at 7.7 million dollars. Attempts to introduce the eastern oyster to the West Coast, first tried about 1872 (Moore, 1898) and in England, have not been very successful. The industry on the West Coast is dependent upon two different species, the native Olympia oyster (*O. lurida*) and an imported species, the Japanese or Pacific oyster (*O. gigas*). The commercial oysters of England and Europe are the European oyster (*O. edulis*) and the inferior Portuguese oyster (*Gryphaea angulata*).

Oysters have long been known and used for food. In historical interest they probably antedate all our commercial shellfish. They were highly valued by the ancient Greeks for therapeutic purposes as well as for food. At the height of the Roman Empire oysters were often gathered from the English coast for the famous banquets and feasts held in Rome. The Romans are believed to have been the first to cultivate oysters in Europe. Along the Atlantic coast of this country the many shell mounds or kitchen middens testify to the use made of oysters by the early American Indians. Perhaps the most famous of these shell mounds, located at Damariscotta, Maine, has been estimated to contain 8 million bushels of shells (Pease, 1932). Similar mounds were located on Harkers Island and Cedar Island in North Carolina. These were used as fill for road beds in the surrounding countryside during the decade following 1932.

It has been said that the oyster is scientifically the best known marine animal in the world (Clark, 1920); however, Galtsoff (1947) has recently pointed out the many gaps in our knowledge. Perhaps more has been written about oysters than of any other marine invertebrate, for the literature, both scientific and popular, is extensive. A recent annotated bibliography (Baughman, 1947) contains references to approximately 2,400 papers of scientific interest.

In North Carolina, as in many neighboring states, the oyster is the most valuable of the commercial mollusks and often exceeds in production all the other mollusks combined. However, in most states the production when compared to yields of fifty years ago has seriously declined. In the Chesapeake Bay area, for example, the average production of the past fifteen years has been but one third that of the decade between 1880 and 1890. The general decline in production is true for North Carolina. Concern has recently been expressed for the future of the industry in the southern states (Chipman, 1948). Through over-fishing, pollution, and lack of management of public oyster grounds, a shortage of this resource has developed in many states. The shortage has undoubtedly resulted in a decreased per capita consumption of oysters and a possible loss in popularity.

Since 1880 at least four surveys have been made of the waters of North Carolina with reference to their possibilities for oyster culture (Winslow, 1886; Grave, 1904; Coker, 1907; Galtsoff and Seiwell, 1928). The surveys express an opinion that potentialities exist for the development of a great industry. The industry has been slow to adopt modern methods of oyster culture through private enterprise or as a public venture, and many acres of potentially productive bottom continue to lie idle with little or no increase in total production. In the discussion that follows, an attempt will be made to point out the factors responsible for the general decline in production of oysters over the long period of years and for the neglected development of a potentially great industry.

HISTORY OF THE INDUSTRY

Oysters were undoubtedly an important part of the diet of the early settlers in the coastal regions of North Carolina. The oysters were harvested for a local market and supplied the needs of the small cities within access of the coastal regions. According to Ingersoll (1887), Wilmington and New Bern were the two important market centers for oysters prior to 1880. Winslow (1886) states that the beds in the region about Ocracoke Inlet are probably the most important in the State and supply chiefly the needs of the New Bern market. Other markets existed at Beaufort, Washington, and other small cities in eastern North Carolina. The lack of rapid transportation facilities and distance from the large centers of population were undoubtedly factors in keeping the industry from developing. Oysters were not shipped from North Carolina to the northern areas, for the abundance of oysters in Long Island Sound, Delaware Bay, and Chesapeake Bay supplied the needs of such cities as New York, Philadelphia, and Baltimore.

The industry in North Carolina did not become of importance until 1889, when a scarcity of oysters in the Chesapeake Bay region led to the establishment of a number of branch houses at various points in the coastal areas. With the branch houses came the experienced Chesapeake oystermen and their dredging fleet. The influx of these oystermen had a marked influence on oyster production in Pamlico Sound through the introduction of the more efficient dredging and tonging methods used in Maryland and Virginia. The production figures for Maryland and North Carolina for this period show the decline in Maryland to coincide with the sudden increased production for North Carolina (Table 1).

The exploitation of Pamlico Sound by the northern fleet was brief, for laws were immediately passed shortening the season and prohibiting nonresidents from dredging in the State. A marked decline in production resulted for the seasons of 1893 and 1896, probably because of the restrictive legislation, plus the depression of 1893. Meanwhile, local residents adopted the dredging methods that had been introduced. When the season was lengthened in 1897, production of oysters greatly increased. In 1898, according to Grave (1904), new and extensive beds were discovered two miles or more offshore in Pamlico Sound. More oysters were harvested that

TABLE 1

Oyster Production—Maryland and North Carolina—1880 to 1908 *

Year	Maryland	North Carolina
1880	10,600,000 bushels	170,000 bushels
1887	8,148,217	212,980
1888	8,531,658	204,703
1889	———	1,001,620
1890	10,450,087	807,260 (2,700,000 est.†)
1891	9,945,058	———
1897	7,254,934	858,818
1899	———	2,450,000 †
1900	———	1,900,000 †
1901	5,685,561	———
1902	———	1,022,813
1904	4,326,415	———
1908	5,830,000	753,500

* Statistics, except those marked †, revised by the U. S. Bur. Fish., to exclude, so far as possible, seed oysters, from Fishery Industries of the United States, 1930.

† Grave (1904).

season than ever before or since in the history of the industry. The supply seemed inexhaustible, and increased preparations were made for the next year. When the season of 1899 opened, oysters were scarce and the oystermen found it difficult to secure as bountiful a harvest as during the previous year. Grave (1904) states, "On the beds where a dredger could take 400 to 800 tubs of oysters per day during the season of 1898-99, the same men with the same equipment in December, 1900, could average but about 50 to 100 tubs." From personal experience while working in Pamlico Sound, Captain John A. Nelson, Commissioner of Fisheries for North Carolina, recalls the great abundance of oysters in 1898 and the relative scarcity the next fall. Some attributed this scarcity to over-fishing; others, to the severe storms that occurred in August and October of 1899, which were the most violent and destructive to the coast of North Carolina for many years. Grave (1904) investigated the area to determine the causes of the diminished catch and found that 23 per cent of the oysters were sanded in exposed areas. He concluded that "close and indiscriminate dredging has done more damage to the Pamlico oyster grounds in the past two seasons than any such storms as those of August and October, 1899...."

Federal statistics from 1900 to 1927 are spaced at intervals of from 2 to 8 years; the general trend in production through the intervening years was downward and reached a low in 1918. Between 1918 and 1923, production increased nearly threefold. There may be several reasons for this rise. The beds, possibly lying idle or worked at a minimum during the war years, had an opportunity to recuperate and to build up a natural supply in excess of the drain. During the early 1920's, the cull laws were more rigidly enforced, shell plantings were conducted, and many areas temporarily closed to fishing were opened at spaced intervals. During Governor Morrison's administration from 1921 to 1924, one and one-half million bushels of oysters and shells were planted. This shell planting program apparently had an influence on the rise in production in 1923 and was expected to be of continued benefit. However, following the 1923 production of 560,000 bushels, a decline occurred to a little over 400,000 bushels in 1928. There are perhaps two reasons for this decrease in production. In 1924 an epidemic of typhoid fever occurred in some midwestern cities which was presumably caused by the consumption of oysters. The panic which resulted in the oyster market along the eastern coast had a marked effect on production figures for the next few years. Scallops were rapidly gaining a ready market in North Carolina; therefore many of the small fishermen undoubtedly devoted their efforts to gathering scallops instead of oysters. The slight gain in production in 1929 was probably correlated with the prosperity of the times. Following the onset of the depression, production of oysters fell to an all-time low. The hurricane of 1933 caused untold damage to the outer banks, completely ruined the oyster beds in the Harbor Island region, and caused serious damage in other localities. In 1934 the State transplanted 825,000 bushels of seed oysters and planted 78,567 bushels of shells under the direction of Dr. H. F. Prytherch (Higgins, 1936). All the replanted areas were then closed for a period of two years. The opening of these areas in 1936 resulted in an increased production to the level of 1929. Since 1936 there has been a gradual decline until the period 1942 to 1946, when production gained slightly, presumably because of the unusually high prices received for oysters throughout the war years. During 1947 there was a gradual decline in production possibly because oysters were in a poor condition until late in the season. In the fall of 1948, with the opening of the season, oysters were in good condition and the market was favorable. There was some concern about a scarcity of market-sized oysters in Pamlico Sound after the season had been open for a month; however, production increased over the 1947 season.

The production figures, from available State and Federal statistics, for oysters through the years from 1880 to 1945 are tabulated in Table 2. The general trend in production with a maximum just before the turn of the century and a gradual decline in the ensuing years parallels the trend for the Chesapeake region.

NATURAL HISTORY

An understanding of the biology and life history of the oyster is important in oyster culture in order to carry out successfully a conservation

TABLE 2

Oyster Production of North Carolina, 1880 to 1948

	Bushels *	Value
1880	170,000	$ 60,000
1887	212,980	48,353
1888	204,703	46,129
1889	1,001,620	194,272
1890	807,626 (2,700,000 est.) †	175,567
1894	60,000 †	———
1896	40,000 †	———
1897	858,818	241,099
1899	2,450,000 †	———
1900	1,900,000 †	———
1902	1,022,813	268,363
1903	658,769 ‡	———
1904	505,141 ‡	———
1905	459,485 ‡	———
1906	291,846 ‡	———
1908	753,500	227,300
1910	332,257	63,405
1918	216,962	70,280
1923	559,628	229,576
1927	434,375	200,742
1928	414,241	167,490
1929	512,395	245,533
1930	411,354	155,148
1931	251,352	92,061
1932	210,395	51,339
1934	208,011	53,092
1936	500,101	160,631
1937	351,612	112,051
1938	334,170	98,468
1939	313,234	72,965
1940	204,260 §	52,560
1941	276,095 § ‖	———
1942	235,272 § ‖	———
1943	484,332 § ‖	———
1944	508,670 § ‖	———
1945	554,254	400,210
1946	391,521 § ‖	———
1947	200,323 § ‖	———
1948	223,680 § ‖	———

* Production figures from Federal statistics.
† Grave, 1904.
‡ Coker, 1907.
§ Yield from public grounds only.
‖ Figures based on tax return to N. C. Division of Commercial Fisheries.

program. Through trial-and-error methods and observation, oystermen have discovered the most favorable times to plant shells, to secure seed oysters and transplant young oysters. On a long-range basis the activities may coincide more or less with the events in the life history of an oyster; but for precise information, scientific observations are necessary each season to achieve the greatest efficiency in the management of public areas. In the brief review of the biology of the oyster, an attempt will be made to point out the importance of knowledge of the life history in regulating the various activities.

SPAWNING. In the late spring and early summer the reproductive organs or gonads of oysters become greatly distended and milky white in color; such oysters are designated "in milk." The sex of an oyster cannot be distinguished externally or from the extrusion of the sex products, as is often done in some species of fish. It is necessary to examine the sex products with the aid of a lens or microscope. Our native eastern oysters are generally considered of separate sexes.

Spawning occurs when the animals are physiologically ripe. The season of actual spawning varies with the ecological conditions of localities. In general, spawning first occurs in North Carolina in April or May and may continue until November (Grave, 1904). It was believed that spawning is directly correlated with water temperatures; however, in recent years evidence has been presented to show that such factors as salinity, tidal cycles, hydrogen-ion concentration, pressure, and phases of the moon may influence spawning activities. Temperatures at which spawning first occurs may vary from 16.4° to 25° C. (61.5° to 77° F.) (Nelson, 1928; Galtsoff, 1938; Loosanoff, 1939-b; Stauber, 1947).

Active spawning has been described as observed in nature and in the laboratory. During spawning, the shells of the female rhythmically open and shut about once every thirty seconds, expelling a fan shaped cloud of eggs. In the male the valves gape open slightly and a thin stream of sperm issues forth. In confined areas the surrounding waters may soon turn milky. The time of spawning is important, for preparations can be made for planting of shells. Some oysters spawn out completely in the early summer and may develop new sex products to spawn again in the same season, while other individuals may spawn over an extended period throughout the entire summer.

EARLY DEVELOPMENT. The development of larval oysters from the egg to the setting stage has been described by many workers (Brooks, 1880; Ryder, 1884; J. Nelson, 1910; Stafford, 1913; T. C. Nelson, 1921 and others). For a detailed account, reference should be made to these publications. The liberated eggs and sperm unite in the water each fertilized egg to form, in about four hours, a microscopic mass of cells capable of locomotion.

Within one day a complete animal with a shell and all necessary organs is developed. Gradual changes in size and shape of the larval oyster take place through approximately two weeks, after which the oysters cement themselves to various objects by means of a secretion from a gland in the foot. The attachment ends the free-swimming state of the oyster, and locomotive structures, such as the foot and swimming organ, disappear.

SETTING. The period of attachment or setting of the larval oysters is most important to the industry. At this time, shells or similar materials are scattered about to provide a solid substrate to which larval oysters may attach themselves. After the set or "spat" (as the young oysters after attachment are called) have been secured, the oystermen may transplant them to more favorable locations or allow development to an adult or marketable size to take place where attachment occurred.

Through microscopical examinations of water samples for the presence of larval oysters the period of setting can be accurately predicted. This information is of value when heavy sets are desired in order to have the shells or other collectors function most efficiently. Indiscriminate planting of shells, too early or too late in the season, may result in the shells becoming covered with various animal and plant life or with fine sediment, or failure of the oysters to secure the necessary substrate. Many studies have been made on the periods and intensities of setting. A comprehensive review of the literature on the subject was recently prepared by Korringa (1940).

RATE OF GROWTH. The rate of growth varies considerably with the locality and environmental factors. Salinity, food conditions, temperature, chemical constituents, type of bottom, and probably heredity all play an important role in controlling growth. Moore (1904) states that in South Carolina oysters not more than six or seven months old may reach a length of 2½ inches, and in some warm sounds of North Carolina an oyster may grow to 1½ inches in length in from two to three months. In the southern states a marketable sized oyster of from three to six inches may grow in less than three years. In northern areas, it may require four to seven years for oysters to reach the same size. An unusual growth rate was recently noted in North Carolina waters. Oysters which had set on shells planted in Bay River, a tributary of Pamlico Sound, during the summer of 1947 were found to be three to four inches long after 18 months. Information on periods and rates of shell growth are important in determining the most favorable times when oysters can be transplanted.

TEMPERATURE. Temperature plays an important role in the physiology of feeding, respiration, spawning, and shell growth, and has a direct bearing on the sanitary control of the industry. Experimental studies by Galtsoff (1928) have shown that at temperatures of 5° C. (41° F.) and below, oysters cease to function normally in their feeding and growth and go into hibernation. The optimum temperature for functioning of the gills is believed to be between 25° and 30° C. (77° to 86° F.). Through these gills water passes continuously when the shells are open; oxygen is absorbed; carbon dioxide diffuses out; and food is strained from the water. Above 30° C. (86° F.) the rate of pumping begins to decrease and ceases at about 40° C. (104° F.). Since these results were obtained experimentally in the laboratory, it is possible that in nature the normal activities may cease or decrease within different temperature ranges. During extremely hot weather oysters are believed to go into estivation—that is, summering, the opposite of hibernation or wintering. From observations in North Carolina waters it appears that growth rates are greater in the spring and fall.

SALINITY. Oysters are found growing in a wide range of salinity. Churchill (1920) gives the range from about 2.5 to 33 parts of salt per thousand and states that oysters cannot withstand salinities below 9 parts per thousand for prolonged periods. He places the optimum salinity between 14 and 28 parts per thousand. Hopkins (1936) has shown the effects of significant changes in salinity upon the feeding mechanism. He places the optimum salinity above 20 parts per thousand and possibly as high as 30 to 35 p.p.t. The rate of water pumping is generally higher at salinities of about 28 parts per thousand. The effects of salinity changes depend upon the degree of change and the conditions to which the animal has become accustomed through generations. From the point of view of the industry the minimum range of salinity is perhaps the most important.

TYPES OF BOTTOM. Although oysters are found growing on various types of bottom ranging from mud to hard sand, they survive best upon a firm bottom. Since oysters are immotile in the adult stage and cannot move about as clams and scallops do, bottoms which tend to shift or are of too soft a consistency might result in the smothering of the oysters. Oysters are occasionally found partly buried, with but a small portion of the shell extending above the bottom. This small portion is sufficient to allow the passage of water currents between the shells and enables the oyster to feed and grow. The organic and chemical constituents of the bottom may contribute necessary elements for growth of various food organisms.

FOOD AND FEEDING. The problem of what an oyster can utilize as food has attracted interest for over fifty years. Martin (1923) states that three theories exist regarding the nature of the food of oysters: namely, that plankton organisms constitute the principal source of nutriment; that nourishment is derived from detritus, the finely divided constituents of plant and animal cells; and that dissolved organic matter may be directly utilized. Of the three theories the first two are still prevalent, and possibly both are important. Many factors are involved in the physiology of feeding, such as the size of the particles, concentration of food, types of organisms, and proportion of inert matter ingested. Oysters are capable of pumping as high as 34 liters of water per hour while feeding for 94 per cent of a 24-hour period (Loosanoff and Nomejko, 1946). Thus, the concentration of food organisms is of importance in feeding.

Within the past decade the artificial enrichment of the waters through the use of various chemicals to stimulate growth of minute organisms (collectively known as plankton), has received a good deal of attention. Some promising results have been obtained in fish ponds. Production of oysters may possibly be increased through similar means. Studies of fattening methods are of importance since criteria of value have changed. The weight and volume of meat content are concerned in the evaluation of the product rather than bulk measures of oysters in the shell. The proportion of meats to the whole oysters may vary considerably. Poor oysters yield as low as three or four pints of meats per bushel; good oysters may yield up to eight pints of meats per bushel and in unusual cases yield as high as 12 pints per bushel. The significance of increased yields per given unit is evident.

SEX REVERSAL. The important phenomenon of sex change was first shown in the European oyster by Orton (1921) and in our native eastern oyster by Needler (1930), Burkenroad (1931), and Coe (1932). The studies have shown a correlation to exist between size of the oyster and sex, and between the age of the oyster and sex. Small oysters are predominantly males. Coe has shown that in the first year of maturity the percentage of males varies from 70 to 95 per cent. A differential rate of sex reversal appears with increase in age, resulting in an approximate equality in sex ratio. One significance of these studies to the industry may be in the cull laws that exist. Many states require the return of small oysters to the beds in order to insure a future supply of oysters. Such a procedure may possibly result in the removal of a greater percentage of large oysters which proportionally produce more sex products as well as the removal of a greater percentage of females. Thus a natural balance may be upset in some localities.

"COON" OYSTERS. In the waters of North Carolina and throughout the south there are found great masses of oysters growing in clusters on natural reefs along the shores. From the typical elongated, narrow shape they are commonly called "cat's tongue" or "coon" oysters. The name "coon" probably had its origin from the word raccoon, and is applied to these oysters supposedly because raccoons frequently feed upon oysters that grow on reefs exposed between tides. Grave (1904) says that the name is applied to the oysters because they resemble, in shape, the paw of a raccoon.

Although many believe that these oysters constitute a different variety, there is no definite basis for the belief. The elongated shape, which is generally in a vertical position, is attributed to the crowded conditions under which the oysters live or attempt to keep above the surface of the bottom.

Glaser (1904) showed that young "coon" oysters, when separated and given ample space, quickly recover from the elongated shape and grow into well-shaped oysters. The shape and condition of the oysters appear then to be due to environmental effects.

The presence of these oysters in waters of high salinity in North Carolina seems to indicate that some correlation exists between high salinity and the shape or condition of the oysters. Coon oysters are generally considered as worthless and inferior, and are used for the lowest grades in canning. They are, however, indirectly valuable to the industry in providing a source of spawn to replenish the seed supply in the immediate area.

ENEMIES. North Carolina is fortunate in that the enemies of the oyster are not as numerous as in many other oyster producing areas. Pamlico Sound is virtually free of predatory forms except crabs and some species of fish. The destruction by oyster drills, starfish, and conchs in Core, Bogue, and other sounds is perhaps small in comparison with that in other states. The boring sponge, *Cliona,* is known to cause damage to oysters in the North and New rivers area. Old (1941) reports five species of *Cliona* in the Beaufort area. The mud worm, *Polydora,* is prevalent in oysters from widely distributed areas in North Carolina. Heavy infestations are found in oysters from Bogue Sound and at Ocracoke Inlet. The various species of this worm have been described by Hartman (1945) for North Carolina. In the Beaufort area, Prytherch (1940) has reported oysters heavily infected with the sporozoan parasite *Nematopsis ostrearum.* The extent of damage by this parasite has not been reported. The occurrence of the parasite *Bucephalus,* the cercaria (larval form) of a trematode parasite *Gasterostomum,* has been found in oysters from Pamlico Sound and Newport River (Grave, 1904; Tennent, 1909). This parasite prevents the formation of reproductive elements and renders the host incapable of withstanding adverse conditions.

SANITARY REGULATIONS

From the standpoint of sanitary regulations the oysters sold for public consumption are among the purest food products on the market. Following the epidemic of typhoid in some midwestern cities which was presumably caused by eating oysters, strict rules and regulations were formulated by the Federal Public Health Service and the various state Boards of Health. North Carolina adopted the set of rules and regulations formulated by the United States Public Health Service in 1925. Within the past decade some remarkable advances have been made in the State toward the building and maintenance of sanitary shucking houses. The North Carolina State Board of Health surveys the waters of shellfish growing areas for indices of pollution and periodically examines the packing houses. According to Mr. N. McK.

Caldwell, Shellfish Sanitarian, over 27,000 acres of shellfish growing areas were restricted during 1948, chiefly in areas that are heavily populated.

FOOD VALUE OF THE OYSTER

Shucked oysters are one of the few animals that can be eaten in their entirety, either raw or cooked. In nutritive value, the oyster is fairly close to milk, which is often called the most nearly perfect food. Both are nutritionally balanced and contain the three classes of food stuffs: fats, carbohydrates, and proteins, but in different proportions. One pint of milk with a caloric value of 310 calories very nearly equals in caloric value (340 calories) one pound of high grade oyster meats (Pease, 1932). A combination of the two foods as in an oyster stew containing six oysters and eight ounces of milk contains ¼ of the vitamin B_1; ¼ of Vitamin B_2; ½ of the calcium; ⅓ of the phosphorus; ⅔ of the iron; and ⅕ of the vitamin A daily requirements (Bowes, 1943).

In addition to the organic foodstuffs and minerals, the oyster is a good source of vitamins, of which the present generation has become increasingly conscious. From the food the oyster gathers out of the surrounding waters, it stores and accumulates in various amounts the following vitamins: vitamin A, thiamin, riboflavin, ascorbic acid and vitamin D. The amounts of the various vitamins have been reported as follows per half pound of oyster meats (Newcombe, 1944):

Vitamins	A	B_1	B_2	C
Fresh Oysters	0.3 mgm	0.56 mgm	1.04 mgm	6.8 mgm

The nutritional value of oysters has perhaps been over-publicized as in the case of many other foods. There are many foods or synthetic preparations which would supply far more vitamins and minerals than oysters.

OYSTER CULTURE

Through the application of oyster culture, thousand of acres of once barren or unproductive river or bay bottom have been converted into valuable oyster producing areas. Many acres of potentially productive bottom underlying the waters of North Carolina are suitable for oyster culture.

The cultivation of oysters was practiced as long ago as the time of the Roman Empire and has been practiced in countries such as France, Holland, Australia, and Japan. It is not definitely known when or where oyster culture was first attempted in America, but as early as 1840 grounds were taken up in North Carolina for the purpose of growing oysters. Grave (1904) states that a Mr. Hardesty bedded a small quantity of oysters in the Beaufort region about the year 1840. Many other plantings were made until about 1859, but these beds were chiefly used to provide small quantities of oysters for family use rather than for commercial purposes. There were, between 1872 and 1898, a total of 1,200 grants for the purpose of oyster culture in Carteret, Dare, Hyde, and Pamlico counties. There were 828 grants in Carteret County with an average of nine acres each. Winslow (1886) reports that following the passage of laws in 1883 there was a great interest in taking up bottom for oyster culture. This interest died down until 1889 when, following the completion of Winslow's survey, more area was taken up than ever before. Winslow (1889) attributes this in part to the interest he stimulated through lectures given on oyster culture in the coastal region. Grave (1904) says that the completion of the railroad line from Jacksonville to Wilmington in 1890 was responsible for the renewed interest in leasing of bottom in Carteret County. In 1896 there was another revival of interest in taking up of grounds in Carteret County as a result of some successful plantings made in North River and Jarrett's Bay in 1891. It was believed that a good proportion of the bottom that was taken up was for speculative purposes and that of the number of grounds taken up few were ever used. The interest soon waned and Grave states that in 1899 there was not a single bed anywhere in North Carolina that he was able to determine "which was being cultivated or which was yielding or had yielded its owner an income in anyway commensurate with the labor and expense put upon it."

Oyster culture as a private enterprise has not progressed much in North Carolina since 1900. A number of grants made during this period are still being held, and a few of these are providing a source of income. The number of grants or privately leased areas is probably far less than the 1,200 grants that existed from 1872 to 1898. According to Mr. N. Webb, clerk, as of June 30, 1948, there were 264 leased areas with a total of 3,232 acres under the jurisdiction of the Division of Commercial Fisheries. There are in addition a number of old grants. Since the records of these are available only from county courthouse records the total number has not been ascertained. Except for a relatively few grounds under lease, the majority are being used primarily for the same purpose as fifty years ago, merely to keep a small amount of oysters to supply the family needs. There has been a renewed interest in the past six months (July, 1948, to January, 1949), in leasing small portions of bottom for oyster culture.

It would seem, as Grave expressed it in 1904, that oyster cultivation had been given a fair trial, had proved a failure and was a thing of the past, so far as North Carolina was concerned. The failure was more apparent than real in most cases and Grave sums up the causes for the failure as:

"1. Those individuals engaged or who have engaged in it, have, as a rule, had erroneous ideas as to the requirements for successful oyster culture...."

"2. Many of those who entered grounds for oyster planting did so with the expectation that large profits would be immediately forthcoming and were not sufficiently interested to continue in the work....

"3. The laws framed for the encouragement and protection of oyster culture were defective or have not been observed."

Grave (1904) conducted further experiments in the North and Newport rivers to ascertain thoroughly the possibilities of oyster culture. He states that on the whole the experiments were satisfactory but pointed out that the lower parts of the two rivers were not suitable for cultivation of market oysters but could be valuable for securing seed. The upper parts of the rivers are well adapted to oyster planting, but the industry could never be extensive on account of the limited area. Both areas have through the years continued to produce small quantities of market oysters from the upper regions of the rivers. The lower portions have not been utilized except for the gathering of "coon" oysters for the canneries.

One of the causes of the failure of oyster culture was, as Grave stated, that those engaged in oyster culture had an erroneous idea of the requirements for such a venture. Oyster culture consists of more than the mere shifting of oysters from a natural bed to an area under lease and keeping them until they grow or a favorable market develops. This practice is common in many areas and often is profitable. There are three distinct businesses which are recognized as oyster culture. These have been described in various ways but fundamentally they are: the production of seed; the growing of oysters from seed to marketable size; and the preparation of oysters for market.

Each of the three businesses may consist of several different activities. The production of seed requires preparations to secure a set of oysters. Spawning sanctuaries containing adult oysters are necessary to provide a source of spawn. At the right time it is necessary to plant shells or other material in the most effective manner.

The growing of oysters necessitates: first, the clearing of the ground upon which the oysters are to be raised; second, the transplantation of the seed to growing areas, usually to waters of a higher salt content than the area where the setting occurred. In growing oysters, the control of enemies is a vital factor in determining the ultimate yield that will be realized. The theoretical yield from a heavy set would probably exceed 50 bushels of market oysters from a bushel of shells planted. In the Delaware Bay region, oystermen who do not control enemies secure one to two bushels of market oysters for every bushel of seed planted. Those that practice some means of control realize a yield of four or five bushels of market oysters. In the Long Island Sound area, yields up to 8 bushels of market oysters are obtained from a bushel of seed planted when enemies are controlled. With new methods some oystermen are expecting to double this yield and secure from 14 to 15 bushels of market oysters per bushel of seed planted.

The preparation of oysters for market involves different procedures. Oysters for the shell trade may require the production of a uniform smaller sized oyster than those designated for a shucking house. Transplantation may be necessary to an area where a desired flavor will be obtained. Oysters going to shucking houses present the problem of securing the greatest yield of oyster meats from a given measure. Thus, it may be necessary to transplant oysters to areas that are rich in food organisms. Such areas may be produced in the future through artificial enrichment of the waters by adding necessary constituents to stimulate the growth of food organisms.

In areas where successful oyster culture is carried on, the methods differ considerably. The industry cannot be governed in its practices by any set of rules. In North Carolina, where oyster culture has not been extensively carried on, it would be necessary to determine which methods best satisfy the local conditions and, if necessary, to modify the procedures that are successfully being employed elsewhere.

THE OYSTER INDUSTRY

North Carolina has maintained a rather modest position in oyster production over the past fifty years. In 1940 North Carolina was third from the bottom of the list of oyster-producing states along the Atlantic and Gulf coasts. However, production in 1945 markedly increased to place North Carolina in sixth position among the same list of states (Table 3).

The bulk of the industry is located in the Pamlico Sound area. Although production of oysters has been of significance in Core and Bogue sounds and their tributaries, over four-fifths of the oysters are produced in Pamlico Sound and its tributaries. This is to be expected when one considers the vast area of Pamlico Sound, over 1,140,000 acres as compared to 105,000 acres for Core and Bogue sounds combined (Winslow, 1889). Only a small portion of this total area, however, is actually producing oysters. Winslow (1886) calculated over 10,000 acres as consisting of natural beds and estimated that between 609,000 and 807,000 acres were of possible and probable value for oyster culture. The acreage of natural oyster beds as given by Winslow is probably low, for Grave (1904) states that the natural beds of Hyde County, as determined by Stevenson from inquiries, were from 18,000 to 36,000 acres in extent. This apparent discrepancy was due to unawareness, at that time, of the existence of beds that were located nearly two miles offshore in Pamlico Sound, which were not discovered until nearly ten years after Winslow's survey. Many of the beds in the Pamlico Sound area that existed in Winslow's time are still more or less productive. A survey comparable to that conducted by Winslow has not been attempted

TABLE 3

Oyster Production, Atlantic and Gulf Coasts, 1940 and 1945

	1940		1945	
State	Pounds *	Value	Pounds *	Value
Massachusetts	383,600	$ 170,164	169,100	$ 101,680
Rhode Island	1,749,600	342,306	915,500	406,588 †
Connecticut	3,857,000	538,754	1,393,500	554,644
New York	7,067,200	1,403,068	5,073,500	2,067,276
New Jersey	5,941,800	711,610	7,747,800	3,065,625
Delaware	974,200	67,227	732,000	218,725
Maryland	19,743,200	1,644,497	15,033,500	5,261,725
Virginia	17,713,900	1,542,750	17,536,400	6,359,353
North Carolina	690,400	52,560 ‡	1,707,100	400,210
South Carolina	2,202,700	81,817 †	722,100	117,147
Georgia	264,800	15,178 †	255,100	50,026 †
Florida	877,300	61,898	1,633,300	780,026
Alabama	936,000	101,151	1,605,700	717,007
Mississippi	2,270,100	147,157 ‡	265,200	119,842 ‡
Louisiana	12,412,200	694,785	9,884,100	2,829,007
Texas	1,297,200	108,204	718,800	232,361 ‡
Total	78,381,200	$7,683,126	65,392,700	$23,281,242

* Edible meats, exclusive of shells.
† Yield from private grounds only.
‡ Yield from public grounds only.

since, but from many indications the changes would not be expected to be very great.

The oyster resources and industry of the State have been in more or less a static condition and present a problem peculiar to the area. When the industry of the State first became of recognized importance, the oysters were marketed through branch houses established in the area by Chesapeake dealers and canneries. These oysters were shipped to the Chesapeake area and sold chiefly through the Baltimore market as "Chesapeake oysters" (Grave, 1904). Although this procedure undoubtedly benefited the area economically at the time, it is perhaps unfortunate that this development occurred, for it has kept the North Carolina oyster from standing on its own merits. The bulk of the oysters produced at present continue to be marketed through the Chesapeake dealers.

The industry in North Carolina is virtually a free fishery and a seasonal occupation. There are few individuals that are wholly dependent upon oystering for their livelihood. This has a marked effect upon oyster production, for the individuals engaged in oystering depend upon fishing, shrimping, clamming, crabbing, and farming for their income. Although the oyster season comes when the other activities are temporarily curtailed by weather conditions, there is some overlapping between seasons. The individuals engage in the occupation that offers the greatest immediate financial returns.

The Pamlico Sound area is exceptional in that there is no concentration of the industry in any one locality. There are at present approximately 25 shucking houses in a variety of locations. Some are found along small creeks in remote places, others at some distance from good navigable waters and a few in good locations from the standpoint of a harbor and transportation facilities. The industries in the north have been developed, on the whole, around a central location. To cite a few examples, in the Chesapeake Bay area Baltimore was the first marketing center; then the Hampton Roads area in Virginia and Crisfield, Maryland, were developed as marketing centers. In the Delaware Bay area, the oysters have been marketed for many years through Bivalve, New Jersey, where at present there are located 15 shucking houses within the radius of one mile. Circumstances have dictated the use of much hand labor in carrying out some of the activities concerned with the industry in North Carolina, because of the locations and lack of facilities, and thus prevent the use of labor saving devices and mechanization.

DISCUSSION

Many factors favor North Carolina as an oyster producing area. The first and perhaps most important is an abundance of seed. This has been a factor in limiting the supply of marketable oysters in other states. The abundance of available sets of oysters in Core and Bogue sounds and other localities has not been utilized and remains undeveloped. The natural beds have in general been supplied by a natural restocking.

The quality of oysters is generally good and compares favorably with oysters from the northern areas. Winslow (1889) says of the oysters in the New River area, "Probably no better stock can be found anywhere in the world." Galtsoff and Seiwell (1928) state that the beds along the Neuse River produce oysters of good quality and from the Point of Marsh area, "the oysters are well shaped and appear to be of excellent quality." Conditions have changed in some of these areas but many beds at present produce high quality oysters.

North Carolina appears to be ideally situated, geographically, for oysters. It is located about midway between the extremes in the range of distribution. The winters are not severe, nor are the summers extremely hot. These conditions have a definite relationship to the growth and feeding of oysters. It is possible to produce an oyster of marketable size in two years or less. This growth rate is close to the minimum. Although oysters throughout the south are in general not as firm in body as northern oysters, the North Carolina oyster can compete with northern oysters. The fact that North

Carolina oysters have since 1890 been sold as Chesapeake oysters is testimony that should not be overlooked.

The relative absence of the many enemies of the oyster in its waters favors North Carolina as an oyster-producing area. It is necessary in such oyster-producing regions as Long Island Sound and Delaware Bay to practice control of enemies if a maximum production is to be attained. North Carolina has indeed been fortunate not to be concerned with pollution in Pamlico Sound. During 1948 there were no areas closed to oystering in Pamlico Sound because of pollution.

The conditions briefly discussed above all point to the possibilities that exist for the development of a great industry. Since the time of Winslow's survey, the potentialities have been frequently noted with an emphasis upon private leasing for oyster culture. This is the supposed solution to the problem of increasing oyster production and development of the industry. The repeated failure of private oyster culture appears to be discouraging. The conclusion could be drawn that future attempts would not be successful. The industry in general has not made much progress, in spite of the favorable conditions that appear to exist for the area. Perhaps many explanations are to be offered.

The lack of education concerning oysters had undoubtedly much to do with the failure of oyster culture in the past. However, all the answers to the practical problems of the oyster planter are not known (Galtsoff, 1947). The scientific workers have been too few and have often had too little time to devote to the necessary studies. The public and the industry are often too impatient for results and for authoritative advice to allow the scientists time to complete their studies.

Oystering requires a good deal of experience and common sense in applying the known information. Good results can be secured through trial and error, but many persons have undertaken oyster culture without the necessary experience and knowledge of water conditions, type of bottom, and other pertinent information. The necessary capital for initial investment has often been lacking to those that might be interested in cultivating oysters. This is true in fishing, shrimping, and crabbing, but in these activities the returns are more or less immediate and the dealers often will risk short-term loans for nets, gasoline, and supplies. Since oyster culture, because of past failures, does not have a good reputation and doubt exists as to its practicability, individuals may find it difficult to secure long-term loans for engaging in it.

A man must have a strong incentive to engage in such a business as oyster farming. Many facts may readily discourage such attempts. The present regulations are restrictive in nature with limits placed on the number of acres an individual can lease in North Carolina. In Pamlico

Sound the maximum acreage that can be leased by an individual, firm, or corporation is two hundred acres, but leasing of bottom is prohibited within the waters of Pamlico and Hyde counties. In the various tributaries the maximum is fifty acres. The Department of Conservation and Development has the authority to specify the acreage any one person may lease in Pender, New Hanover, and Brunswick counties. It is doubtful that developing such small plots of ground as fifty acres could be profitable. Many who are interested in leasing bottom and attempting oyster culture will not do so because of the lack of protection afforded to their holdings. Persons living close to the water's edge have leased bottom, where they can readily watch the area, but too often such locations are not the best suited for growing oysters. The number of areas that fulfill this prerequisite are naturally limited.

Other causes contribute to the static condition of the industry in North Carolina. With its first development in 1890 to 1900, oysters were shipped to the Chesapeake area and marketed as Chesapeake oysters, as already stated. This condition still exists and the majority of the oysters produced in Pamlico Sound are sent to Baltimore markets for reshipment. The Pamlico Sound area has been depending in the past upon a market that would come to it, rather than aggressively striving to create a market of its own. This attitude has placed the oystermen in a position where they are more or less dependent upon the weather. When severe winter weather makes it difficult to harvest oysters in the north, a market demand arises in North Carolina. During warm weather, the oystermen engage in activities on land or in fishing until a demand for oysters is created. In some instances the oyster dealers have recognized the disadvantages of this situation and are attempting to create markets for their products.

The position of North Carolina in the south creates a condition that is not always desirable. Oysters may develop their sex products to spawn in the fall months, with the consequence that they are in poor condition immediately after spawning, and yield a low volume in meat content. A month or longer may be required to recover from spawning, so that the first oysters to go to market in the fall may be in poor condition and cause the dealers and buyers to seek other sources.

The oyster industry in the northern areas, where it is chiefly controlled by private enterprise, has become highly mechanized, with new methods and ideas constantly being applied. The result is that greater investments are incurred and an effort is made to produce high quality products in as great a quantity as possible. In areas such as North Carolina, the emphasis is more on quantity than quality, and in order to compete with quality it is necessary to undersell and thus offer a lower grade product to the ultimate consumer. The effects of this are often disadvantageous.

An undesirable feature of southern oysters is the presence of pigmentation on the mantle which causes a dark color. Similar oysters are sometimes encountered in Chesapeake Bay but they are common in North Carolina and become more prevalent further south.

The natural beds of North Carolina differ markedly, in one respect, from those in many northern areas in that there is very little substratum. The beds are situated on the surface of a sandy or firm muddy bottom with very little depth of shells. Intensive dredging of the beds soon removes this layer, and the recovery becomes a slow and prolonged process, unless shell plantings are made and oysters returned to the bed to build up a future supply.

In spite of the many obstacles that present themselves in the path of the development of a great industry, the North Carolina waters appear to contain potentialities. In a consideration of the many factors involved, oyster culture has not been given a fair trial. Many unproductive, barren areas lie idle and undeveloped. In some cases, production could undoubtedly be increased from five- to tenfold if efforts were made toward this end. From the biological point of view, Pamlico Sound offers a promising field and appears to be favorable for developing a much greater industry than now exists. In order to promote and achieve this aim, a coordinated effort will be needed through a program of education, demonstration, and continued study of the problems peculiar to the area. Some changes may be necessary in the existing legislation in order to assure progress toward a greater oyster industry in the State.

THE HARD CLAM

Venus mercenaria (Linnaeus)

INTRODUCTION

The hard clam is known by various names: "little neck," quahaug or quohog, hard-shell clam, round clam, and "cherrystone." Its specific name, *mercenaria,* is believed to have originated in the use of the shell by Indians for wampum. The shells were cut to divide the purple and white portions, the purple color being the more highly valued. Although the hard clam is essentially a southern or warm-water form, the bulk of the production is from New England and Long Island Sound. The total production of hard clams from the Atlantic coast in 1940 amounted to nearly 13 million pounds of edible portions, exclusive of shells, valued at nearly two million dollars (Table 4).

According to Dall (1889) there are twelve species of *Venus* along the southeastern coast, eight of which are reported from the waters of North Carolina. The species *mercenaria* is the only one of commercial impor-

TABLE 4

Atlantic Coast Production of Hard Clams *

	1940		1945	
State	Pounds *	Value	Pounds *	Value
Maine	5,000	$ 425	489,400	$ 91,942
Massachusetts	2,411,100	336,251	2,295,600	675,338
Rhode Island	1,978,000 †	237,311 †	1,910,900 ‡	524,365 ‡
Connecticut	59,000	9,734	41,800	14,797
New York	2,807,700 †	478,800 †	3,401,700 †	2,068,370 †
New Jersey	2,366,300 †	340,101 †	4,837,700 †	1,629,469 †
Delaware	33,400 †	4,380 †	31,100 †	9,352 †
Maryland	78,900	17,250	119,300	62,036
Virginia	1,764,100 †	352,460 †	1,010,400 †	525,408 †
North Carolina	530,200	45,067	502,200	151,447
South Carolina	2,900	203	1,300	375
Florida	707,800	67,368	690,700	173,425
Total	12,744,400	$1,889,350	15,332,100	$5,926,324

* Edible portions, exclusive of shells.
† Includes yield from private grounds.
‡ Exclusive of ocean quahaugs—1,311,900 pounds, valued at $109,387.

tance, although *Venus mortoni* is the form commonly harvested in the Florida waters (Fiedler, 1943). The range of the hard clam is from the Gulf of St. Lawrence to the Gulf of Mexico, where it was first reported in Louisiana by Kellogg (1905). In North Carolina, clam beds are located in the sounds near the inlets in relatively saline waters.

In comparison to the oyster, the literature on hard clams is meagre. Kellogg (1900-a, 1901, 1903) and Belding (1909, 1912) were among the pioneer workers in the field. Since then there has been little published on this form except for Loosanoff's studies on gonadal changes and spawning (1937-a,b, 1939-a). Recently there has developed a stimulus for research on hard and soft shell clams along the Atlantic coast as a result of appropriations from the Federal Government and of private grants. Little or no scientific studies on hard clams or the clam industry in North Carolina have been published. However, the known information on the biology of the clam would hold true in general for clams native to North Carolina and would form a basis for future studies.

NATURAL HISTORY

The sexes in the hard clam, as in the eastern oyster, are separate; but also as in the native eastern oyster, clams are capable of changing their sex. Nearly all the young clams first develop as males, approximately 50 per cent becoming females during the second year (Loosanoff, 1943). The development of spawn in the clam has been described in detail by Loosanoff (1937-a). Soon after spawning has ceased in the fall, the sex products commence to develop, often reaching maturity by mid-winter, but because of cold temperatures, spawning of the new generation is delayed until the next spring. Normally the ovaries and testes are white in color, but in old clams they may have a reddish or yellow tint (Kellogg, 1903). Spawning is believed to be directly correlated with temperature, but other factors may exert an influence making it as complicated as it is in the oyster. Belding (1912) found spawning to occur in Massachusetts from mid-June to mid-August, commencing at a temperature of 76° to 77° F. (23-25° C.). Loosanoff (1937-b) found spawning to occur earlier at about 73° F. and to continue for a longer period in Long Island Sound. Studies have not been conducted in North Carolina to determine the period of spawning but it would be expected that spawning occurs earlier in North Carolina and continues longer than it does in the north. Some practical clammers and dealers believe that hard clams may spawn throughout the year in North Carolina, especially during mild winters.

Sexual maturity in the clams occurs at a very early age. Loosanoff (1943) states that young clams may spawn at an age of three or four months, but the majority spawn after they reach their first year. Belding (1912) found on an average, that clams must be two years old before they spawn. He states that "little necks" and "blunts," or old clams, do not spawn and that only the small "sharps" (2½ to 3 inches) and large clams (3 to 3¾ inches) spawn, although both "little necks" and "blunts" contain varying amounts of spawn.

The embryology and early development of the clam are similar to that of the oyster. The sex cells are extruded into the mantle cavity and pass out of the animal through the excurrent siphon (Belding, 1912; Loosanoff, 1937-b). After fertilization of the eggs in the water, cell division occurs and continues until a small mass of cells capable of swimming is developed. Within 36 hours a small shelled animal called the veliger results. Increase in size continues during the next 6 to 12 days, when free swimming ceases and attachment of the larval clam occurs. Meanwhile, a byssal gland has developed in the foot. This gland secretes a substance which hardens on contact with the water to form a tough thread, called a byssus, by means of which the larval clam attaches to or "sets" upon such objects as seaweed, stones, and shells. This attachment marks the transition period between the free swimming stage and the beginning of the adult.

The primary function of the byssus is believed to be protective, for the young clams are liable to be covered by fine silt and mud or be washed ashore during strong winds. Attachment in a suitable location thus protects the small clams and affords them an opportunity to grow to a size when they burrow in the sand and are said to "set." Since setting frequently occurs below the low tide level, "sets" often pass unnoticed. There is a need for the development of commercial methods for collecting clam sets during these periods.

In the adult stage the hard clam differs markedly from the oyster in that the clam retains power of locomotion. The adult clam possesses a well developed foot which it uses to burrow, to crawl for short distances, and to turn over. Although hard clams can crawl, there is little migration of the clams from the areas where they set. Belding (1912) shows that the average distance traveled in 38 days was two inches, with a maximum of six inches, from the spot where the clams were first bedded.

The adult clams do not bury themselves very deep, for they feed through siphons which extend to the surface. The siphons are short (about one inch), in comparison to those of the soft clam (*Mya*), which extend about six inches. Hard clams rarely bury themselves to a depth greater than the length of the shell. The depth to which clams burrow appears to be correlated with periods of feeding, water temperatures, and tidal cycles.

ECOLOGY

CURRENTS. Many of the early investigators of oysters and clams (Lotsy, 1895; Moore, 1898; Kellogg, 1900-b, 1903; Grave, 1904; Belding, 1909, 1912) emphasized the importance of water currents, which they correlated with feeding. Presumably the greater the current, the more food is available to the animal. Nelson (1947), however, has recently shown the importance of the bottom microorganisms in the food supply. Currents do play an important role in replenishing the oxygen supply and in carrying away the metabolic waste products.

DEPTH OF WATER. Belding (1912) reports that hard clams live as well in the intertidal zone as at depths up to 50 feet. They are most frequently found on the flats in relatively shoal waters, a few feet below the low tide zone.

SOIL. Clams grow in a variety of bottoms ranging from sand to gravel and rocks. A bottom consisting of an equal mixture of mud and sand is considered the most favorable. Such a bottom not only makes it easier for the clam to burrow but greatly facilitates harvesting of the crop. Soils that contain organic acids may cause corrosion of the shell and retard the growth of clams.

SALINITY. There appears to be a rough correlation in North Carolina between the distribution of clams and salinity. Clams are confined to areas of higher salinities than the oyster and are rarely found in the western and northern Pamlico Sound areas where the salinities range from 8 to 20 parts per thousand. Belding (1912) states that salinity has little effect on clams.

He reports clams growing in waters of densities ranging from 1.009 to 1.026 with no apparent differences in rates of growth. Loosanoff (1943) reports that natural clam beds occur in brackish water with salinity ranges from 10 to 28 parts per thousand and that clams can tolerate wide fluctuations over short periods.

Following the hurricane of 1933, which caused great damage to the outer banks of North Carolina and ruined the oyster beds in the Harbor Island region, a great abundance of clams appeared in the vicinity. Prior to 1933, clams did not exist in commercial quantities in the northern part of Core Sound from Atlantic to Wainwright Island. The appearance of clams in this area seems to be correlated with the increase in salinity due to the new inlets cut through the banks, particularly Drum Inlet. Galtsoff and Seiwell (1928) report the average salinity for this locality as 23 parts per thousand. In August and September 1948 the salinity in this area was 32 parts per thousand. The increased production of clams in 1936 is attributed to the abundance of clams in this region. In recent years these clam beds have been productive and of importance because of their accessibility to the marketing centers.

GROWTH. Hard clams grow more slowly in northern waters than the other economic mollusks. In the New England area, the average size of a clam at the end of the first growing period (i.e., from the fertilization of the egg to cold weather) is less than a quarter of an inch. About four and one half years are required to produce a clam three inches in length. Kellogg (1903) states that the growth of clams is greatest in the intertidal zones where they are exposed for intervals each day. However, Belding (1912) says that clams which are covered constantly by water grow more, for they are able to feed for longer periods. Belding's experiments show that 14-millimeter clams have the greatest growth rates; that above this size the amount of new shell laid down diminishes with increase in age. Crowded conditions may result in competition for food and space; but often under such conditions clams are forced out of the bottom and exposed to enemies. Belding (1912) found that "sharps" do not result from the planting of "blunts" and concluded that shell growth once retarded, as in "blunt" clams, does not readily recover.

TEMPERATURE. In the colder waters, shell growth does not occur during the winter months. Belding (1912) showed that shell growth commences when the water temperature reaches 49° F. (9° C.) and ceases when temperature declines to about 45° F. Loosanoff (1939-a) has confirmed this, showing that hibernation begins soon after the temperature decreases to 5 to 6° C. (41 to 43° F.).

ENEMIES. The youngest stages are exposed to more enemies than the adults. Fish, crabs, various snails, and starfish prey upon the young clams before they have an opportunity to bury themselves. The adult clams are protected by their shells and by their location below the surface of the bottom. Among the enemies that attack adult clams are the clam borer (*Polynices*), conchs (*Busycon*), and starfish.

CLAM CULTURE

There is no evidence that attempts have been made to cultivate clams in North Carolina. At present several beds which are used solely for clams are under lease, but these areas are for the temporary bedding of surplus clams until a favorable market develops. Many areas exist in the State where cultivation of clams could be successfully carried on for these clams are hardy and capable of living on many types of bottom at various depths.

The decreased clam supply in the northern states has provided an incentive to cultivate clams in that region to augment the decreased natural supply. Since this condition has not been prevalent in North Carolina, little attention has been given to cultivation.

In those states where clam culture has been attempted, it has not become as highly developed as oyster culture. The many factors to be considered for such a venture to be successful are similar to the requirements for successful oyster culture. Two alternative methods of clam culture can be considered. It may be carried on by the State through seeding of public areas or by private interests in the development of an industry. The success of clam farming depends upon the selection of locations that fulfill certain prerequisites. The grounds should be accessible to good roads or marketing centers. The depth of the water should be considered in determining the methods to be used in harvesting the crop. It is necessary to locate the beds in areas protected from adverse climatic conditions, and sometimes the problem of pilfering becomes a serious one. Other desired features are the nearness to a seed supply, distance from sources of pollution, and the flavor of the clams from the particular locality.

In cultivating clams, the planting of seed would normally be the first procedure. The local conditions regulate the number of clams to be planted, with an average of 20 small clams planted per square foot. The expected yield, according to Belding (1912), from a planting of 20 clams per square foot would be about 1200 bushels of 2½ inch clams per acre.

The desired aim of clam farming is to produce clams that are uniform in size and to maintain a population of various size groups that command the best prices.

THE CLAM INDUSTRY

In North Carolina the bulk of the clams are produced in Core and Bogue sounds. The clams are sold chiefly in the shell and graded according to size.

Four grades are generally recognized: Cherrystones, little necks, large, and chowders. Since cherrystones and little necks usually command the highest price, this represents a situation that differs markedly from the marketing of the other commercial mollusks in that usually the larger sizes are desired. Clams for shucking purposes are generally sold by weight in North Carolina; a basket weighing ninety pounds is the usual measure. The price received by the clammers depends upon the market demand, size of the clams and condition of the meats.

Hand labor is used in the harvesting of clams in North Carolina. Clams are gathered by raking in shoal areas or by the use of tongs in waters up to 20 or 25 feet deep. In some cases the clams are treaded; that is, the clammer will go overboard to feel the clams with his feet, and pick them up by hand. In other areas along the Atlantic coast clams are harvested by dredging. Dredging is permitted in Carteret County of North Carolina, but very little is done because the area does not lend itself readily to the usual dredging methods. An illegal method often employed by fishermen with small motor boats is to anchor the boat by the stern, in shoal water, and wash the clams out by the propellor wash. This method can be quite effective, but often causes considerable damage to clam beds and should not be encouraged.

The clam producing areas of North Carolina are confined to the regions coming under the influence of the various inlets through the banks. The clams are marketed chiefly from Atlantic, Williston, Beaufort, Davis, Swansboro, Wilmington, and Southport with a limited number from the Hatteras area marketed through Englehard. In recent years the largest dealer in clams markets fresh shucked clams destined for the manufacture of clam chowder by food processing concerns. The bulk of the crop harvested in Core Sound and from the Ocracoke area is handled by this firm.

The production of clams in North Carolina, according to Federal statistics, shows a peak production of clams about the year 1902 (Table 5). This large production is attributed to the establishment of a firm at Ocracoke by Mr. J. H. Doxsee.

The following information concerning the Doxsee plant was supplied by Mr. R. S. Wahab, Ocracoke, North Carolina, who was employed at the plant during 1903-1904. Mr. J. H. Doxsee, Sr., came to Ocracoke in 1898 from Long Island and established a clam factory at the entrance to Silver Lake. Clams were bought at forty cents per bushel from Bogue Sound to Hatteras Inlet and processed at the plant as clam juice, clam chowder, and whole clams. Many of the cans were labeled as quahaugs with the origin as Islip, Long Island. Mr. Wahab estimates that as many as three thousand bushels of the clams were canned from March 1 to October 1 during

TABLE 5

Hard Clam Production, North Carolina, 1880 to 1948

	Pounds *		Value
1880	310,000		$ ———
1887	78,000		3,233
1888	148,000		6,150
1889	155,000		8,265
1890	226,000		12,090
1897	938,000		53,703
1902	1,175,000		86,662
1908	726,000		82,000
1918	197,000		46,598
1923	263,000		64,064
1927	315,000		70,940
1928	324,000		61,168
1929	380,000		59,843
1930	317,000		40,680
1931	332,000		30,775
1932	261,000		17,278
1934	338,000		33,647
1936	839,000		75,326
1937	430,000		34,343
1938	358,000		27,756
1939	628,000		50,360
1940	530,000		45,067
1941	1,302,000	(170,264 U.S. bu.) †	———
1942	502,000	(65,592 U.S. bu.) †	———
1943	260,000	(34,005 U.S. bu.) †	———
1944	343,000	(44,825 U.S. bu.) †	———
1945	502,000		151,447
1946	227,000	(29,717 U.S. bu.) †	———
1947	243,000	(31,878 U.S. bu.) †	———
1948	207,000	(27,110 U.S. bu.) †	———

* Production figures of edible portions from Federal statistics except as noted.

† Figures based on tax returns to N. C. Division of Commercial Fisheries, bushels converted to pounds by the factor of 7.65 lbs. per bu.

the peak of operations. After about three years of apparent success, the clam supply diminished and the plant moved to Witt (now Sea Level), North Carolina, just shortly after Mr. Doxsee died. The business was then taken over by his son, Harvey Doxsee. Later the plant moved to Marco, Florida. Following this period, production in North Carolina gradually declined until 1918 and remained below 400,000 pounds until 1934. Immediately after the hurricane of 1933 clams appeared in great abundance in upper Core Sound, as mentioned above.

The production of clams appears to be influenced by other fishing activities to a considerable extent. The amount of hand labor and difficulty of working conditions often discourage local fishermen from clamming except as a last resort. Weather conditions exert a profound influence in the local area, for the men usually gather clams while wading on the flats, often in water up to their armpits, during the summer months.

DISCUSSION

The potentialities for increased production of clams appear to be great in North Carolina, the resource being virtually untapped in some areas. A limiting factor is the lack of ready transportation facilities from such isolated areas as Ocracoke and Hatteras, where reports indicate that a bountiful supply of clams exists. In addition to the transportation problem, a constant supply cannot be depended upon because of the methods used in harvesting and the unreliability of the clammers. Ingersoll (1887) states that some years previously, Virginia dealers sent boats to the sounds of North Carolina, particularly to Ocracoke Inlet, to buy clams, but the venture proved unprofitable because of the long voyage and because clammers could not be relied upon to secure clams when a vessel arrived. Dealers at present often complain that they are not able to fill orders because of the unreliability of clammers. The uncertainty of labor could be overcome by employing some of the new mechanical methods that have been developed recently, such as the Brown Shellfish Harvester and the Jurisich Oyster-Clam Harvester.

The clam does have several distinct advantages over the oyster in the marketing problem. The "R" month tradition has a marked influence on the oyster market during the summer months, whereas clams are salable throughout the year and provide a non-seasonal occupation. The meat content of oysters is greatly influenced by the spawning periods, for the meat volume immediately after spawning is below the minimum to market oysters profitably. This condition exists in the clam to a limited extent, but by the presence of the muscular foot, the volume of meat is kept at a higher level.

In the past the bulk of the clams was marketed through brokers or were shipped to the Baltimore market for reshipment. In recent years the larger dealers have attempted to create their own market for their product, but their lack of knowledge in marketing methods often is a handicap. The sale of clams for the shell trade requires careful grading of the various sizes, for grading has a definite influence on the price received for the product. The various grades are chowders, cherrystones, little necks, and large clams. These in turn command the following price ranges, to illustrate from prices at New York in March, 1949: chowders—$2.50 to $3.00 per New York basket; cherrystones—$5.00 to $5.50; large—$4.50; little necks—$6.50 to $7.50. The wholesalers and large retail dealers are more familiar with the methods of grading than the clammers and small local dealers who often do not receive the maximum market price because of poor grading.

Future scientific studies are necessary before recommendations can be made concerning clams and procedures in clam farming. The hard clam resources of North Carolina represent perhaps the most promising field for immediate development if a steady market could be established. Clams are abundant in many localities but are not harvested because of the lack in market demand and often because rigorous labor is involved. Potential clam dealers should be encouraged to engage in the industry and progressive individuals could readily overcome such a problem as uncertain labor.

THE SCALLOPS

Pecten species

INTRODUCTION

The scallop has been said to rival the oyster in historical interest. The beauty of the shell has probably attracted more attention than the edible portions contained within, for the shell has been copied for ornamental purposes since medieval times. The shells found in kitchen middens show that the edibility of the scallop was known to the early American Indians.

Throughout the world there are a number of different kinds of scallops. Some of the European species are distinct from those along our Atlantic seaboard and on our west coast. Seven species have been reported from the waters of North Carolina (Dall, 1889). The two species gathered for commercial use along the Atlantic coast are commonly distinguished as the bay scallop (*Pecten irradians,* Lamarck) and the giant or sea scallop (*Pecten grandis,* Solander.) The distribution or location of these two forms is indicated by the common names, one being found in the shoal waters of protected bays and estuaries while the other is found in the deep waters overlying the continental shelf off the coast. This review is concerned primarily with the bay scallop, the only species that has been of commercial importance to North Carolina.

The bay scallop is a marine bivalve mollusk with roughly rounded shells containing a series of ridges spreading fanlike from the long, straight hinge. The shells are secured at the hinge by a flexible ligament and a small cartilage which tend to keep the shells open. This action is antagonistic to the adductor muscle, located nearly in the central region of the shell, which when contracted keeps the shells closed in the living animal. The adductor muscle comprises the scallop meats marketed for consumption. This is often the only portion of the scallop with which the average person is familiar.

The range of the bay scallop is from Nova Scotia to Texas (Dall, 1889; Kellogg, 1905). Commercially, the northern limit of the scallop is at Cape

Cod and the southern limit at Florida. However, not all the states within these limits market scallops. Commercial quantities of bay scallop are gathered in Massachusetts, Rhode Island, Connecticut, New York, Virginia, North Carolina, and Florida.

Since 1930 the production of scallops has been small and in many areas, including North Carolina, the industry has become virtually non-existent. There appears to be a definite correlation between the disappearance of eelgrass (*Zostera*) from the coastal regions and decline in production of scallops during this period. Table 6 contains the production figures for the Atlantic coast during the years 1929, 1937 and 1940. Production has declined in all states, except Florida and Rhode Island.

TABLE 6

Production of Bay Scallops

	1929	1937	1940
	Pounds *	Pounds	Pounds
North Carolina	686,220	61,900	33,800
Florida	24,094	118,600	128,400
New York	619,626	36,000	19,300
Massachusetts	1,498,240	1,292,100	870,300
Rhode Island	98,948	99,400	222,500
Connecticut	———	89,600	38,600
Virginia	1,145,598	———	———
Maine	———	71,400	———
Total	4,072,726	1,769,000	1,312,900

* Weights of scallops refer to edible portions, exclusive of shells.

NATURAL HISTORY

The early development of the bay scallop is essentially the same as the other bivalves discussed herein, the oyster and clam. Since both sex products are present in a single individual, it is a hermaphroditic form. The ovaries and testes are located in separate places and self-fertilization is believed to occur seldom. In the process of spawning the scallop usually discharges one kind of sex cells at a time, although Belding (1910) reports a few instances when a mixture of both eggs and sperm were observed on the first discharge. Spawning occurs under natural conditions when the water temperature rises to 61.5° F. in June (Belding, 1910). However, Gutsell (1931) found spawning to occur in North Carolina when the water temperature was declining in the autumn, and to continue until January. Both authors report that spawning generally continues over an extended period rather than a complete discharge of the sex products within a brief time. Although self-fertilization is supposed to occur but rarely, both Belding and Gutsell were successful in securing fertilization experimentally from the sex products of one individual.

Fertilization of the egg occurs in the water. Differential development takes place during the first hours after fertilization, followed by the earliest larval stage (trochophore) which resembles an annelid or worm larva. At this stage the animal is capable of some locomotion with the aid of fine hairs (the cilia and a flagellum). The velum, a ciliated swimming organ, soon develops, and the animal is then in its veliger stage. During this stage the shell (prodissoconch) quickly develops and covers the animal, forming the typical straight-hinge larva of the bivalve mollusks. Belding obtained the straight-hinge stage in 17 to 40 hours. Gutsell did not obtain this stage until 42 to 48 hours at 25° C. In four or five days some marked changes occur, such as the appearance of a well developed foot, complete alimentary tract and changes in the shell to resemble the adult. The characteristic ribs of the shell appear when the animal has reached a size of about one millimeter (1/25 inch).

At this stage (dissoconch) the animal begins a crawling habit and can attach by means of fine threads, or byssus secreted by a gland in the foot. By this means a "set" of young scallops results when attachment is made to eelgrass, stones, shells, or other similar material. The young can cast off or break the byssus at will to spin another. Thus, the early life consists of a series of attachments and breakings free, with intervening periods of crawling and swimming. The young scallop swims with its foot extended until contact is made with an object to which the byssus is attached. The attachment is of great significance when the young scallops are subjected to rough weather conditions. If they were not attached to some object, the waters would soon cast the scallops on the shores to perish.

The ability to swim develops soon after the young reach a few millimeters in size. The power of swimming makes the scallop unique among the commercial bivalves. The whole animal is modified for this purpose, with a strong light shell, powerful adductor muscle, a well-developed cartilage in the hinge, and the margins of the mantle provided with infolded ridges and circular muscles. Swimming is effected through coördinated efforts of the various components. In swimming, the animal moves forward, hinge aft, as though biting the water, rather than hinge foremost as might be expected. The mantle edges close together preventing the water from escaping along the free edges of the shell so that the water is forced hingeward and out of an aperture on each side of the hinge when the powerful adductor muscle closes the shells. Scallops are able to swim to the surface and along the surface for short distances. When suddenly disturbed, the shells may snap shut and the animal will dart along the bottom in the opposite direction, with the hinge foremost. Other movements have been described, such as those of turning over, rotating horizontally, and a sort of "sculling" movement. Although scallops are able to swim, it is doubtful that this ability is used to any great extent among the adult animals or that distinct migrations occur. As a result of the swimming habit, the adductor muscle develops to a large size, thus rendering economically feasible the practice of utilizing only the muscle.

Another unique character of the scallop is the possession of eyes of deep blue color, located on short stalks among the tentacles of the mantle. The eyes have been the object of much study and discussion. Each eye contains a cornea, lens, iris, retina, and optic nerve, and is capable of perceiving motion of objects. To see the metallic glitter of the eyes in a bright light is a striking sight.

ECOLOGY

DEPTH OF WATER. Scallops are found at various depths and are apparently not influenced by the depth. Deep water affords a protection in northern areas during severe winters, for freezing often causes considerable mortality among populations found in shoal water and areas that are exposed during the ebb tide. Deeper water also protects scallops from such enemies as the herring gull.

CURRENTS. The water currents are of importance in the dispersal of the larvae. In the adults, which are filter feeders, the currents may play an important role in the food supply. In concentration of large numbers of scallops in a localized area, the exchange of the water replenishes the oxygen and carries away the metabolic wastes.

SALINITY. Scallops are confined to more saline water than oysters and clams. Gutsell discusses the minimum salinity, indicating a salinity of 20 parts per thousand as the minimum tolerated by scallops over prolonged periods, but adult scallops are able to endure salinities as low as 13 parts per thousand for brief periods.

TEMPERATURE. On exposed flats and in shoal water extreme winter weather often causes considerable destruction of scallops. Freezing weather is probably of greater significance in the northern states than in North Carolina, although Gutsell reports that the chilling of water in North Carolina below freezing was responsible for the mortality of many scallops in 1928. Temperature also influences feeding, growing, and spawning. Belding states that the minimum temperature for growth is 45° F.

BOTTOM. The type of bottom on which scallops are found varies from mud to hard sand. A grassy bottom is generally considered necessary for the growth of scallops. The bay scallop is confined largely to areas where an abundance of eelgrass (*Zostera*) occurs. In the early 1930's when a wasting epidemic disease killed off the eelgrass, scallops disappeared from many areas shortly afterwards. Since that period wherever patches of eelgrass have appeared scallops have soon followed. Many studies have shown a possible positive correlation between the abundance of eelgrass and bay scallops, but as Marshall (1947) points out, the relationship is complex and indirect. Forms other than scallops disappeared from some areas following the eelgrass. Stauffer (1937) describes the absence, five years after eelgrass disappeared from an area, of nine out of thirteen species that had been found in a former typical eelgrass habitat. Marshall (1947) reports scallops flourishing in the absence of eelgrass in Long Island Sound. Belding (1910) and Gutsell (1931) both suggest that eelgrass was important in offering a surface for attachment of young scallops and afforded some means of protection to the adult. The presence of any suitable grass, algæ, or other surface for attachment would be expected to serve the same purpose. Scallops do occur in commercial quantities in New England, presumably because the rocky, weed-covered bottom offers a surface for attachment and some protection. A few young scallops were recently found attached to old shells and bryozoa in Core Sound, North Carolina. Market-sized scallops occur sporadically in the vicinity of Hatteras and the western end of Bogue Sound usually correlated with the appearance of some eelgrass.

GROWTH. The growth of the scallop is rapid in comparison with the oyster and the clam. A marketable size of three inches in diameter is attained in a year or even less in the waters of North Carolina. According to Gutsell commercial crops are of an age group between 12 and 20 months. Belding reports that few scallops live to be 2 years old but found a few living to an age of 30 months. In controlled experiments Belding showed that unmolested scallops in their second year begin to show signs of physical decline by slower growth, thickening of shell, and degeneration of the adductor muscle, and by becoming more susceptible to adverse conditions. Twenty per cent of the scallops reach the two-year mark and probably less than 10 per cent pass it. This factor has been the justification for protecting scallops less than one year of age, for they spawn to provide future seed. Spawning may occur in the second year, but the majority of the scallops die before their second spawning.

Growth lines or annual rings corresponding to the one-and two-year periods are characteristically found on the shell. Belding attributes the formation of the annual ring to cessation of shell growth during the winter months. Gutsell says that the ring is formed in the North Carolina waters usually in the fall and thus is not correlated with cold weather. Risser (1901) showed that the growth line corresponds well with the spawning period. The most plausible explanation of the growth line appears to be the correlation with spawning.

THE SCALLOP INDUSTRY

The scallop fishery in North Carolina has been chiefly confined to Carteret County, in both Bogue and Core sounds. A limited number of scallops are gathered in the vicinity of Ocracoke and Hatteras. The industry at present represents but a mere vestige of a once important fishery in North Carolina. In 1928 North Carolina marketed more pounds of bay scallops than any other state. After the disappearance of eelgrass from the area during the early 1930's and following the hurricane of 1933, the production dropped from a total of 686,220 pounds of meats valued at $37,960 during 1929 to 91,458 pounds for 1934 valued at $6,560.

HISTORY. The scallop industry first developed at Beaufort, which was then a popular summer resort, reaching its height about 1860. The first shipments of scallop meats were made about 1870 by Mr. George N. Ives from Connecticut who started to ship the meats by rail from North Carolina to northern markets. The height of this shipping was reached about 1876-77 when several thousand gallons of meats were shipped to the northern markets. Marketing of scallops was temporarily curtailed when a southeast gale in August of 1879 destroyed many scallops.

Shortly after 1880 Mr. J. H. Potter of Beaufort began shipping scallops to the New York markets. After 1910 the industry became firmly established and well organized. The road building programs led to the development of shipping points along Core Sound at Marshallberg, Atlantic, and other points.

In 1918 the scallop industry was described as one of the leading shellfish industries of the State. Production increased steadily until 1928, when nearly 1,400,000 pounds of meats were harvested from North Carolina.

The bulk of the shipments about 1928 were made to New York and Boston and small quantities were shipped within the State. The competition from other scallop-producing areas affected the price locally, and conversely the production from this area of North Carolina was great enough to affect the market prices in New York and Boston.

Table 7 shows scallop production from North Carolina, as determined from statistics compiled by the Federal Government. In the decade 1918 to 1928 production of scallops increased more than threefold. The reason for this is not certain; probably several factors are responsible. Increased fishing intensity undoubtedly resulted in greater production, and was probably stimulated by the economic condition of the country with increased demand. The typhoid epidemic of 1924 nearly ruined the oyster industry, and potential oyster consumers may have turned to other fishery products such as scallops. The production for 1929 and 1930 dropped to the level of 1918. This decline was probably due to the unusually cold weather that

TABLE 7

Scallop Production,* North Carolina, 1880 to 1948

	Pounds	Value
1880	7,000	$ ———
1887	4,000	160
1888	4,000	180
1889	16,000	700
1890	18,000	800
1897	118,000	5,653
1902	13,000	980
1918	423,000	31,618
1923	554,000	46,214
1927	835,000	119,767
1928	1,394,000	125,845
1929	686,000	37,960
1930	432,000	53,923
1931	495,000	50,250
1932	91,000	6,560
1934	36,000	6,000
1936	99,000	14,175
1937	62,000	11,680
1938	30,000	7,971
1939	33,000	6,660
1940	34,000	3,685
1941	5,600 (700 gal.) †	———
1942	12,320 (1,540 gal.) †	———
1943	———	———
1944	———	———
1945	22,000	7,770
1946	2,888 (361 gal.) †	———
1947	48,816 (6,102 gal.) †	———
1948	———	———

* Production figures from Federal statistics except as noted.
† Figures based on tax returns to N. C. Division of Commercial Fisheries.

occurred in December, 1928. Gutsell (1931) states that "the considerable scallop mortality which followed (late in December, 1928) was due to unusual chilling (of the water) . . . accompanied by extreme ebb tides that left the scallop flats exposed for considerable intervals." Following the disappearance of eelgrass in the early 1930's and the severe hurricane of 1933, production of scallops dropped to less than 100,000 pounds and has never regained its former magnitude.

INDUSTRY. Scallops are harvested by raking or dredging. A raker wades over the flats, generally through the low tide period, to rake the scallops by hand. The rake resembles a potato or peanut digger with 6 tines fitted with a small wire basket to aid in retaining the scallops. Dredging is done from various small boats up to 35 and 40 feet in length.

The quantity of scallops caught per day depends upon their abundance. Gutsell (1929) quotes prices, wages, catch and other facts concerning the industry from which the bulk of this information is taken. A harvest of 40 bushels is (or was, in the 1920's) considered a good day's catch for one man dredging. A raker could gather from 8 to 15 bushels a day. The price received for the scallops depends upon their size and the grade of meats shucked and the total production. Usually the scallops are shucked by the fisherman and his family. In some cases, others were hired to do the shucking. The only part of the scallop utilized is the adductor muscle which is proportionally large but represents less than one-half of the bulk of the animal. The remaining parts are discarded as waste, a small amount of which is used for fertilizer. The U. S. Fish & Wildlife Service has recently been advocating the utilization of scallop waste for fish bait, particularly to stimulate interest among the sea scallopers to save their waste and thereby realize an additional source of income. In some countries all the soft parts are used for human consumption. They are discarded in this country, presumably because of their conspicuous coloration and the tough mantle margin.

The yield of meats from a bushel of scallops depends upon the size of the animal. Small scallops yield from two and one-half to a little over three pints of meat per bushel. Large scallops may yield one gallon of meat per bushel. An expert opener can shuck about a bushel of scallops an hour. Scallops are graded into various size groups: small, medium, extra mediums, large, and jumbos. Gutsell (1929) made some actual counts of the number of adductor muscles in the various grades and found considerable differences. In one case he found 113 and in another case, 63 in a quart of large grade. At different seasons of the year such discrepancies may be expected, for a mixed population would undoubtedly continue growth at parallel rates for short-time intervals. Thus scallops that were small at the beginning of the season may grow in a few months to mediums or even large-size meats, but correspondingly those scallops that were large at the beginning of the season would also continue growth.

CONSERVATION. The scallop presents a problem that is more complex than that of the oyster or clam. For many years conservation has been a matter of legal regulation which may be considered restrictive conservation. Knowledge of the life history simplifies to an extent the problem of proper regulatory measures. The open season for scallops is in accord with the findings of Gutsell (1931) insofar as the spawning season is concerned.

In attempting constructive conservation, problems arise which are peculiar to the scallop. Its ability to swim and move about may hinder cultivation. It would not be expected that the animals would migrate from favorable grounds, but if certain areas are closed for conservation purposes, it is possible that the scallops would move out beyond the arbitrary limits. The short life span of the scallop makes impracticable such measures as the establishment of spawning or breeding sanctuaries except for brief periods.

Attempts have been made to cultivate scallops in Massachusetts, but the results have not been certain. Some success has been achieved by transplanting scallops from heavily populated areas to depleted beds or by moving them from shallow to deeper waters as protection from severe cold. In transplantation the scallop presents a difficulty in that it does not survive for extended periods out of water, and must be transplanted rapidly. Small scallops appear to be hardier than old scallops.

The possibilities of restoring the scallop fishery of North Carolina should not be completely abandoned. Although the industry is almost non-existent in comparison to former production, over 22 thousand pounds of scallop meats were marketed in 1945. Scallops continue to appear sporadically in localized areas, often following the appearance of eelgrass. It might be that scallops would become re-established by the introduction of a vegetation to substitute for eelgrass.

The bay scallop has been in demand and has been preferred to the sea scallop. In March, 1949, the price received on the New York market for bay scallops ranged from $8.00 to $10.50 per gallon as compared to $4.25 per gallon for sea scallops. The restoration of the bay scallop fishery in North Carolina to its former productivity appears to merit serious consideration. A program designed toward increased scallop production would economically benefit the fishermen, since a demand exists for such a product.

THE SEA SCALLOP

The majority of sea scallops (*Pecten grandis*) are harvested from the deep oceanic waters of the north overlying the well-known fishing "banks." This scallop has never been of commercial importance to North Carolina. Fishing trawlers and draggers working off the coast from Cape Hatteras northward report catching an occasional sea scallop in their nets. It may be possible that some extensive scallop beds do exist. Since some nets fish the waters above the bottom, they may pass over the scallops, the presence of which would not be known.

Little is known at present of the life history of the sea scallop. It differs from the bay scallop in that the sexes are separate. Drew (1906) reported sea scallops to spawn in August. Since Drew was working with scallops that had been moved from their natural habitat and kept in floating cages, a change in environmental conditions may have initiated spawning. It is perhaps significant that these scallops had not spawned under natural conditions until August. Casual observations of the scallop fishermen working in deep waters indicate that migrations of the sea scallops are more extensive than those of bay scallops.

THE CALICO SCALLOP

A small scallop frequently caught by fishing trawlers in depths over ten fathoms in the vicinity of Cape Lookout and Cape Hatteras resembles the bay scallop, except for the bright coloration of the shell in the former. The distribution of the small calico scallop (*Pecten gibbus*) is from North Carolina to Florida. The calico scallop is about two inches in diameter and the meats are reported to compare favorably with those of the bay scallop. It is possible that calico scallops could be marketed as bay scallops if they are present in the offshore waters in commercial quantities. The trawler, "Penny," on a survey cruise for the Institute of Fisheries Research, April, 1949, located an abundance of these scallops in ten fathoms of water off New River Inlet. However, the small size of the calico scallop, even if present in commercial quantities, may not make it feasible to shuck the scallops for market. It is recommended that further investigations be conducted to determine the abundance and distribution of the calico scallop in North Carolina waters and that some preliminary determinations be made of the amount of meats yielded per bushel of scallops.

THE SOFT-SHELL CLAM

Mya arenaria (Linnaeus)

INTRODUCTION

The soft-shell clam is commonly known as the "mananose" ("maninose," "nanynose") in North Carolina. In other places it is known as the "long neck," long clam, or soft clam. These clams are not harvested in commercial quantity in North Carolina and many of the fishermen, clammers, and oystermen are unaware of their presence. In the numerous tributaries of Pamlico Sound, at Swanquarter Narrows, Rose Bay, Bay River, Pingleton Shoal, and Beaufort Inlet, shells of soft clams have been dredged up during the summer and fall of 1948. A large bed of these clams was known to exist south of Hatteras Inlet, on the shoals in Pamlico Sound, before the hurricane of 1933, which destroyed this bed.

The distribution of *Mya* is principally along the Atlantic coast from South Carolina to Canada (Dall, 1889). Belding (1930) states that *Mya* is scarce south of Cape Hatteras. Soft clams are found in greatest abundance along the New England coast, New York, and New Jersey, and have become established, after introduction, on our Pacific coast and the coastal areas of England. The industry has been confined to the northern states from New Jersey to Maine, with Massachusetts as the leading producer and

Maine a close second. The total production from these states amounted to over sixteen and one-half million pounds of edible portions, valued at over one million dollars in 1940 (Table 8).

TABLE 8

Production of Soft Clans, Atlantic Coast States

	1940		1944	
	Public		Public	
State	Pounds *	Value	Pounds	Value
Maine	6,278,500	$ 266,571	4,275,900	$ 606,222
New Hampshire	403,200	50,720	226,700	60,272
Massachusetts	8,598,100 †	832,138 †	4,547,000	1,351,557
Rhode Island	75,000	6,105	62,300	10,902
Connecticut	28,200	4,580	17,200	3,486
New York	436,900	36,495	484,000	149,800
New Jersey	780,400	47,357	717,400	141,370
Total	16,600,300	$1,243,966	10,330,500	$2,323,609

* Net edible meats, exclusive of shells.
† Includes catch from private areas.

NATURAL HISTORY

In the early development the soft-shell clam does not differ markedly from the other economic mollusks. Spawning is believed to be directly correlated with temperature. Belding (1930) reports spawning as occurring at 70° to 74° F., but Nelson (1928) places the spawning temperature at 10° to 12° C. (50° to 54° F.). Loosanoff (1943) finds that spawning begins when water temperatures reach 55° to 60° F. and continues from three to six months. The sexes are separate and fertilization of the egg occurs free of the parent. Following the embryonic development, the free swimming stages extend ten to fourteen days, after which attachment of the larval clam occurs. Kellogg (1900-b) describes the attachment of young clams by means of a byssus to various seaweeds. (*Enteromorpha, Ulva*), eelgrass (*Zostera*), stones, and other objects. The byssal thread may be broken at will to allow the small clams to move a short distance to another location. This attachment of the small clams serves as protection against washing ashore during storms; the sand grains and pebbles to which the young are attached function as anchors.

As the young clams increase in size, they develop the ability to bury themselves. Small clams under two millimeters in length are not able to burrow, while clams between two and eight millimeters can work their way downward sufficiently to cover themselves. Young clams of two or three centimeters in length can dig to depths of five or six inches. During these stages they frequently wander short distances on the surface. Once an adult clam buries itself, it rarely comes out on the surface again. The anterior end containing the mouth is buried deepest while the posterior end is upward, the siphons extending to the surface through which the clams gather in their food and exchange water.

ECOLOGY

TYPE OF BOTTOM. Soft clams grow best in a bottom composed of a firm mixture of mud and sand in which they burrow with some ease. Loosanoff (1943) considers a mixture of fine sand and mud in a ratio of two parts of sand to one part of mud as the most desirable type of soil. The consistency of the bottom should be firm enough to prevent ready shifting. Clam flats are sometimes composed of various types of bottom from sand or hard clay to rocky or gravel beaches. The young clams often work their way down between roots of grass or other vegetation making it difficult to dig them out.

SALINITY. The soft clam can endure salinities ranging from brackish to salt water. It is found growing in waters of a salinity as low as six to eight parts to as high as twenty-eight parts of salt per thousand. Adult clams can apparently be transferred from one extreme to the other without detriment.

RATE OF GROWTH. A marketable clam of more than two and one-half inches can be produced in two years in the New England region. Shell growth may occur throughout the year in some localities, but in New England the most rapid growth is during the summer months. The age limit of soft clams is estimated to be ten to twelve years (Loosanoff, 1943).

SOFT-SHELL CLAM CULTURE

These clams are hardy and lend themselves to cultivation which has been successfully carried on to a limited extent in New England. Unproductive, barren areas can be restored or replenished with small clams. Circulation of water is essential for a supply of oxygen, and a good current is necessary for rapid growth. A knowledge of the clam's life history and microscopical examinations of the water aid in getting the suitable materials overboard at the proper time to allow clams to attach. After a set of clams has been secured, it is necessary to move them before they begin to burrow. The natural set is usually sufficient to supply seed. These are gathered by sifting the clams out of the sand, digging shallow trenches into which the tide will wash them or by transporting both soil and clams from areas with thick sets. The bottom should be cleared of weeds and softened by raking to allow the clams to burrow more easily. About two hundred and fifty bushels of seed clams planted per acre is considered sufficient (Kellogg, 1900-a). Belding was able to obtain a yield of eight quarts of clams for every quart of seed clams planted.

Protection of the small clams against enemies and adverse weather is a vital factor in farming, but little can be done other than selecting locations for beds in sheltered areas. The young clams are most vulnerable before they bury themselves. Oyster drills and snails, crabs, horseshoe crabs, and starfish destroy small clams. Skates and sting rays excavate clams from the beds. The writer found the stomach of a sting ray from Delaware Bay to contain about a cupful of *Mya* siphons. Bottom feeding fish may devour numerous small clams before the latter bury themselves. There has been some concern in northern areas over the destruction of young clams by ducks feeding on the flats.

Clams are at depths from a foot to two feet below the surface and are dug by hand labor, raking or digging. Mechanical means might be devised if the industry were expanded sufficiently to demand more efficient methods. The soft, fragile shells require careful handling and present an additional problem in employing mechanical devices.

Clams are marketed either in the shell or as shucked meats. A bushel of soft clams will yield about 16 pints of meat.

DISCUSSION

Although soft clams have never been harvested in marketable quantities from North Carolina, this fact should not discourage the investigation of such a possibility. Scattered clams are found throughout some of the areas, and extensive beds of these clams may exist. They are dug for home consumption by persons living along Core Sound and Bay River and at Ocracoke. At least one bed of soft clams of unknown size exists in Bay River.

Where there are tides clams are generally found in the intertidal zone on flats and beaches. A difficulty in Pamlico Sound is that it is practically devoid of tides; any beds that exist are below water and the clams are not so easily dug, nor by the same methods, as they are on mud flats at low tide. In the regions adjacent to the inlets where a rise and fall of tides occurs, a simple survey of the exposed flats would readily determine the presence of these clams.

The decline and scarcity of soft clams in the New England states has stimulated research and appropriation of funds for rehabilitation of this resource. An economic result of the decreased supply has been a higher price for clams. The presence of native clams may be an indication that clam farming could be successfully carried out in North Carolina and should be investigated. The establishment of successful soft clam farming would provide an additional source of income to the residents and revenue to the State.

MISCELLANEOUS MOLLUSKS

A great variety of mollusks are found in North Carolina, perhaps because Cape Hatteras forms a natural boundary between the southern and northern forms. Many of the mollusks are of little interest commercially but their presence may indicate a dormant potentiality, since a number of species in North Carolina waters are harvested in commercial quantities farther north or south. A few species of commercial importance are mentioned briefly.

RIBBED MUSSELS

The ribbed mussels, also known as horse mussels (*Modiolus plicatulus,* sometimes listed as *M. demissus*) grow in the intertidal zone, imbedded in the bottom between the roots of marsh grass held together by a byssus in clumps or "tumps." The little meat content, characterized by a yellow-orange color, is generally regarded as not edible, although many local people along the coast steam the mussels or make fritters and report them to be "rich" with an excellent flavor. Prior to and during the war years chemical concerns extracted from the meats a provitamin D which was converted to vitamin D by ultra-violet irradiation. Apparently the demand decreased when spinal cords from meat packing plants were found to be a more satisfactory source. In the Beaufort area, a cannery steamed these mussels for the market that existed, but the industry was short-lived perhaps because of an exhausted supply. The mussels are gathered in considerable quantity on the eastern shore of Maryland and in Virginia, New Jersey, and South Carolina. The range of the ribbed mussel is from Nova Scotia to Georgia.

SEA MUSSELS

Sea mussels (*Mytilus edulis*), known as blue or black mussels, have become of significant importance in the New England area, where they are steamed and canned. The potentialities of this industry are great in the northern states where this mussel is abundant. Sea mussels are circumpolar in distribution, and are considered a cold water form; however, the southernmost limit is South Carolina and it may be that beds of these mussels grow off the coast. They have been popular in Europe for many years, and some progress has been made toward making them more popular in this country. For an account of the sea mussel in all its most important aspects, the extensive paper of Field (1922) should be consulted.

The state of Maine was the leading producer of sea mussels in 1945. The catch by states in 1945, according to Federal statistics was as follows:

	Pounds *	Value
Maine	2,733,400	$ 72,146
Massachusetts	49,800	9,486
New York	429,600	86,696
New Jersey	3,600	450
Virginia †	49,500	7,073
South Carolina †	43,000	5,375
Total	3,308,900	$181,226

* Edible portions, exclusive of shells.

† Inquiries have shown that there is no known production of *Mytilus edulis* in Virginia. This figure probably represents the production of *Modiolus plicatulus,* the ribbed mussel. This may be the case in the South Carolina for *Mytilus edulis* is not gathered in commercial quantities in that state.

SURF CLAMS

The surf clams or skimmers (*Spisula solidissima*) have long been known to grow in abundance along the beaches of the northern states. Their chief market was for fish bait and more recently as minced clams and chowder. They grow in the hard sand of beaches and are often washed out of the sand in great quantities during storms. In the process of feeding, the clams accumulate considerable quantities of sand which must be thoroughly washed out in processing them for chowder. It is reported that only the large foot is used and that the gills and viscera are discarded. The abundance of these clams along the coast of North Carolina is not definitely known. The distribution of the surf clam is from Labrador to North Carolina. However, a southern variety, *Spisula solidissima similis,* replaces the northern form in southern waters. The production in 1945 for the various states was as follows:

	Pounds *	Value
Massachusetts	263,800	$ 80,935
Rhode Island	7,900	1,986
New York	3,982,200	499,670
New Jersey	526,500	47,000
Total	4,780,400	$629,591

* Edible portions, exclusive of shells.

RAZOR CLAMS

Razor clams (*Ensis* and *Solen* spp.) are commonly found in North Carolina and may possibly exist in commercial quantities. The greatest harvest of these clams is on the Pacific coast. Production figures for 1945 along the east coast show Massachusetts (11,900 lbs.) as the only producer in commercial quantities.

CONCHS

The most common of the several species of conchs in North Carolina is *Busycon caricum.* A limited market exists in North Carolina, but the majority of the conchs are gathered in the northern states, the New York market bringing the highest prices. The meat is reported to be of an unusual flavor and possibly a better market might be developed for it. Conchs were selling locally in the Beaufort area at a dollar a dozen dressed, in December, 1948, but the demand was not great. Production in 1945 along the Atlantic coast was as follows:

	Pounds *	Value
Massachusetts	100	$ 6
Connecticut	12,200	1,409
New Jersey	9,700	540
New York	400	67
Maryland	9,000	2,250
Virginia	13,600	5,260
Florida	18,200	3,965
Total	63,200	$13,497

* Edible portions, exclusive of shells.

SQUID

The market for squid (*Loligo, Illex,* spp.) as a food is limited to the foreign populations of large cities and to the export trade. The chief use of squid is for fishing bait. They are taken commercially from South Carolina northward, small quantities being harvested on the North Carolina coast, often of insignificant amounts. The total yield for the Atlantic coast is often as high as 4 to 6 million pounds. Production in 1945 was as follows:

	Pounds	Value
Massachusetts	1,217,200	$ 60,320
Rhode Island	273,100	13,573
Connecticut	161,700	16,865
New York	640,200	62,730
New Jersey	599,700	41,979
Delaware	600	42
Maryland	47,200	6,473
Virginia	102,200	5,110
North Carolina	2,300	230
Louisiana	3,900	78
Total	3,048,100	$207,400

The possibilities of developing squid commercially should be considered. The sporadic occurrence of squid in the New England and Middle Atlantic regions often causes considerable concern among the fishermen, who depend upon this bait. During periods of scarcity surveys for their presence in North Carolina waters may prove of direct economic benefit. Squid are voracious destroyers, especially of the young, of many species of fish.

PERIWINKLES

These small snails (*Littorina* sp.) from one-half to one inch in height, abound in great numbers in the intertidal zone on exposed flats. *Littorina littorea* is believed to have been introduced accidentally from Europe about 1857 in Nova Scotia and has spread southward to New Jersey. In Europe tons of these small snails are roasted and sold from push carts. They are sufficiently abundant along the Atlantic coast for commercial exploitation. However, the demand would probably be small in North Carolina, for the demand of foreign population in the northern cities can readily be supplied from more northerly sources. Production of periwinkles in 1945 (including cockles) was as follows:

	Pounds *	Value
Maine	51,000	$ 6,128
Massachusetts	2,300	650
Rhode Island	112,500	28,125
Total	165,800	$34,903

* Edible portions, exclusive of shells.

COQUINA

These small, wedge-shaped clams (*Donax variabilis*) are found on the beaches from North Carolina to Texas. They burrow in loose sand in the intertidal zone, frequently in large numbers. Despite their small size, about three-fourths of an inch long, they are gathered and used to make "coquina chowder." Florida was the only state reported to market these clams in commercial quantities in 1945, with a production of 54,000 pounds valued at $13,500. Coquina clams are abundant on some beaches of North Carolina and it is recommended that a survey be conducted to determine their distribution and abundance.

BIBLIOGRAPHY

Anderson, A. W., and E. A. Power.
1949. U. S. Fish & Wildlife Service. Fishery Statistics of the United States, 1945. Statistical Digest No. 18 (1949), 372 p., illus.

Baughman, J. L.
1947. An annotated bibliography of oysters, with pertinent material on mussels and other shellfish and an appendix on pollution. The Texas A. & M. Research Foundation, 1947, 794 p. College Station, Texas.

Belding, David L.

1909. A report upon the mollusk fisheries of Massachusetts. Boston: Wright & Potter Printing Co., 1909, 243 p.

1910. A report upon the scallop fishery of Massachusetts, including the habits, life history of *Pecten irradians,* its rate of growth, and other facts of economic value. Boston: Wright & Potter Printing Co., 1910, 150 p.

1912. A report upon quahaug and oyster fisheries of Massachusetts, including the life history, growth and cultivation of the quahaug (*Venus mercenaria*), and observations on the set of the oyster spat in Wellfleet Bay. Boston: Wright & Potter Printing Co., 1912, 134 p.

1930. The soft-shelled clam fishery of Massachusetts. Commonwealth of Massachusetts, Department of Conservation, Division of Fish & Game, Marine Fisheries Section, Marine Fisheries Series, No. 1, 1930, 65 p., 7 pls. Boston.

Bowes, Anna DeP.

1943. Nutrition needs today. Address given at Annual Convention of Oyster Institute of North America, National Shellfisheries Assn., Philadelphia, June 2-3, 1943, mimeographed. The Oyster Institute of North America, Washington.

Brooks, W. K.

1880. The development of the oyster. Studies Biol. Lab., Johns Hopkins Univ., Vol. 4, 1880, 106 p., 10 pls. Baltimore.

Burkenroad, Martin D.

1931. Sex in the Louisiana oyster, *Ostrea virginica.* Science, n.s. Vol. 74, 1931, p. 71-72.

Chipman, Walter A., Jr.

1948. A serious situation confronting the oyster industry. Comm. Fish. Rev., Vol. 10, No. 6, June, 1948, p. 7-10.

Churchill, E. P., Jr.

1920. The oyster and the oyster industry of the Atlantic and Gulf Coasts. Rept. U. S. Comm'r. Fish. for 1919 (1921), Appendix VIII, 51 p., 29 pls., bibliog. (Doc. 890, 1920).

Clark, A. H.

1920. The Smithsonian Institution, its functions and its future. Science, n.s. Vol. 63, 1920, p. 147-157.

Coe, Wesley R.

1932. Sexual phases in the American oyster (*Ostrea virginica*). Biol. Bull., Vol. 63, No. 3, 1932, p. 419-441.

Coker, Robert E.

1907. Experiments in oyster culture in Pamlico Sound, North Carolina. N. C. Geol. & Econ. Surv., Bull. 15, 1907, 74 p., map, 11 figs., 17 pls. Raleigh.

Dall, William Healey.

1889. A preliminary catalogue of the shell-bearing marine mollusks and

(1903) brachiopods of the southeastern coast of the United States, with illustrations of many of the species. Bull. U. S. Nat. Mus., No. 37, revised reprint of 1889 ed., 1903, 203 p., 95 pls.

Drew, Gilman Arthur.
1906. The habits, anatomy and embryology of the giant scallop (*Pecten tenuicostatus*, Mighels). The University of Maine Studies, No. 6, 1906, 71 p. Orono.

Fiedler, R. H.
1943. U. S. Fish & Wildlife Service. Fishery Statistics of the United States, 1940 (1943). Statistical Digest No. 4, 225 p.

Field, Irving A.
1922. Biology and economic value of the sea mussel, *Mytilus edulis*. Bull. U. S. Bur. Fish., Vol. XXXVIII, 1921-22 (1923), p. 127-259, 132 figs., extensive bibliog. (Doc. 922, 1922).

Galtsoff, Paul S.
1928. Experimental study of the function of the oyster gills and its bearing on the problems of oyster culture and sanitary control of the oyster industry. Bull. U. S. Bur. Fish., Vol. XLIV, 1928 (1929), p. 1-39, 12 figs., bibliog. (Doc. 1035, 1928).
1938. Physiology of reproduction of *Ostrea virginica*. II. Stimulation of spawning in the female oyster. Biol. Bull., Vol. LXXV, No. 2, 1928, p. 286-307.
1947. Oyster the unknown. Southern Fisherman, Vol. VII, No. 3, 1947, p. 176-177, 248.

Galtsoff, Paul S., and H. R. Seiwell.
1928. Oyster bottoms of North Carolina. U. S. Bur. of Fish., Econ. Circ. No. 66, 1928, 11 p.

Glaser, O. C.
1904. Observations and experiments on the growth of oysters. Rept. U. S. Comm'r. Fish. for 1903 (1905), p. 329-341, 1 pl., 1 chart.

Grave, Caswell.
1904. Investigations for the promotion of the oyster industry of North Carolina. Rept. U. S. Comm'r. Fish. for 1903 (1905), p. 247-315, 6 pls.

Gutsell, James S.
1929. Scallop industry of North Carolina. Rept. U. S. Comm'r. Fish. for 1928 (1929), Pt. I, Appendix V, p. 173-197, 11 figs. (Doc. 1043, 1929).
1931. Natural history of the bay scallop. Bull. U. S. Bur. Fish., Vol. XLVI, 1930 (1931), p. 569-632, 32 figs., extensive bibliog. (Doc. 1100, 1931).

Hartman, Olga.
1945. The marine annelids of North Carolina. Duke University Marine Station, Bull. No. 2, 1945, p. 1-51, 10 pls., bibliog., index. Durham.

Higgins, Elmer.
1936. Progress in Biological Inquiries, 1934 (oyster investigations, p. 372-380). Rept. U. S. Comm'r. Fish. for 1935 (1936), Appendix III, p. 331-399.

Hopkins, A. E.
1936. Adaptation of the feeding mechanism of the oyster (*Ostrea gigas*) to changes in salinity. Bull. U. S. Bur. Fish., Vol. XLVIII, 1940, p. 345-364, 11 pls. (Bulletin 21, 1936).
Ingersoll, Ernest.
1887. The oyster, scallop, clam, mussel and abalone industries. *In* The Fisheries and Fishery Industries of the United States, by G. Brown Goode and a staff of associates, Section V, Vol. II, Part XX, 1887, p. 507-626, United States Commission of Fish and Fisheries.
Kellogg, James L.
1900-a. The clam problem and clam culture. Bull. U. S. Fish Comm., Vol. XIX, 1899 (1901), p. 39-44, 1 chart.
1900-b. Observations on the life history of the common clam, *Mya arenaria.* Bull. U. S. Fish Comm., Vol. XIX, 1899 (1901), p. 193-202, 3 figs.
1901. Clam and scallop industries. Bull. New York State Museum, Vol. 8, No. 43, 1901, p. 603-631. Albany.
1903. Feeding habits and growth of *Venus mercenaria.* Bull. New York State Museum, Vol. 10, No. 71, 1903, p. 3-28. Albany.
1905. Notes on marine food mollusks of Louisiana. Gulf Biologic Sta., Cameron, La., Bull. No. 3, 1905, 43 p., issued by La. State Bd. of Agric. & Immig. Baton Rouge.
Korringa, P.
1940. Experiments and observation on swarming pelagic life and setting in the European flat oyster, *Ostrea edulis.* Arch. Neerland. Zool., Tome V, 2e livr., 1940, p. 1-249.
Loosanoff, Victor L.
1937-a. Seasonal gonadal changes of adult clams, *Venus mercenaria* (L). Biol. Bull., Vol. LXXII, No. 3, 1937, p. 406-416.
1937-b. Spawning of *Venus mercenaria* (L). Ecology, Vol. 18, No. 4, 1937, p. 506-515.
1939-a. Effect of temperature upon shell movements of clams, *Venus mercenaria* (L). Biol. Bull., Vol. LXXVI, No. 2, 1939, p. 171-182.
1939-b. Spawning of *Ostrea virginica* at low temperatures. Science, Vol. 89, No. 2307, 1939, p. 177-178.
1943. Soft and hard clams of the Atlantic Coast of the United States. U. S. Fish & Wildlife Service, Fishery Leaflet 13, 1943, 11 p.
Loosanoff, Victor L., and Charles A. Nomejko.
1946. Feeding of oysters in relation to tidal stages and to periods of light and darkness. Biol. Bull., Vol. 90, No. 3, 1946, p. 244-264.
Lotsy, John P.
1895. The food of the oyster, clam and ribbed mussel. Rept. of U. S. Comm'r. Fish. for 1893 (1895), p. 375-386.
Marshall, Nelson.
1947. An abundance of bay scallops in the absence of eelgrass. Ecology, Vol. 28, No. 3, 1947, p. 321-322.

Martin, G. W.
1923. Food of the oyster. Bot. Gaz., Vol. LXXV, No. 2, 1923, p. 143-169.
Moore, H. F.
1898. Oysters and methods of oyster-culture (with notes on clam culture). *In* Manual of Fish Culture, Rept. U. S. Comm'r. Fish. for 1897 (1898), p. 263-338 (notes on clam culture, p. 339-340), 18 pls. (Manual of Fish Culture revised and separately published, 1900).
1904. Anatomy, embryology and growth of the oyster. Rept. U. S. Comm'r. Fish. for 1903 (1905), p. 317-327, pls.
Needler, Alfreda Berkeley.
1930. Sex reversal and rate of growth in the eastern American oyster (*Ostrea virginica*). Ann. Rept. Biol. Bd. Canada, 1930, p. 24.
Nelson, Julius.
1910. The influence of climate on oyster propagation at Barnegat, N. J. Report of the Biologist for 1909 (1910), p. 223-266, 5 pls.
Nelson, Thurlow Christian.
1921. Aids to successful oyster culture. I. Procuring the seed. Bull. N. J. Agric. Exp. Sta., Bull. No. 351, 1921, 59 p.
1928. On the distribution of critical temperatures for spawning and for ciliary activity in bivalve molluscs. Science, Vol. LXVII, No. 1730, 1928, p. 220-221.
1947. Some contributions from the land in determining conditions of life in the sea. Ecol. Monog., Vol. 17, 1947, p. 337-346.
Newcombe, Curtis L.
1944. The nutritional value of seafoods. Virginia Fisheries Laboratory of the College of William and Mary, and Commission of Fisheries, Educational Series No. 2, 1944, 17 p. Richmond.
Old, Marcus C.
1941. The taxonomy and distribution of the boring sponges (Clionidae) along the Atlantic coast of North America. Chesapeake Biological Laboratory, 1941, 30 p. Solomons Island.
Orton, J. H.
1921. Sex-change in the native oyster (*O. edulis*). Nature, Vol. 107, 1921, p. 586.
Pease, Herbert D.
1932. The oyster—modern science comes to the support of an ancient food. J. Chem. Education, Vol. 9, 1932, p. 1674-1712.
Prytherch, Herbert Francis.
1940. The life cycle and morphology of *Nematopsis ostrearum*, sp. nov., a gregarine parasite of the mud crab and oyster. Jour. Morph., Vol. 66, No. 1, 1940, p. 39-65.
Risser, Jonathan.
1901. Habits and life-history of the scallop (*Pecten irradians*). Thirty-first Ann. Rept., Commissioners of Inland Fisheries, State of Rhode Island and Providence Plantations, p. 47-55, 1 graph, 15 pls. Providence.

Ryder, John A.

1884. The metamorphoses and post-larval stages of development of the oyster. Rept. U. S. Comm'r. Fish. for 1882 (1884), p. 779-791.

Stafford, J.

1913. The Canadian Oyster. Its Development, Environment and Culture. Commission of Conservation, Canada. Committee on Fisheries, Game and Fur-bearing Animals. Ottawa: Mortimer Co., 1913, 159 p.

Stauber, Leslie A.

1947. On possible physiological species in the oysters, *Ostrea virginica*. Anat. Rec., Vol. 99, No. 4, 1947, p. 58.

Stauffer, R. C.

1937. Changes in the invertebrate community of a lagoon after disappearance of eelgrass. Ecology, Vol. 18, 1937, p. 427-431.

Tennent, D. H.

1909. Account of experiments for determining the complete life cycle of *Gasterostomum gracilescens*. Science, n.s. Vol. 29, 1909, p. 432-433.

Winslow, Francis.

1886. Report of the waters of North Carolina, with reference to their possibilities for oyster culture; together with the results obtained by the surveys directed by the resolution of the General Assembly, ratified March 11, 1885 (1886), 151 p. Raleigh.

1889. Report on the sounds and estuaries of North Carolina, with reference to oyster culture. Bull. U. S. Coast & Geod. Surv., No. 10, 1889, 136 p.

THE SHRIMPS IN NORTH CAROLINA

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CONTENTS

INTRODUCTION

Although small elongate marine crustaceans are caught and sold as human food under the name "shrimp" in New England, California, and Alaska, the shrimp fishery of the United States is virtually the property of the South Atlantic and Gulf regions. Here, three species of a single family of shrimps contributed, in 1945, 98.8 per cent of the catch and 99.6 per cent of the value of an industry worth twenty-one million dollars to the fishermen of the nation. Within the South Atlantic and Gulf regions, the shrimp fishery comprised 39.2 per cent of the total value of all fisheries in 1945.

North Carolina, situated at the northern limit of abundance of the common commercial shrimp, lands but a small percentage of the shrimp taken. In 1945 North Carolina's share of this fishery was 10,614,000 pounds, or 5.5 per cent of the total catch, and $849,160 or 3.97 per cent of the total value. Within the State shrimp ranks second to menhaden in value among individual fisheries and third in value if edible finfish are grouped as a single resource (data from U. S. Fish & Wildlife Service, 1949).

THE SHRIMP FISHERY

GEAR

Shrimp today are taken largely by otter trawls although other types of gear are used. Johnson and Lindner (1934) list haul seines, cast nets and night trawls as gears of minor importance. In North Carolina, a special gear, the channel net, has proved successful under local conditions.

Shrimp trawls vary in width, the average in North Carolina being about 50 feet. They are made of 2-inch stretched mesh webbing and consist of a bag for collecting the catch and wings for guiding the shrimp into the bag. Trawls are held open by otter boards or "doors" which function in water much as a kite does in air. The boards, secured to the trawler by lines, hold the net open and against the bottom when the net is pulled through the water.

Haul seines vary from 150 to 300 fathoms in length and are made of 1-½ inch stretched mesh (Johnson and Lindner, 1934). Night trawls are of comparatively recent origin. They consist of two trawls or bags of ¾-inch mesh mounted in rectangular frames and secured at right angles to the hull of the boat. They fish the upper meter of water and are used exclusively at night.

Seines, night trawls, and cast nets are not used commercially for shrimp in North Carolina.

A channel net is a shrimp trawl anchored at the surface of the water. Otter boards are not used, but the net is held open by three or four poles secured to the lead and cork lines. Extra floats keep channel nets at the surface. One end is usually secured to an anchored boat; the other end is held in position by a separate anchor. The net is fished by emptying the cod end or bag into a skiff. Channel nets are fished only on ebb tides during the hours of darkness. The use of this gear is limited to a local spring fishery in Back and Core sounds.

VESSELS

Shrimp trawlers vary in tonnage, motive power, and size. During heavy runs of shrimp virtually every type of boat able to pull a trawl is pressed into service. According to Johnson and Lindner (1934) the boats range in size from 5 to 30 tons, the majority less than 5. The two types most prevalent in North Carolina are the Florida trawler and the Core sounder.

Florida trawlers, which average about 50 feet in length, are usually propelled by about 100 horsepower diesel engines with power take-off driven winches. These trawlers are equipped for several days' uninterrupted fishing and have considerable hold space for shrimp and ice. Florida trawlers operate chiefly in the outside waters. They are usually owned by shrimp dealers who employ crews to operate them.

Core sounders are smaller boats, usually under 40 feet in total length. Their hull design is of a type developed for use in North Carolina's extensive inside waters. Core sounders are usually powered by gasoline engines of about 100 horsepower. They may or may not be equipped with winches. Often the catch and ice are carried in boxes stowed on deck. Boats of this type are usually owned by the men who operate them.

THE FISHERY

In late spring shrimp begin to appear in comercial quantity in North Carolina. An early run in Core and Back sounds is fished with channel nets, the shrimp taken often being designated as channel shrimp. The intensity of trawler activity in the spring is governed by the size of the early population. By mid-July, the season is in full swing and continues until late fall, when the shrimp disappear from the coastal waters. The season in Pamlico Sound is usually somewhat earlier than the season in the outside waters.

During the season, extending roughly from July to December, fleets of shrimp trawlers leave port daily in the pre-dawn hours. The length of the trawling day, regulated by law, is from 4:00 A.M. to 8:00 P.M. The duration of a set varies from one to two hours depending upon the anticipated size of the catch. Population density is sometimes sampled by try-nets while the trawls are overboard. At the end of the set, the trawler heaves to, the net is hauled, and the catch dumped on deck. Another set is made before the catch is sorted. Shrimp, edible fish, and hard and soft crabs are culled and iced. The remainder of the catch is shovelled overboard. The catch is landed daily. The boats return to port or sell their shrimp to "buy-boats," floating agents for dealers that carry out gasoline, ice, and cash and return with shrimp, fish, and crabs.

In the United States shrimp are sold fresh, canned, frozen, dried or cooked, and peeled. In some localities the heads are dried, ground, and sold as shrimp bran, a stock feed. Almost all of the North Carolina catch is sold fresh, there being virtually no processing facilities in the State. Until recently, shrimp heads were discarded, but there are now several reduction plants making meal from shrimp heads and scrap fish. That portion of the North Carolina catch destined to be canned or frozen is sold as fresh shrimp to processors outside the State. Shrimp landed nightly in North Carolina are headed by hand, iced in boxes and delivered by trucks to markets, chiefly Baltimore and New York. The trucks leave the State within 24 hours after the shrimp have been caught.

NAMES AND CLASSIFICATION

Shrimps of commercial importance in the southeastern United States belong to five species. Weymouth, Lindner, and Anderson (1933) list *machrobra-*

chium sp., a fresh-water shrimp taken in Louisiana; *Xiphopenaeus kroyeri,* a small, marine shrimp; *Penaeus setiferus,* the common commercial shrimp, and *Penaeus brasiliensis,* the grooved shrimp. Since 1933, *P. brasiliensis* has been shown by Burkenroad (1939) to be actually three species: *P. brasiliensis, P. aztecus,* and *P. duorarum.* All but *machrobrachium* are members of the family *Penaeidae* and, together with certain other genera belonging to the same family but of incidental importance, constitute the shrimp catch of the South Atlantic and Gulf regions.

Machrobrachium does not enter the fishery in North Carolina. The occurrence of *Xiphopenaeus,* and *Sicyonia,* another peneid, are incidental. The species of *Penaeus* are the only shrimps of commercial importance. All of these have been recorded from North Carolina, but the possibility exists that the single specimen of *P. brasiliensis* recorded from off Cape Hatteras (Burkenroad, 1939) was a stray, this species being rare if existing at all in this State.

Penaeus setiferus (Linnaeus), the common commercial shrimp of the South Atlantic and Gulf regions, occurs in North Carolina as far north as Cape Hatteras. It is taken in all shrimping areas of the State, but is most abundant in the region of the Cape Fear estuary. Females with maturing eggs are taken in the spring. Following an early summer slump, *P. setiferus* furnishes the bulk of the fall catch in the outside fishery. *Penaeus aztecus* (Ives) (restricted) has been the most abundant shrimp in North Carolina in recent years. It furnishes a large summer fishery in Pamlico Sound and the other inside waters of the State. *P. aztecus* appears in late spring and disappears in the fall before *P. setiferus*. *Penaeus duorarum* (Burkenroad) occurs in local abundance in the early spring, especially in Core and Back sounds, where it is taken in channel nets almost to the exclusion of other species (see above). Following a disappearance during the summer months *P. duorarum* is again encountered in the fall at about the time of the disappearance of *P. aztecus*. Small specimens of this shrimp are frequently taken by oystermen during the winter months (see below). Fishing trawlers operating offshore in the vicinity of Cape Hatteras and Cape Lookout frequently take large specimens of *P. duorarum*, but rarely in quantity. *Penaeus brasiliensis* (Latreille) (restricted) has been identified but once from North Carolina waters.

The various species of *Penaeus* may be distinguished from one another in the field, although positive identification requires examination by a specialist. Burkenroad (1934, 1939) has divided the genus into two divisions. Shrimp of Division I lack grooves on the head (extended adrostral carinae, post ocular crest present). *P. setiferus,* the only local species of Division I, is therefore readily recognizable by the lack of grooves on the head. This shrimp, known locally as the white shrimp, is whitish opaque to translucent (smaller specimens) in color. The tail is edged in green. Its antennae and "horn" (rostrum) are comparatively longer than those of the other species. Two species belonging to Division II are taken by North Carolina fishermen: *P. aztecus* and *P. duorarum*. *P. aztecus* is the most common of the grooved shrimps. In color it is brownish to orange, although the color is often so light as to make the shrimp seem white. Its tail is usually edged in purple to red-purple. Although *P. duorarum* may be indistinguishable from *P. aztecus* in color, it often is somewhat blue to blue-gray in hue. Its tail is usually edged in blue. A character relied on locally by the fishermen to differentiate between these species, "channel shrimp" and "brown shrimp" is a more or less distinct red or blue spot on each side of the third abdominal segment. This may be a valid field diagnostic of *P. duorarum,* for such a spot is certainly lacking in *P. aztecus.*

As has been implied, *P. aztecus* and *P. duorarum* seem to be relatively more abundant in North Carolina in recent years than they have been in the South Atlantic and Gulf regions as a whole. The only available estimate (Weymouth, Lindner, and Anderson, 1933) places the percentage of all shrimp other than *P. setiferus* at about 5 per cent of the total catch with *P. setiferus* accounting for the remaining 95 per cent. An estimate for North Carolina for the year 1948 based upon tax collection figures places the percentage of *P. setiferus* at less than 50 per cent, with the bulk of the catch made up of *P. aztecus*. Although it is possible that the grooved shrimp have become more abundant generally in recent years, population percentage figures from the various states are not available.[1]

DISTRIBUTION

The geographic distribution of the Atlantic species of *Penaeus* is listed by Burkenroad (1939). Adults of *P. setiferus* are found from Fire Island, New York, to Louisiana, Texas, and Vera Cruz, Mexico, and in Cuba and Jamaica. The records of the three species of grooved shrimps show considerable difference in distribution of the various forms. *P. duorarum* alone occurs in Africa; *P. aztecus* alone occurs north of Cape Hatteras and south of Rio de Janeiro. *P. brasiliensis* is absent from the northeastern Gulf of Mexico.

Burkenroad (1939) finds a preference for low salinity (or a greater dependence of post larvae upon low salinity nursery grounds) in *P. aztecus* and *P. setiferus;* a high salinity preference (independence of brackish nur-

1. Since this section on the shrimp was written, a new and very productive fishery for one of the grooved shrimps, *P. duorarum* (North Carolina "channel shrimp") was discovered in February, 1950, in the Tortugas region west of the Florida Keys in the Gulf of Mexico. (See Clarence P. Idyll, New Fishery for Commercial Shrimp in Southern Florida. Comm. Fish. Rev. Vol. 12, No. 3, Mar. 1950, p. 10-16).

sery conditions) in *P. brasiliensis*. *P. duorarum* seems more adaptable to salinity differences than the other shrimps.

Shrimp are warm-water forms. Weymouth, Lindner, and Anderson (1933) list the limits of temperature within which *P. setiferus* is taken as 9° to 31° C. (48° to 88° F.). Burkenroad (1939) suggests that temperature higher than 20° C. (68° F.) during some time of the year may be necessary for the maintenance of the various species.

NATURAL HISTORY

LARVAL DEVELOPMENT

In studies of shrimp, as in studies of most animals which contribute to the world's fisheries, too little attention has been given to the developmental stages. Yet the success with which the various larval stages meet is the prime determinant of the fishery. Each stage in the life history is as important as the adult, for each must be passed by each generation. Shrimp do not hatch from eggs as miniature adults, nor do the habits of these larval stages resemble those of mature shrimp. Thus, knowledge of the larvae (their food, habitat, natural enemies, tolerances, and tropisms) is as much a part of the natural history of the various species as is an understanding of the adult animals.

Published information on shrimp larvae is, however, limited. Of our Atlantic species, the development of *P. setiferus* has been described (Pearson, 1939), but there is no account of the larvae of our other species of *Penaeus*. Since the various commercial shrimps are closely related, similarity may be expected in their larval histories. At the same time, the differences in morphology, behavior, and distribution of the adults should have their counterparts in the larvae. The lack of information regarding shrimp larvae is, therefore, a serious deficiency in our understanding of the natural histories of the various species.

Of *P. setiferus*, Pearson (1939) reports ten distinct stages, falling into three general headings, between the egg and the post-larva or subadult. The eggs are found only at sea, and the ten larval stages live as plankton or floating small-life in the open ocean.

Shrimp belonging to the family Penaeidae, do not carry the eggs about as do most crustaceans, but lay them directly on the bottom where they are left to hatch. The eggs of *P. setiferus* are about 0.28 mm. (1/90 inch) in diameter and are described by Pearson as having a "characteristic purplish-blue" color. They are demersal (that is, they sink) in sea water. A female may lay as many as half a million eggs in a single spawning. "Nearly all" of the eggs found by Pearson were in late developmental stages. Of those that hatched, all did so within twelve hours.

The creature that hatches from a shrimp egg is a tiny, pyriform (pear-shaped) individual having three pairs of appendages. This stage in the life history is known as a nauplius and is typical of all crustacea, although usually passed in the egg among higher forms. These nauplii measure from 0.30 to 0.56 mm. (1/80 to 1/45 inch) in length. They lack eyes but have a simple, light-receptive organ which will disappear in later development. They swim feebly, thrashing upward enough to offset sinking. They do not feed, but live on stored yolk material from the egg. There are five naupliar stages, each successive moult being accompanied by growth and development. The entire naupliar period is passed within 36 hours (Pearson 1939).

The fifth nauplius moults to yield the first protozoea, the next stage in development. There are three protozoeal stages measuring from 0.80 to 2.6 mm. (1/30 to 1/10 inch) in length. The protozoeae have eyes and are active swimmers. They feed by filtering smaller organisms from the plankton. At the third protozoeal stage, the larva has 8 pairs of appendages.

The third protozoea moults to yield the first mysis. There are two development stages listed under this heading. The second mysis has the adult number of 19 appendages. These forms are strong swimmers and continue to feed by filtering. They measure from 3.2 to 4.4 mm. (1/8 to 1/6 inch) in length.

The second mysis moults to the first post-larva or subadult. The post-larvae generally resemble mature shrimp, although further changes, chiefly in proportions, will accompany maturity. Usually the second post-larva enters an estuary and begins a demersal or bottom existence, specializations in structure of appendages having made it impossible for the post-larva to continue the larval mode of life. At this time, the post-larva is about 7 mm. long (¼ inch).

On the basis of observed growth rates, Pearson has estimated that the duration of larval life for *P. setiferus* is from two to three weeks, and the post-larvae enter the brackish inside waters about that length of time after the eggs from which they developed were spawned.

Very little is known of the ecology of larval shrimp. They are members of the ocean plankton and, after the nauplius stages, probably feed largely on diatoms, one-celled floating plants. Presumably their enemies include the herrings and other filter-feeding organisms of the sea as well as smaller animals which may prey on individual members of the plankton. Quantitative analyses of these relationships have not been attempted and, indeed, much further groundwork is necessary before such can be tried. Pearson (1939) has observed a "positive, though probably complicated" phototrophism (attraction to light) of nauplii and protozoeae of *P. setiferus*. Nothing is known of the mechanism of transfer of the larvae from their oceanic habitat to the brackish estuaries which are the habitat of the post-larvae and young adults, although recent hydrographic researches may shed some light on this interesting problem (see below).

The distribution of the larval stages yields certain key information about the natural history of the species. Pearson found eggs of *P. setiferus* off the Louisiana, Georgia, and Florida coasts, in limited numbers in St. Augustine Inlet but only on flood tides, and not in inshore plankton tows. The distribution of the larval stages agrees generally with that of the eggs, the only inshore record being that of three myses taken at St. Augustine Inlet. During May and June maximum seasonal numbers of post-larvae are found at inlets where flood tides sweep them into brackish nursery areas. Here they adopt a demersal life and commence feeding on bottom organisms. Growth of post-larvae is rapid, increments in length of *P. setiferus* as great as 29 mm. (1-1/6 inch) in 43 days being recorded in aquaria by Pearson (1939).

ADULTS

The growth which follows larval development is accompanied by regular migration back toward deeper water of high salinity. Weymouth, Lindner, and Anderson (1933) state for *P. setiferus,* the common white shrimp:

> During July, at an average length of about 99 mm (4 inches), they (shrimp from eggs laid during the preceding spring) enter the commercial catch, appearing first in bays, creeks and other "inside" waters and later outside.
>
> They continue in the fishery furnishing all of the fall catch with its peak in October until the following spring and summer, when the survivors spawn and disappear at the age of one year. By late fall they have reached a length of about 120 mm (4¾ inches) which they maintain during the winter. Resuming growth in the spring, they show a rapid and striking differentiation in the size of the sexes and spawn at lengths of 130 to 170 mm (5⅛ to 6¾ inches) for the males and 135 to 190 mm (5¼ to 7½ inches) for the females. Their fate is unknown, but their complete disappearance from the fishery is undoubted.
>
> The breeding season is characterized by (1) development of the sex organs; (2) a rapid differentiation in size between the sexes; (3) a difference in the behavior of the sexes so that the proportion of sexes, uniform during the winter, shows wide fluctuation. Far more mature shrimp of both sexes are found outside than inside the sound.
>
> The shrimp is most abundant in shallow coastal waters near river mouths or deltas.

This summary outline is based principally on length-frequency data obtained chiefly in Georgia by examination of thousands of shrimp during a period of 19 months in 1931 and 1932.

Burkenroad (1934) interprets the disappearance of year-old shrimp from the coastal feeding grounds as a spawning-migration to waters farther offshore. He points out that disappearance of mature adults occurs without "any indication that these individuals have already spawned." He further states that the disappearance of adults from the inshore waters is not sufficient evidence to conclude that the life span is only one year.

In 1939 Burkenroad published the results of field observations beyond the range formerly investigated. He found white shrimp in water as deep as 40 fathoms and grooved shrimps in even greater depths. Shrimp taken in deeper water were more than one year old and, in at least one specimen, showed definite evidence of repeated spawning. Mating was found to bear no close relationship to spawning, many impregnated females having "very unripe" ovaries.

King (1948), in describing the reproductive organs of *P. setiferus,* states that the spawning season in Louisiana offshore waters extends from March through September and that a single female may spawn more than twice during that season. King also refers to unpublished manuscripts (by Lindner, Anderson, and King, 1948) indicating that 1½ years is the age limit at which one year-class can at present be distinguished from another. The normal life span of the individual shrimp is a matter still undetermined.

The information regarding the natural history of the grooved shrimps is far less extensive than that for *P. setiferus*. Burkenroad's (1934) statements about *P. brasiliensis* probably refer to *P. aztecus*. His later (1939) findings seem to confirm this probability. Small individuals are found in some abundance in coastal and inside waters in the summer. Larger individuals are taken offshore. The small inshore population is made up of immature shrimp, males and females occurring in about equal numbers. They are brownish-gray in color. Considerable size difference between the sexes is evidenced in the offshore population, as is excess in the numbers of females over males. The color of specimens from the outer littoral zones tends to orange. Since the offshore males are all mature and since the size difference between immature males and females is not as striking as is that between mature animals, Burkenroad suggests a greater longevity for female *P. aztecus* than for males. Again, there is evidence of repeated spawning. The time of mating is correlated with the time of shedding, females being impregnated while soft.

The occurrence of *P. aztecus* off the Atlantic coast of southern New Jersey during only September and October indicates (Burkenroad, 1939) a "northward dispersal of juveniles and subadults from more southern areas of spawning and metamorphosis, possibly followed by a successful return of the maturing individuals."

The only reference to the natural history of *P. duorarum* (Burkenroad, 1939) states that since only small, sexually immature adults are taken inshore, the species probably "retires permanently to deeper water after a littoral youth."

The occurrence of *P. brasiliensis* in this country is probably very rare.

MIGRATORY MOVEMENTS

As has been shown, there is a general offshore movement of shrimp coincident with maturity. The spring run of "lobster shrimp" in Louisiana is interpreted by Burkenroad as a shoreward migration of individuals that have spent the winter in deeper waters.

It is of especial interest to determine the mechanics of the migration of planktonic larvae from the deep-water spawning grounds to the inlets and estuaries where they enter the inside waters. Since the larvae are planktonic, this migration must be made possible through shoreward-moving currents. Bumpus and Wehe (1949) have postulated a series of such currents from Cape Hatteras to the Florida Capes on the results of recent hydrographic studies.

Higgins (1937, '38, '39, '40) has reported coastwise migration of white shrimp in the western Atlantic. Shrimp tagged at the northern extremities of the geographic limit of abundance have been recovered farther south, individuals sometimes being recovered as far as 200 miles from the place of tagging. A southward migration during fall and winter is followed by a northern migration in the spring. This migration is recorded as extending from North Carolina to Florida. Burkenroad's (1939) mention of the appearance of *P. aztecus* off the coast of New Jersey in early fall suggests a similar migration for this species.

HABITS

No systematic examination of stomach contents has been reported. The shrimp is, however, according to Weymouth, Lindner, and Anderson (1933) a "voracious and well-nigh omnivorous feeder." They list worms, crustacea (not excluding shrimp of the same species), small mollusks and plant débris as items in the diet of adult shrimp. Considerable amounts of mud and sand are usually present in the intestine, and it seems not unreasonable to assume utilization of contained organic matter. In aquaria, shrimp have been observed to attack and devour small fish and other shrimp of the same species (Weymouth, Lindner, and Anderson, 1933) and to feed upon beef liver and oyster meats.

Shrimp move about in three ways. The periopods, or walking legs, are used in walking about on the bottom. In swimming, the walking legs are flexed under the cephalothorax, or "head," and the animal is propelled through the water by rhythmic beating of the pleopods, or swimming legs. When the shrimp is alarmed, the abdomen is flexed rapidly, the uropods and telson, or fantail, serving as a fin to propel the animal backward through the water. Several repeated backward flips may carry the animal a distance of thirty feet or may, if it be near the surface, result in repeated and haphazard backward leaping from the water. Except when alarmed, shrimp swim forward.

Although usually found on the bottom, shrimp do swim near the surface, often at night. The effectiveness of the night trawl and channel net (see above) depend upon the shrimp's presence at or near the surface.

The conditions under which shrimp bury themselves in the mud have not been studied, but this phenomenon is mentioned by Weymouth, Lindner, and Anderson (1933) and reported by oystermen and clam diggers in Pamlico Sound, where specimens, presumably from the mud, can be collected during the winter months. Examination of these "mud-shrimp" reveals a high percentage of *P. duorarum.*

DISCUSSION

Since most of the published information regarding shrimp is based on observations made largely in the Gulf of Mexico and almost entirely outside of North Carolina, application of the present knowledge to local conditions presents certain problems and leaves many questions unanswered. The fishing season for *P. setiferus* in North Carolina agrees generally with that listed by Weymouth, Lindner, and Anderson (1933). A slightly earlier disappearance of this species suggests a southward migration as reported by Higgins (1937, '38, '39, '40). Specimens of *P. setiferus* measuring 150 to 190 mm. in length are taken frequently in the fall. These must represent shrimp spawned during the preceding year (see section on adults, above) and are probably migrants from farther south. The spring run of *P. setiferus* most certainly is made up of ripening individuals entering the local waters from outside the State. The disappearance of these shrimp in early summer seems to be a spawning migration. The possibility that these large shrimp entered the fishery from the deep waters offshore seems remote.

Migration of shrimp from North Carolina to the south during the fall suggests their absence from these waters during a part of each year. Out-of-season trawling by the "Pelican" in 1940, the *Reliance* in 1948, and the *Penny* in 1949 has failed to reveal the presence of more than a few shrimp in North Carolina in early spring. Although the bathymetric (depth) limit attained by the latter two vessels is less than that at which shrimp were taken by Burkenroad, the "Pelican" made hauls covering the entire continental shelf in March of 1940. That year, however, failed to produce a spring fishery. The possibility, therefore, that shrimp in off season may exist in the deeper waters off North Carolina must be admitted, although the weight of evidence is against it. *P. duorarum* (see below) is an interesting exception.

No information has been published on the geographic distribution of larval forms, and spawning areas have not been located in the Atlantic

Ocean off North Carolina. The absence of shrimp from North Carolina during a part of the spawning season suggests the possibility that spawning does not occur in this state's offshore waters. Preliminary examination of specimens from offshore has failed to yield evidence of mating activity. The possibility must therefore be admitted that our shrimp population may be a migrant one, the young being supplied from breeding areas to the south and this young population being augmented by the spring and summer migration of larger individuals from southern waters. At the same time, the presence of a spring run suggests the possibility that spawning activity may occur in the southern waters of this state or in the waters of South Carolina. Information fixing the northern or southern limit of spawning areas is not available; yet the data on migration suggest that such limits may exist. If this be so, the fall migration may then end in an almost complete disappearance of shrimp (*P. setiferus* and *P. aztecus*) from these waters until the spring run. While this hypothesis is suggested by the available literature, contradictory evidence is lacking insofar as *P. setiferus* is concerned.

P. aztecus is a species of considerable value in North Carolina, possibly more so here than in any other state. Weymouth, Lindner, and Anderson's 1933 figures represent the only available estimate of the percentage of *P. aztecus* in the total catch of the United States. This species has become more abundant in the catches of recent years, but percentage estimates are not available. In North Carolina, however, this species has been shown to be of considerable economic importance. The season starts and ends before the season for *P. setiferus,* large individuals being common in Pamlico Sound as early as July. Since no growth rate data for this species exist, it is impossible to designate the age or source of these individuals.

The large specimens of *P. duorarum* taken frequently by fishing trawlers in all depths up to 30 fathoms in the vicinity of Cape Hatteras suggest a resident population of this species. The absence of these large individuals from the inshore waters concurs with Burkenroad's observations (see above). Small individuals of this species are taken in the spring inshore. There is evidence indicating a winter residency of these forms in the Sound waters. Except in the early spring runs, the percentage of *P. duorarum* taken is low. In the offshore waters, however, *P. duorarum* has been taken almost to the exclusion of other species during the winter of 1949. This fact not only indicates the permanent residency of *P. duorarum* in North Carolina, but also strengthens the hypothesis regarding the migratory nature of the other species.

The data on fecundity, growth rate, and duration of life of shrimp indicate considerable ability to withstand exploitation. A single female may lay as many as a million eggs in a season. Within six months, these eggs will have produced marketable shrimp and spawning shrimp within a year, Such production potentials are not uncommon among marine Crustacea. Depletion of the population by natural causes is, of course, great, and shrimps are a highly prized food item of fish as well as man. The relationships between the various stages and their environments are complex. Quantitative analysis of these relationships has not been attempted, and is, indeed, at the present time, impossible.

LEGISLATION AND REGULATION

The regulations specifically governing the shrimp fishery in North Carolina limit the size of nets used to 50 yards in length and ½ inch bar mesh in the counties of New Hanover, Brunswick, and Pender. In all other counties, bar measure must be at least ⅞ inch. The length of the trawling day is designated, it being illegal to trawl from 8:00 P.M. to 4:00 A.M. or on Sundays (N. C. Dept. Conserv. & Develop., 1948). In February, 1950, a closed season from January 1 to July 1 was imposed on the shrimp fishery.

The literature reveals no indication of danger to the species. Indeed, Anderson, Lindner, and King (1949) assert that "in the states for which there are records complete to the present time it is impossible to detect what might be called 'definite signs of depletion' of the resource." At the present time the various important relationships between the shrimp and its environment are too little understood to offer a program of management. Such a program can be derived only from quantitative studies of production potentials, predation rates, food requirements, and population studies of the shrimp and its predators. Fisheries management programs not based upon such knowledge tend to confuse the general picture and may delay the eventual enlightenment which leads to intelligent utilization of a natural resource.

BIBLIOGRAPHY

Anderson, A. W., and E. A. Power.
1949. Fishery Statistics of the United States, 1945. U. S. Fish & Wildlife Service, Statistical Digest No. 18 (1949), 372 p., (pictorial section, p. 355-372).

Anderson, W. W., M. J. Lindner, and J. E. King.
1949. The shrimp fishery of the southern United States. U. S. Fish & Wildlife Service, Commercial Fisheries Review, Vol. 11, No. 2, 1949, p. 1-17.

Bumpus, D. F., and T. J. Wehe.
1949. Hydrography of the western Atlantic. Woods Hole Oceanographic Institution, Reference 49-6, 1949 (technical report).

Burkenroad, M. D.
1934. The Penaeidae of Louisiana with a discussion of their world relationships. Bull. Am. Mus. Nat. Hist., Vol. 68, 1934, p. 61-143.

1939. Further observations on Penaeidae of the northern Gulf of Mexico. Bull. Bingham Oceanog. Coll., Vol. VI, 1939, p. 1-62.

Higgins, E.

1937. Progress in biological enquiries, 1935. Rept. U. S. Comm'r. Fish. for 1936 (1938), App. IV (1937), p. 381-452.

1938. Progress in biological enquiries, 1937. Rept. U. S. Comm'r. Fish. for 1938 (1940), App. I (1938), p. 1-70.

1939. Progress in biological enquiries, 1938. Rept. U. S. Comm'r. Fish. for 1939, App. I (1939), p. 1-81.

1940. Progress in biological enquiries, 1939. Rept. U. S. Comm'r. Fish. for 1940, App. I (1940), p. 1-96.

Johnson, F. F., and M. J. Lindner.

1934. Shrimp industry of the South Atlantic and Gulf States. U. S. Bur. Fish. Investig. Rept. No. 21, 1934, p. 1-83.

King, J. E.

1948. A study of the reproductive organs of the common marine shrimp, *Penaeus setiferus* (Linnaeus). Biol. Bull., Vol. 94, 1948, p. 244-262.

North Carolina Department of Conservation and Development.

1948. Rules and regulations of the Department of Conservation and Development relative to the commercial fisheries of North Carolina. 50 p. Revised July 29, 1948. Morehead City.

Pearson, J. C.

1939. The early life histories of some American Penaeidae, chiefly the commercial shrimp, *Penaeus setiferus* (Linnaeus). Bull. U. S. Bur. Fish., Vol. XLIX, Bull. No. 30 (1939), p. 1-73.

Weymouth, F. W., M. J. Lindner, and W. W. Anderson.

1933. Preliminary report on the life history of the common shrimp, *Penaeus setiferus* (Linnaeus). Bull. U. S. Bur. Fish., Vol. XLVIII (1940), Bull. No. 14 (1933), p. 1-26.

THE BLUE CRAB IN NORTH CAROLINA

BY John C. Pearson
U. S. Fish & Wildlife Service

CONTENTS

HISTORY

The edible crab, *Callinectes sapidus* (Rathbun) of the Atlantic and Gulf coasts of the United States was first observed in North Carolina waters in 1588 by that historian of the Roanoke Colony, Thomas Hariot, who noted: "There are also in many places plenty... of sea crabs, such as we have in England." During the brief life of the Lost Colony, John White, a prominent leader in the English settlement, portrayed in color the blue crab along with some dozen fish and shellfish found in the shallow waters of Croatan Sound.

Over a century later, in 1714, John Lawson, a chronicler of colonial North Carolina, remarked:

"The smaller flat crabs I look upon to be the sweetest of all the species. They are the breadth of a lusty man's hand, or rather larger. These are innumerable, lying in most prodigious quantities all over the salts of Carolina. They are taken not only to eat, but are the best bait for all sorts of fish that live in the salt water. These fish (crabs) are mischievous to night hooks because they get away all the bait from the hooks."

Later, in 1737, John Brickell brought out a natural history of the State—a description of natural resources to large degree copied verbatim from John Lawson—and called attention to the soft-shelled crab. He unwittingly described the mating behavior of this crustacean, in which the soft-shelled crab is seized and fertilized by the hard-shelled male. Brickell said:

"These sorts (crabs) cast their shell every year at which time they make holes in the sand and cover themselves, or those with hard shells lie on them till their shells harden; otherwise they would be destroyed by other fish. These sort have the same virtues that the former."

This outline of the early recognition and utilization of the blue crab in North Carolina may be concluded here by quoting a record of the establishment of a modern fishery for crabs within the State. Townsend (1900) in a report of the United States Commissioner of Fisheries in 1899 (p. 179) informs us:

"A comparatively new industry in Carteret County since the former investigation (1890) is that of shipping soft-shell crabs to the Northern markets, the total number shipped in 1897 being 13,600 dozen. This business is growing steadily."

The blue crab, along with the shrimp, supported a minor fishery in the 1880's, when statistics began to be collected, and well into the 1890's. With the turn of the century, the blue crab fishery, especially that of Chesapeake Bay, far outstripped the general run of fisheries in rate of growth in relation to human population, as did the shrimp to an even greater extent. Table 1 summarizes this growth for the blue crab.[1] The growth of the fisheries for these two crustaceans, the blue crab and shrimp, taken together, has been

TABLE 1

Growth of the Blue Crab Industry, Atlantic and Gulf States, New York to Texas, inclusive

	Hard crabs		Soft crabs		Total crabs	
	Pounds (000)	Dollars (000)	Pounds (000)	Dollars (000)	Pounds (000)	Dollars (000)
1890–1	13,006	457	(soft and hard crabs combined)		13,006	457
1901–2	23,005	197	6,894	346	29,899	543
1908	38,265	421	10,299	359	48,564	780
1929	61,616	1,204	4,819	523	66,435	1,727
1930	67,475	2,206	8,860	789	76,335	2,995
1931	66,877	914	6,119	497	72,996	1,411
1932	65,684	695	5,587	391	71,271	1,086
1937	74,623	1,430	5,622	549	80,245	1,979
1938	76,228	1,279	6,497	627	82,725	1,906
1939	82,335	1,414	6,499	532	88,834	1,946
1940	72,513	1,408	4,389	418	76,902	1,826
1945	95,975	4,837	6,118	3,011	102,093	7,848

1. For further statistical treatment of the blue crab (in comparison with shrimp and oysters), see Part III of this Survey, Table 22, and the accompanying text.

one of the phenomenal developments of the fisheries industries of the country. They are almost exclusively confined to the Chesapeake, South Atlantic, and Gulf regions.

DISTRIBUTION

The blue crab occurs in most estuarine waters from New York to Texas. While more crabs have always been taken from Chesapeake Bay than from other areas of our coast, the commercial yield from South Atlantic and Gulf regions has been steadily increasing, suggesting a natural abundance of crabs in these waters far greater than hitherto known. Unlike its relative, the shrimp, the blue crab is only occasionally found in the open sea off North Carolina, as elsewhere, but prefers shallow bays, sounds and river estuaries, where it thrives in waters ranging from ocean saltiness to brackish or even fresh. However, it is recognized that heavy freshets in coastal streams, such as the Neuse and Pamlico rivers, often drive crabs out of the rivers toward the more saline waters of Pamlico Sound. Blue crabs usually seek shallow inshore areas in warm weather and retreat into the deeper channels in winter.

NATURAL HISTORY

The life history of the blue crab is best known in Chesapeake Bay because the fishery there has been long established, and extensive biological research has accordingly been undertaken. However, the general features of the life history are probably quite similar in all sections of the coast.

Each year between April and August a new generation of blue crabs is produced in North Carolina. Sometime during this period the adult female or sook crab extrudes from 1½ to 2 million eggs, each egg about 1/100 inch in diameter, and these together form a large mass known as the sponge, which is firmly attached to the abdomen of the crab. The eggs hatch in about 15 days in the saltier waters adjacent to the inlets and ocean. Subsequently, a second sponge of eggs may be produced in the same season by the female crab. The newly hatched crabs are quite unlike their parents in appearance; they pass through two stages of metamorphosis in neither of which do they have any recognizable resemblance to adult crabs as we know them. The first of these is called the zoea, about 1/25 inch in size, free-swimming or drifting about helplessly in the water. The zoea molts several times, believed to be six, and is transformed at its last molt into the next stage, the megalops. This stage, no larger than the first zoea, about 1/25 inch, begins to take on at least a little more resemblance to the crab as we know it; at the megalops' first and apparently only molt at about one month after hatching of the egg, it becomes a crab in general appearance, and settles to the bottom, which it inhabits throughout the rest of its life. Thereafter the young crab molts or sheds its shell about 15 times before reaching maturity.

Crabs, being confined in rigid shells, do not grow at a steady rate of increase in size but only by a series of quick expansions mostly within an hour or two while in the soft state at each of these molts. After the shell hardens each time, it remains of constant size until the next molt, but of course the crab inside increases in weight. Most crabs attain their full growth and mate during their second summer, when from 12 to 14 months of age.

Young crabs, hatched near the sea, begin a movement up the sounds and rivers into brackish waters. Cold weather in the first winter interrupts this journey, and the young crabs settle to the bottom to remain dormant until conditions become more favorable. In the spring movements are resumed and growth proceeds rapidly until they reach maturity in summer or early fall. The female crab is fertilized during this last molt or growth stage and subsequently tends to move from brackish water to more saline areas nearer the ocean. The adult male usually remains behind. In the following spring the females move out of the deeper waters where they have passed the winter and seek shallow inshore areas to spawn. Most female crabs reach their life span after the end of the first spawning and die when from 2 to 3 years old. While the first spawning is known to occur in the third summer in Chesapeake Bay, it is possible, in a milder temperature, that spawning may occur as early as the second summer in more southern regions. A significant feature in the life of the blue crab is the fact that this crustacean, like the shrimp, is a short-lived creature, seldom living more than two full years. Blue crabs are available to any fishery only during the last half of their customary two-year life cycle.[2]

FISHERY

TYPES OF CRABS

Both adult and immature crabs are taken in the commercial crab fisheries of North Carolina. Adult crabs provide the major source of hard crabs and are sold alive by weight or volume to processing or picking houses at the end of each day's fishing. Adult crabs average 3 to 4 individuals to the pound and are generally marketed in 100-pound barrels. From 10 to 15 pounds of edible crab meat may be extracted from 100 pounds of crabs—the amount varying with the skill of the picker and on the size, sex, and physical condition of the crab. Male hard crabs are most sought after because of their higher yield of meat. Crabs, soon after molting, are known

2. Additional information on the details of the life history of blue crab will be found in Hay (1905) and Churchill (1919) and, on the zoological classification of the crabs, shrimps, etc., in Hay and Shore (1918).

as buckrams and provide little marketable meat. Crab meat is graded and usually classified for the market as claw, flake, and lump. Present (1948) North Carolina law sets the minimum commercial size of a hard crab at 5 inches measured from tip to tip of the spines on the shell or carapace. Egg-bearing crabs are also protected at all times.[3]

Immature crabs are sought for the soft-crab industry and are taken either as soft crabs or more generally as peelers or young hard crabs preparing to shed their shells within several days. Peelers and soft crabs average from 3 to 5 to the pound and are sold to the shedding houses on a numerical rather than on a weight basis. Peeler crabs furnish the bulk of the stock which provides the soft crab of commerce. These crabs are impounded in floats and tended carefully until they have become soft and suitable for shipment. A variable mortality of immature crabs occurs during this time. The degree of this mortality, which may range from 20 to 60 per cent of the catch, varies according to natural conditions of weather and salinity as well as according to the skill with which the crabs are cared for in the floats. Soft crabs are marketed by the dozen and are often graded by size (width of spines) as jumbos, hotel primes, primes, mediums, and culls. The entire body of a soft crab is edible although the gills and abdominal segment are usually removed before cooking. Legal measures in North Carolina restrict the commercial size of a soft crab to a minimum of 3 inches from tip to tip of the spines (1948).

AREAS AND SEASONS

Hard crabs are available to fishermen in North Carolina throughout the year although relatively few crabs are taken from November to February. Owing to a less intensive fishery for blue crabs in North Carolina compared to Chesapeake Bay, a greater proportion of male crabs are sought and utilized in the State than in the Chesapeake. The fishery is prosecuted most vigorously in the more brackish water areas along the western shore of Pamlico Sound and in the lower Neuse and Pamlico rivers. An early spring fishery occurs in Core Sound, the most southerly point in the State at which any considerable volume of crabs is taken. The fishery in Carteret County reaches a peak in March but falls to minor proportion after May. The fisheries in the more northerly regions of the coast do not reach a peak until mid-summer but have a full five months of productivity from May to October. The seasonal catch of hard crabs in the major producing counties of the State, based on the monthly percentage of an 8-year catch, is given in Table 2. Beaufort County surpasses all other sections in the volume of catch.

3. Additional information on the commercial blue crab fishery and industry will be found in Roberts (1905) and Churchill (1919-a).

TABLE 2

Monthly Yield of Hard Crabs in the Major Producing Areas of North Carolina, Expressed as the Percentage of an 8-Year Catch in Each Area from 1939 to 1946. Catch Calculated on Basis of State Tax Collections on Each Barrel Containing about 100 Pounds of Live Crabs

Month	Carteret County	Pamlico County	Beaufort County	Dare-Currituck Counties
	Percent	Percent	Percent	Percent
Jan.	...	...	...	2.3
Feb.	4.3	.1	...	...
March	57.2	4.6	3.4	2.2
April	27.4	6.8	3.9	4.9
May	...	13.0	10.9	4.0
June	2.2	14.5	15.0	16.4
July	2.0	19.4	23.5	19.8
Aug.	...	23.7	24.1	21.0
Sept.	4.1	13.7	12.3	10.4
Oct.	2.3	3.2	5.2	14.6
Nov.	.3	.4	1.3	3.7
Dec.	...	.5	.2	.7
Total catch in barrels	39,704	58,347	183,005	34,090

TABLE 3

Monthly Yield of Soft Crabs in Carteret County Expressed as the Percentage of Total Yield from 1939 to 1946. Catch Based on State Tax Collections

Month	Percent
Jan.	.6
Feb.	.6
March	9.9
April	19.6
May	30.2
June	15.0
July	13.6
Aug.	5.6
Sept.	3.2
Oct.	1.7
Nov.	.1
Total catch in dozens	341,195

Immature crabs, upon which the soft-crab fishery depends, are taken principally from April through July and largely in Core Sound, where extensive shedding of peeler crabs is conducted. The general region of Core

Sound provides an excellent environment in which young crabs may molt and grow, and the shallow, clear waters of the sound enable fishermen to capture young crabs in greater commercial quantities than elsewhere along the coast. The monthly catch of soft crabs, based on an 8-year production record in Carteret County, is given in Table 3.

GEAR

The baited trot-line is generally employed to catch blue crabs in North Carolina. A colonial seaman, Samuel Kelly, who visited the Carolina coast in 1782, described the use of this type of fishing gear:

"There is a blue and yellow crab here about the size of a man's hand, and they are plenty. The way to catch them is to get into the boat alongside with a line to reach the bottom and to which any animal substance may be fastened. After lying at the bottom a few minutes, it is drawn up softly and you will find the crabs fast to the bait, which they will hold fast to the water's edge. Then, having a cabbage net extended on a small hoop, you place this gently beneath the crabs and secure them, for they always quit their hold on being lifted out of the water."

Essentially the same method for catching crabs is in use today. The common form of trot-line consists of a ground line of ¼ inch Manila rope, 1,000 feet or more in length, that is baited with pickled tripe or salted eel. The line is run over a roller that extends from the side of a small power boat. Crabs hold on to the bait and are brought to the surface as the boat goes forward, forcing the roller under the line. As the crab-bearing bait approaches the surface of the water, a dip-net is used to take up the crabs.

The patent dip trot-line gear is also widely used and differs from the former type in that a large conical bag made of netting is suspended below a metal frame which is situated under the roller in such a way that the crab automatically drops into the entrance of the net when it releases its hold on the bait. Thus, dipping by hand is not required. This rig may employ over a mile of line and can be operated from a larger, more seaworthy boat than the simple trot-line. Baits are generally fastened on the line from 2 to 3 feet apart and the line is laid down in a locality where crabs are known or believed to be abundant.

INTENSITY OF FISHING

North Carolina ranked fifth among twelve seaboard states in the production of blue crabs in 1940. The trend of the annual yield within the state has been upward during the past thirty years. Since 1930, the catch has always exceeded one million pounds annually, reaching a peak of 6,375,000 pounds in 1936. Table 4 presents the annual production and value of blue crabs in the State.

TABLE 4

Production and Value of Blue Crabs in North Carolina, 1887-1945

	Crabs, hard		Crabs, soft	
	Quantity pounds (000)	Value dollars	Quantity pounds (000)	Value dollars
1887	47 *	1,105 *	——	——
1888	47 *	1,110 *	——	——
1889	50 *	1,250 *	——	——
1890	47 *	1,185 *	——	——
1897	40	1,000	987	3,992
1902	3	100	200	14,553
1908	113	1,100	277	33,000
1918	146	1,983	234	23,821
1923	331	5,395	182	27,692
1927	956	19,512	269	44,257
1928	847	16,821	629	96,365
1929	855	15,170	351	52,620
1930	1,160	18,995	379	57,068
1931	1,852	25,211	311	46,586
1932	1,848	18,448	309	33,921
1934	4,544	67,238	251	36,210
1936	6,375	132,316	216	60,486
1937	3,246	51,538	142	22,600
1938	3,830	72,455	124	18,652
1939	2,854	53,574	173	26,030
1940	4,008	75,957	286	42,900
1945	5,696	284,820	184	55,290

* Hard and soft crabs not separated.

An outstanding characteristic of the crab fishery in North Carolina has been close relationship with, and dependence until recent years upon, the older established industry in Chesapeake Bay. Each year, in March and April, before crabs readily seek the bait in Chesapeake Bay, it has been the practice of packers in Maryland and Virginia to buy nearly the entire production of hard crabs in Carteret County. These crabs are trucked alive to processing plants on Chesapeake Bay. Likewise, in late summer and fall, large exports of crabs from Dare and Currituck counties are sent to the Chesapeake region to augment the local supply, especially during periods of scarcity. Production of soft crabs in Carteret County is stimulated in large measure by the Chesapeake Bay packers.

There is an inverse correlation between the annual catch of crabs in Chesapeake Bay and in North Carolina according to comparable statistics from 1929 to 1942. Data in Table 5 indicate that years of low production in Chesapeake Bay, such as prevailed in 1934, 1941, and 1942 (due largely to decreased natural abundance of crabs), were accompanied by relatively high yield in North Carolina. Years of high yield in the Bay, like those from 1929 to 1932 and in 1939, were periods of low production in North Carolina. It is certain that when natural abundance of crabs in Chesapeake Bay is low and insufficient economically to satisfy the industry, imports of both hard and soft crabs from North Carolina will increase. Again, local producers of crab meat in North Carolina tend to procure larger markets for their products when competition from Chesapeake Bay is reduced.

The inverse correlation in yield between Chesapeake Bay and North Carolina has given rise to a belief among many crab packers that a high natural abundance in one region is accompanied by a low abundance in the other and vice versa. Although any relationship in natural abundance of crabs in the two regions cannot be ascertained with available catch data, there is more reason to believe that varying intensity of fishing in North Carolina as influenced by economic pressure accounts for the correlation. Table 6, for example, shows that the catch in Carteret County was at a high level in 1940 and 1941 at a time when low natural abundance of crabs was known to prevail in Chesapeake Bay and at a low level in 1946 when a high natural abundance of crabs occurred in the Bay.

TABLE 5

Total Annual Catch of Hard Crabs in Chesapeake Bay Compared with Total Annual Catch in North Carolina. Figures for 1929 to 1940 Based on Data from Fish & Wildlife Service. Chesapeake Bay Catch for 1941 and 1942 Based on Fish & Wildlife Service Records; North Carolina Catch for 1941 and 1942 Based on State Tax Collection Records

Year	Catch in Chesapeake Bay in millions of pounds	Catch in North Carolina in millions of pounds
1929	55.8	.9
1930	60.6	1.2
1931	58.9	1.9
1932	56.4	1.8
1933	50.6	...
1934	36.1	4.5
1935	37.0	...
1936	39.4	6.4
1937	44.1	3.2
1938	49.4	3.8
1939	51.0	2.9
1940	38.0	4.0
1941	27.7	5.2
1942	32.7	4.5

TABLE 6

The Annual Catch of Hard Crabs in Barrels in Several Counties of North Carolina from 1939 to 1946. Based on State Tax Collections on Each Barrel of Crabs (Amounts Are Probably Under Actual Production But May Be Proportionate from Year to Year). Multiply the Number of Barrels by 100 to Obtain Pounds of Crabs

County	1939	1940	1941	1942	1943	1944	1945	1946
Beaufort	15,429	26,819	33,605	28,629	9,991	21,954	28,670	17,908
Pamlico	1,747	3,506	7,424	4,411	9,147	15,663	8,659	7,791
Carteret	5,144	6,758	9,396	4,925	2,958	3,067	4,568	1,158
Dare and	.....	.....	.....	.....	.....	.....	.....	.....
Currituck	.....	4,947	1,262	7,216	3,689	5,518	5,472	5,986
Totals	22,320	42,030	51,687	45,181	25,785	46,202	47,369	32,843

Although a large part of the annual production of crabs in North Carolina depends upon the variable supply of crabs in Chesapeake Bay, many fishermen believe that natural fluctuations occur in the abundance of crabs in North Carolina coastal waters. While fluctuations in year-class abundance of blue crabs have been found to prevail in Chesapeake Bay (Pearson, 1948), essential information is lacking to determine the presence of fluctuations in North Carolina. Only by some constant unit of measurement of the crab stock (e.g., catch per unit of fishing effort) can variations in natural abundance of crabs be determined over a period of years.

Again, adequate catch records are not available to compare the density of the crab population in North Carolina with that in Chesapeake Bay. However, a broken series of daily catches based on the number of pounds of hard crabs taken per man-day by trot-line operated in Core Sound and Hampton Roads will serve to indicate the degree of monthly and annual variations in the abundance of crabs in the two regions (see Table 7). Natural abundance of crabs was apparently higher in Core Sound in March and April, 1942, than during the same period in 1944. The April catches during 1942 and 1944, as well as the summer catches in the lower Pamlico River in 1944, were substantially lower than in February and March. This condition appears due largely to the fact that while many female crabs with eggs are taken by crabbers in April, they must be excluded by law from the market catch. In early season, before the female crabs have produced their egg sponge, a larger proportion of female crabs enters into the market catch than occurs from April to September.

The smaller daily catches in Hampton Roads during April, 1944, than in the following summer months are accounted for by the fact that water temperatures in this area are generally too low in April to encourage active

TABLE 7

Catch Frequencies of Hard Crabs Taken by Trot-Line in North Carolina and in Chesapeake Bay at Various Periods in 1942 and 1944. (In Percent of Total Number of Man-Days). Catch in North Carolina from February Through April Taken in Core Sound; from June Through September in Lower Pamlico River. Catch in Chesapeake Bay from April Through September Taken in Hampton Roads Area *

Daily catch per man in pounds of crabs	North Carolina						Chesapeake Bay, Va.		
	Feb.	March		April		June-Sept.	April		June-Sept.
	1944	1942	1944	1942	1944	1944	1942	1944	1944
	percent	percent	percent	percent	percent	percent	percent	percent	percent
1–100	11.7	2.7	9.2	6.5	26.0	7.5	4.8	14.3	11.5
101–200	13.0	3.3	21.7	40.3	26.0	42.5	14.3	48.0	9.0
201–300	11.7	14.7	25.0	15.6	24.6	32.5	38.0	14.3	17.9
301–400	5.2	15.3	19.0	19.5	10.8	10.0	19.1	4.8	9.0
401–500	3.9	15.3	13.2	7.8	..	5.0	14.3	4.8	9.0
501–600	1.3	12.7	5.3	6.5	9.2	2.5	4.8	9.5	16.6
601–700	9.1	10.0	2.6	3.9	3.1	..	..	..	5.1
701–800	9.1	6.7	2.0	..	..	..	4.8	4.8	5.1
801–900	2.6	3.3	2.0	..	..	..	..	..	5.1
901–1000	10.4	5.3	..	..	..	..	..	..	2.6
1001–1100	6.5	2.7	..	..	..	..	..	..	3.8
1101–1200	6.5	4.0	..	..	..	..	..	..	..
1201–1300	3.9	2.7	..	..	..	..	..	..	1.3
1301–1400	1.3	..	..	..	..	..	..	..	1.3
1401–1500	2.6	..	..	..	..	..	..	..	2.6
1501–1600	1.3	.6	..	..	..	..	..	..	..
2301–2400	..	.6	..	..	..	..	..	..	..
Total	100.1	99.9	100.0	100.1	99.7	100.0	100.1	100.5	99.9
Number of days	77	150	152	77	65	40	21	21	78

* Catch during June-September in North Carolina and during April-September in Chesapeake Bay based on a single fisherman; catch during February-April in North Carolina based on a variable number of fishermen.

feeding by crabs. Incidentally, the crab stock in the region is composed largely of adult females that are taken and marketed in all breeding stages.

It is evident that differences both in the environment and the economic requirements of the fishery in the two regions make it impossible to compare with accuracy the natural abundance of blue crabs in North Carolina and in Chesapeake Bay. The distribution of the catch frequencies of crabs taken by the same unit of fishing effort in the two areas suggests, however, that the actual density of the stock of crabs may not differ widely in areas with somewhat comparable environmental conditions.

As shown in Table 4, the annual production of soft crabs in North Carolina has steadily declined over the past twenty years. The decrease, examined on the basis of yield from 1935 to 1946 (see Table 8), was halted appreciably only in 1941. Quite significantly, the latter year was a period when the production of soft crabs in Chesapeake Bay was extremely low because of a natural scarcity of crabs in the Bay (Pearson, 1948). As the principal producer of soft crabs, the industry in Chesapeake Bay has sought, by buying soft crabs in Carteret County, to supply their trade at least a month earlier in the season than is possible through production in Chesapeake Bay. When a period of scarcity of soft crabs, as well as hard crabs, occurs in the Bay, a larger production of crabs in North Carolina is required than would otherwise be necessary.

TABLE 8

Production of Soft Crabs in Dozens in Carteret County, North Carolina, from 1935 to 1946, Based on State Tax Collection Data

Year of catch	Carteret County—Production in dozens
1935	74,092
1936	117,857
1937	76,495
1938	68,539
1939	63,157
1940	45,866
1941	57,830
1942	40,889
1943	44,414
1944	36,654
1945	25,738
1946	27,251

The steady decline in annual yield of soft crabs in North Carolina appears due solely to economic rather than biological factors. If depletion by overfishing were responsible for this decrease in production, it would probably be reflected in a similar decline in the yield of hard crabs taken in the same general region. This condition did not prevail according to available catch statistics (see Table 4). The exact economic conditions, other than the variable annual demand from Chesapeake Bay packers, which have been responsible for the drop in production of soft crabs are unknown. However, a general decline in consumer popularity of soft crabs, increasing market competition with Chesapeake Bay, and, since 1940, a shortage of adequate labor for catching and shedding peeler crabs are possible reasons for the continued decrease. It is significant in this respect that market limitations have prevented any appreciable growth of the soft-crab industry in Chesapeake Bay in recent years.

FUTURE DEVELOPMENT

There is no sure way to determine the biological limits of the blue crab population in North Carolina except through unrestricted exploitation by the fisheries. Full exploitation has not occurred up to the present day because of economic restrictions. The magnitudes of both the hard- and soft-crab fisheries have been dependent in varying degree upon the available supply of crabs in Chesapeake Bay. The crab industry in North Carolina has been one based in large measure on primary raw-material production rather than manufacture. For example, compared to some 100 crab-picking houses in operation on Chesapeake Bay in 1946, only 16 houses operated in North Carolina during this period and, prior to 1930, probably not more than a half dozen crab-picking houses were to be found along the entire coast of the State. Significantly, crab packers on Chesapeake Bay have not found it desirable to open subsidiary crab-picking plants in North Carolina, apparently finding it more economical to buy live crabs within the State and bring them to Chesapeake ports when market requirements necessitate. The future expansion of the crab industry in North Carolina depends primarily on the procurement of new markets for crab products by both primary and secondary producers. A most promising step in this direction was the recent establishment (1943) of a crab meat canning industry in Beaufort County.

Since the most promising market for blue crab products lies in the heavily populated East and Middle West, it is essential that costs in the production of crab meat and soft crabs be made substantially lower in North Carolina than in Chesapeake Bay, which is the region not only of heaviest yield but also closest to major marketing centers. Lower costs may be obtained by the use of cheaper raw materials (live crabs) and labor (crab-meat pickers). Complex economic and social factors will determine the extent to which costs can be reduced.

The statistical history of the fishery fails to show that the blue crab resource has been fully utilized in North Carolina. The biological limit of the commercial yield of the crab fisheries is undoubtedly higher than past production indicates. While the crab population, dwelling year-round in the shallow sounds and rivers of the State, appears unlimited so far as the present intensity of the fishery is concerned, it must be remembered that a restricted market now prevails for the relatively high-priced sea-foods of crab meat and soft shell crabs. More efficient ways to catch, to process, and to market blue crabs must be sought to overcome present handicaps to a greater utilization of the crab resources of the State.

BIBLIOGRAPHY

Binford, Raymond.

1911. Notes on the life history of *Callinectes sapidus.* The Johns Hopkins University Circular, No. 230, p. 14. Baltimore.

Brickell, John.

1737. The Natural History of North Carolina. Dublin. Reprinted at Raleigh, 1911, p. 215-250.

Churchill, Edward Perry.

1919. Life history of the blue crab. Bull. U. S. Bur. Fish., Vol. XXXVI, 1917-18 (1921), p. 91-128, 8 plates (Doc. 870, 1919).

1919-a. Crab industry of Chesapeake Bay. Rept. U. S. Comm'r. Fish., 1918 (1920), Appendix IV, 25 p., 12 plates (Doc. 868, 1919).

Hay, W. P.

1905. The life history of the blue crab. Rept. U. S. Bur. Fish., 1904 (1905), p. 397-413, 4 plates.

Hay, W. P., and C. A. Shore.

1918. The decapod crustaceans of Beaufort, N. C., and the surrounding region. Bull. U. S. Bur. Fish., XXV, 1915-16 (1918), p. 369-475, 15 plates (Doc. 859, 1918).

Hariot, Thomas

1588. A brief and true report of the New Found Land of Virginia. London. Reprinted in the Principal Navigations, etc. By Richard Hakluyt, Everyman's Library edition, Vol. 6, p. 182. London, 1907.

Kelly, Samuel.

1782. *Published as* Samuel Kelly, An Eighteenth Century Seaman. Edited by Crosbie Garstin, p. 54. New York, 1925.

Lawson, John.

1714. History of North Carolina. London. Reprinted by North Carolina Society of Colonial Dames of America, p. 162. Richmond, 1937.

Pearson, John C.

1948. Fluctuations in the abundance of the blue crab in Chesapeake Bay. U. S. Fish & Wildlife Service, Research Rept. 14, 1948. 26 p.

Roberts, Winthrop A.

1905. The crab industry of Maryland, Rept. U. S. Bur. Fish., 1904 (1905), p. 417-432.

Townsend, C. H.

1900. Statistics of the fisheries of the south Atlantic states. Rept. U. S. Comm'r. Fish., 1899 (1900), Pt. XXV, p. 171-227.

THE DIAMOND-BACK TERRAPIN IN NORTH CAROLINA

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CONTENTS

VALUE AND LOCAL FISHERY

Of marine and estuarial turtles only the diamond-back terrapin has had significant commercial history in North Carolina. Occasionally the valuable green turtles are taken, particularly the smaller ones, or "chicken turtles"; but the green turtle is here near the northern limit of its normal range. Pope (1939) says, however, that it was abundant in the North Carolina sounds before it was "decimated by turtle-hunters during the nineteenth century." The generally large loggerhead turtles are much more common but are not a market item. Some persons locally eat and esteem them. The loggerhead is the only sea turtle that habitually lays eggs on the beaches of our region. Its interest to North Carolina is for the material it readily affords for scientific studies of development and growth. The smaller Kemp's gulf turtle or "bastard turtle," sometimes, unfortunately, called "hawksbill," is found occasionally but is not valued. The true hawksbill, or tortoise-shell turtle, valued for its heavy covering of richly colored shell, has rarely been recorded from the Carolinas. The largest of all turtles, the trunk turtle or leatherback, is rare in our waters and without known commercial value in this country.[1] We are not concerned here with the freshwater snapping

1. In *Fishery Statistics of the United States, 1945,* green turtle was reported from Florida (12,800 pounds, valued at $1,280) and Louisiana (9,300 pounds, valued at $1,395). Loggerhead turtle was reported as a commercial product from Florida in the small amount of 15,000 pounds, valued at $1,645, and Virginia, 7,400 pounds, valued at $400. The hawksbill was marketed from New Jersey in the amount of 800 pounds, valued at $8. However esteemed "green turtle soup" may be, it is evident that sea turtles are commercially insignificant.

turtles, used for "snapper soup," or with strictly freshwater terrapin, or "sliders," although the latter are sometimes improperly substituted for diamond-backs (Coker, 1906, and Pope, 1939).

The diamond-back terrapin is primarily an estuarial species, occurring along the entire Atlantic and Gulf coasts in brackish water and even occasionally in the rivers above the reach of salt water. It is our only turtle characteristic of brackish waters. It is not found in the sea. All evidence gained from observation in nature and from breeding experiments indicates some dependence upon fresh water. There is as yet no fully satisfactory explanation of its restriction in distribution to brackish water and to only the lower reaches of the fresh waters of certain rivers. Possibly it is a matter of feeding habit, its accustomed food being such as is dependent upon the presence of salt water and the flow of tidal currents. Hay (1904) reported that terrapin have been found in the Potomac as far up as within four miles of Washington. The terrapin themselves are not dependent upon salt water surroundings. I and others have had them live and thrive in captivity, in pens supplied only with water from an artesian well, but in such case they were fed with salt water fish. On the other hand, I have tried to keep them in Mississippi River water in Iowa, where they were fed only freshwater foods; the terrapin survived only a few months (Coker, 1920).

At one time large diamond-back terrapin were per pound the most valuable food product from coastal waters (in the retail market). Measurement of size is by the length of the under-shell, called the plastron. It is a large individual, and always a female, that has the undershell 6 inches in length. Such terrapin might sell at $50 or $60 a dozen. Hildebrand and Hatsel (1926) reported the Boston market price as one dollar per inch of bottom shell; this gives a rate of $72 per dozen for 6-inch terrapin. Larger terrapin up to 7 or 8 inches would bring higher prices. The length of 8 inches on the bottom shell is rarely exceeded and the maximum is believed to be about 9 inches. A leading dealer in the Baltimore market told me of selling two terrapin to a regular customer, whom he named, for $25. Value in the connoisseur market depends not only upon the size but also upon appearance.

Standards of appearance are not precisely describable, but are based primarily upon recognition of the so-called "Chesapeake" type, with the top shell (carapace) flaring behind (widest behind the middle), the head small and relatively pointed, coloration rich and usually dark, the concentric markings on the plates (scutes) of the carapace evident. A terrapin of equal size to the "Chesapeake" but with more nearly parallel sides, larger head, generally lighter or dull color, and smoother shell, would bring a substantially lower price. This would be branded a "Carolina" type, although, as will be seen below, both types occur in North Carolina and probably in the Chesapeake.

What has been said about market values was more generally applicable before World War I. The war, with its immediate inhibitions in respect to luxury foods, and prohibition, with its discouragement of gourmanderie, came together, but the latter long outlasted the War. At any rate, the use of terrapin stew as the gourmet's delight has never come back in full force and the fancy market for terrapin seems not to have had a complete revival. By those who know, however, the superior flavor of the meat of select terrapin is not generally questioned.[2] Consequently, there remains the possibility that diamond-back terrapin will sometime come back into high favor, if not to its former place of topmost esteem. In the North Carolina fishery at this time the terrapin is without significance.[3]

Emphasis has been placed upon size in respect to price. Larger terrapin have greater weight, of course, but the higher value of large terrapin is based not so much upon poundage as upon presumed quality. It has always been assumed, whether correctly or not but probably correctly, that quality of meat and its flavor improves with age and size. Either younger or smaller terrapin, although highly toothsome, are relatively inferior in flavor. All male terrapin, being small, are thus excluded from the selects. The largest male of record in the terrapin experiments at Beaufort was reported as having a length on the bottom shell of 4⅝ inches, and the largest wild male found measured 4½ inches. The average undershell length of males was about 4 inches, a substantial proportion being smaller. It is doubtful if any male ever attains the "legal" minimum length for capture and sale—5 inches.

It is a long time since there was in North Carolina a particular fishery for terrapin (Coker, 1906). Occasional individuals are taken by chance in seine hauls or sighted in passing. At the time of the beginning of the experiments in terrapin breeding at Beaufort (1902), there was only one man in the Beaufort region known particularly as a "terrapin hunter." Working in a small skiff he would pole his boat through the creeks and marshes, looking with keen eyes for a terrapin under water or a head projected above the water and capturing terrapin now and then with his dip net. In his own

2. Not everything served as "terrapin stew," or even as "diamond-back stew," is made from diamond-back terrapin. "Sliders," and sometimes even "chicken," may be substituted for the more expensive diamond-backs.

3. In the Government statistics for 1945 (Anderson and Power, 1949), diamond-back terrapin were reported as marketed from the following States:

Maryland	370,000	pounds	$108,000
Virginia	27,500	"	6,875
North Carolina	2,700	"	675
South Carolina	500	"	125
Georgia	7,500	"	5,625
Florida	5,400	"	1,350

Obviously, the price per pound to fishermen is figured at 25 cents, except for Georgia (75 cents) and Maryland (about 29 cents).

words, and in good Elizabethan and original coastal English, he spent his life "perusing the creeks and progging the marshes." In earlier times in North Carolina the "drag-net" was employed in taking terrapin. In South Carolina I have been told of dogs trained to hunt terrapin in the marshes. Another method was to sail small boats through "creeks" or sloughs in the marshes, knocking occasionally on the bottom of the boat and looking for any nearby terrapin to raise its head above the surface of the water, presumably to look for the source of the sound. According to local informants terrapin are now fairly numerous in the Beaufort area, being taken frequently in shrimp nets used in inside waters. They are usually liberated for lack of local markets.

Terrapin caught by chance or as the result of search were taken to a dealer. Paid for at small prices, these were kept alive in boxes or barrels or, rarely, in pens, until shipping time in the fall. Even undersized terrapin, including the males, called "bulls," and the small females, known as "hens," were not excluded from shipment to bring profitable if not fancy prices, say $12 to $15 a dozen. So far as I could tell, the unrealistic legal restrictions with respect to sizes and to holding in confinement during the breeding season (April 15 to August 15) were not observed.

In the conditions under which terrapin were generally kept, feeding was hardly practicable. Since terrapin can live without food for long periods of time, the lack of food probably caused little if any harm other than to prevent the slight increase in size and value which the very slow-growing animals might have gained if kept under proper conditions. It would have been better, however, if the law had sanctioned and the dealers been inclined, to keep, feed, and water the terrapin in open ranges, used in other states and known as pens, pounds or, more commonly, "crawls." There were then extensive "crawls" at Crisfield, Md., and at Savannah, Ga. Subsequently, in 1913, State authorization was received for the establishment of the Beaufort Terrapin Farm at Beaufort, N. C., under the leadership of Dr. Charles Duncan. This company, to quote Dr. Hildebrand (1929, pp. 26, 27):

".... built concrete pounds and a terrapin nursery house and provided itself with all the facilities necessary for raising terrapins. A large brood stock was obtained, and within a few years from 15,000 to 20,000 terrapins per annum were being hatched. This farm progressed nicely until the beginning of the World War and the adoption of the eighteenth amendment to the Constitution. The cost of labor was more than tripled locally, the market value of terrapins dropped, owing to the general curtailment of the use of luxuries during the war, and it seems to have been believed by the manager that under prohibition terrapins never again would be in demand or command the fancy prices paid for them prior to prohibition and the war.

In view of these seemingly adverse circumstances, the breeding terrapins as well as some of the young that had attained a marketable size were sold, and in 1918 the plant virtually was abandoned. The Beaufort Terrapin Farm was patterned after the experimental plant of the Bureau of Fisheries, and the success attained in raising terrapins compared very favorably with that of the Bureau of Fisheries."

A contributing cause for discouragement to the company was the fact that the heating system for the nursery house was designed for use of anthracite coal, which was unobtainable in Beaufort during the war.

As regards the deprivation of food for terrapin during long periods of confinement, it may be remarked that it is a condition of the preparation of terrapin for the table that they should have been starved for a considerable period, in order that the digestive tract may be entirely empty. Before cooking or serving, terrapin are cleaned only on the outside by scalding for removal of the outer skin and the horny covering of the shell and jaws; after further cooking, bottom and top shells and the head are removed to be used for the soup; only the gall bladder is then discarded; all the remainder goes into the stew.

KINDS OF TERRAPIN

Diamond-back terrapin occur along the Atlantic and Gulf coasts from Buzzard's Bay to Texas, but systematists have recognized distinct species on the Atlantic coast and the Gulf coast and several subspecies. The species *Malaclemmys pileata* (knobbed terrapin) occurs along the Gulf coast with fairly distinct subspecies for, respectively, the region of the west coast of Florida, an intermediate zone westward to the mouth of the Mississippi and the westernmost territory from the Mississippi to and including the coast of Texas. All the Gulf coast terrapin can be distinguished from terrapin of the Atlantic coast south to Florida by the prominent knobs or tubercles on the plates of the middle part of the upper shell.

On the Atlantic side the species *Malaclemmys centrata* (Latreille) occurs from Buzzard's Bay, Massachusetts, to Florida; but two subspecies are recognized in this area. The species *centrata* proper is found from the region of Cape Hatteras to Florida. The range of the subspecies *M. centrata concentrica* (Shaw) is from the Hatteras region northward to Massachusetts. The estuaries of North Carolina are therefore within the ranges of both the southern species proper and the northern subspecies: both "Chesapeake" and "Carolina" terrapin are native to the State. The species *centrata* is believed to have been described from terrapin from Charleston, S. C., *concentrica* from examples from Delaware Bay.

It must be understood that there is no sharp line of division between the described subspecies. Apparently the diamond-backs have to a considerable extent developed characteristic ecological forms or varieties in response to environmental difference or to geographic isolation. Dealers have always recognized geographic varieties: "Connecticuts," "Long Island terrapin," "Delaware Bays," "Chesapeakes," and "Carolinas" (Hay, 1905). South Carolina terrapin are considered inferior to North Carolina terrapin, and Florida terrapin are still less prized. The term "Florida terrapin" in the market has, however, generally been applied to the Gulf species found on the west coast of Florida. I have been told by a well-informed dealer that historically the Long Island terrapin were the premium terrapin of the market. As the limited supply was depleted, Delaware Bay terrapin assumed first rank. Somewhat later, but perhaps a century ago, the less exhaustible supplies of the Chesapeake areas of Maryland and Virginia came to the front and have held top rank ever since.

How extensive was the practice, it cannot be said, but it was certainly not uncommon in the past for terrapin to be sold from Georgetown, S. C., to a dealer in Wilmington, then passed from Wilmington to a dealer in the Beaufort, N. C., region and thence to Crisfield, Md. Thus, terrapin from South Carolina might finally reach the city market as "Chesapeakes." Doubtless the more expert fanciers, being able to recognize the varietal distinction, were not always misled. In later years the "Carolina" terrapin gained in market favor, particularly those not markedly different from terrapin of the Chesapeake area, and shipments were generally made direct from North Carolina dealers to the largest city markets (Coker, 1906, and Hildebrand, 1929, p. 28).

The distinctions between "Chesapeake" and "Carolina" diamond-backs have been given on page 220. In regard to their respective distributions, several qualifications must be made. In the first place, the terrapin of any region are so variable in form that strictly dependable classification of individual terrapin is often impossible: both "Chesapeakes" and "Carolinas" occur outside of their respective "book" ranges. Second, since the supposed limits of the subspecies are within the State of North Carolina, terrapin of either type would be expected to be native to the State. Thirdly, through long periods of years southern terrapin have been shipped in quantities from southern to northern coastal points to be held for months in captivity, and many escapes must have occurred to give opportunity for the mixing of types beyond that provided by nature. Finally, in the culture of terrapin at the U. S. Fisheries Laboratory at Beaufort, large numbers of Chesapeake terrapin have been imported and bred and have been allowed to hybridize with native North Carolina terrapin (Hildebrand, 1929 and 1933). The young reared from both stocks and their hybridization have been widely distributed to all coastal states from Delaware to Alabama, and to Louisiana, New Mexico (!) and California.[4] The immediate geographic source of a terrapin brought to market is now, therefore, even more than in the past, no reliable indication of its type.

EXPERIMENTAL PROPAGATION

The question of exhaustion of a self-reproducing actual resource is not always one that is easily answered with assurance. It would, however, seem unnatural if an animal as highly valued and as eagerly sought as the diamond-back terrapin, as limited in distribution (to estuarial areas), as weak in reproduction, as slow in growth and as helpless against man, had not suffered serious depletion in two centuries of search, capture and destruction. While exact quantitative data were not available, it was not doubted at the turn of the century that the more northern areas of fishery had been depleted of terrapin for many decades, that even the extensive Chesapeake area had long had greatly reduced population, and that the North Carolina terrapin were reduced almost to the vanishing point. At any rate, at the beginning of the present century, two definite moves were undertaken to replenish the supply by propagating terrapin under artificial conditions.

In 1902, studies and experiments were begun at two places—in the Chesapeake Bay area at Lloyd's, Md., in charge of Dr. W. P. Hay, and at Beaufort, N. C., under the direction of the present writer assisted by Mr. Charles Hatsel. These were prompted by the late Dr. Hugh M. Smith, in charge of Scientific Inquiry in the United States Fish Commission[5] and the late Professor Joseph A. Holmes, State Geologist and Director of the North Carolina Geological Survey.[6] The experiments and studies at Beaufort were at first supported cooperatively by the Federal Government and the State. The early studies at Beaufort resulted in part in the publication of Bulletin No. 14 of the Geological Survey (Coker, 1906). In 1904 the support of scientific work at the fisheries station by the State was discontinued. Although the small terrapin stock at Beaufort was kept and maintained by the custodian of the laboratory, Mr. H. D. Aller, and Mr. Hatsel, the Government's emphasis was shifted temporarily to the Chesapeake. In 1909 the activities and breeding stock were transferred to Beaufort, Dr. Hay continuing to give general direction until 1915. During this period Mr. Aller planned and carried out the significant new undertaking of winter-feeding of yearling terrapin in warmed nursery houses. Guidance of the work was later in the hands of the successive Directors, Lewis Radcliffe, S. F. Hildebrand, R. L. Barney, and

4. Letter of Dr. Paul E. Thompson, U. S. Fish & Wildlife Service, Aug. 12, 1949.

5. Part predecessor of the present U. S. Fish & Wildlife Service.

6. Later, North Carolina Geological and Economic Survey, part predecessor of the present Department of Conservation and Development.

H. F. Prytherch. All concerned with the undertaking would subscribe fully to Dr. Barney's statement (Barney, 1922):

"The large share of credit for the continuity and the accuracy of the observations of the entire experimental terrapin propagation project is due to Mr. Hatsel for his exceptionally careful, energetic, and faithful work."

In all, the Fisheries Station at Beaufort, up to August, 1949, had hatched and distributed 249,313 young diamond-back terrapins. Distribution was very wide, as previously mentioned. At the recent close of the experiments older terrapin including brood stock were distributed.

Although many questions in regard to the terrapin remain to be answered, a vast amount of information has been gained in the long-continued experimental and propagational work at Beaufort. The results are embodied in the papers cited in the bibliography by Hay (1904 and 1917), Coker (1906), Hay and Aller (1913), Barney (1922), Hildebrand and Hatsel (1926), and Hildebrand (1929 and 1933). Only a brief summary of results need be included in the following paragraphs.

NATURAL HISTORY AND PROPAGATION

The diamond-back terrapin lives in the zone between pure fresh water and pure salt water. It can pass into and out of the water, but seems habitually to live in the water, coming on the beaches principally in the season of laying to form nests for its eggs on the sand. Without such strong jaws as have the freshwater snapping turtles or the loggerhead sea turtle, it must feed upon such small mollusks, crustacea and other small animals as it can find (Coker, 1906; Hildebrand, 1929). A readily available food in the marshes and along shore in brackish waters is the periwinkle, a small snail, and this was the chief item of food found in the stomachs of wild terrapin that I have examined. Hay, 1904, says that shoots and rootlets of marsh plants are eaten to some extent, as well as insects when available in time of high tides. There are needed more extensive studies of the food of terrapin, as this may well have much to do with the peculiar and esteemed flavor of the meat.

In the breeding pens at Beaufort practicable feed has been found to be chopped fresh fish, including menhaden and low-priced or unsalable foodfish of various kinds, crabs, shucked reef oysters and clams. The cost was found to be about 6 cents per head for a year. Small mollusks and fiddler-crabs were also eaten. Salted mullet was not taken unless the terrapin had been starved. Vegetables of various kinds were tried but they were not eaten by the terrapin. It was thought advantageous to supplement the usual fresh-fish diet from time to time with oysters, clams, and crabs. A supply of fresh water for drinking seemed desirable.

Egg laying is accomplished on sandy beaches—which generally are not too abundant in areas of salt marshes. In late spring or early summer (May, June, and July at Beaufort in the artificial pens) the female using her hind legs excavates a jug-shaped cavity about 3 inches in diameter and 6 to 8 inches or more in depth. In this she deposits a number of eggs. Five to about 15 eggs have been found in a nest, but a female may lay 4 or 5 times. The cavity is then filled, the eggs being covered to a depth of several inches, and the sand tamped down. After the female makes the nest inconspicuous by crawling back and forth over it, the eggs are left to their fate. Hildebrand concluded that, under good conditions of terrapin culture, about 12 eggs per female per year may be expected.

In the experimental pounds terrapin may begin laying at about 6 years of age and continue to do so for at least 10 years. Annual mating is not required, since female terrapin have facilities for retaining sperm in good condition for several years. Females isolated from males after mating produced fertile eggs for four years, although the proportion of fertile eggs diminished rather rapidly after the second year. Since a male may fertilize several females, it is not necessary to keep for breeding purposes an equal number of males and females: one male to 5 females seems to be adequate. As a matter of fact, in the breeding pens at Beaufort the sexes, without selection, developed in about this proportion.

The period of incubation of the eggs is about 90 days, varying with temperature and other conditions. The exact duration is difficult to determine, since the young do not usually emerge from the nest until several days after hatching. The newly-hatched young, about 1$\frac{1}{12}$ inches (27 mm.) on the bottom shell are relatively helpless, and may fall easy prey to crabs, fish, birds, and rats. What the survival rate during the first year may be in nature is quite unknown. In respect to survival in the experimental pens, under conditions of substantial protection from most enemies, Hildebrand (1926) reported that about 60 per cent of the terrapin hatched came to maturity, a reasonable proportion in comparison with the survival rate in poultry production. The mortality rate in nature may be presumed to be much higher.

The chief causes of mortality in pens were disease and unpreventable depredations of enemies, chiefly rats; some possibly escape. The common diseases were described as "sores," referred to by Hildebrand as cancerous, "soft-shell," associated with failure to eat and subject to rapid recovery, and "limber-neck," a form of paralysis from which recovery is rare.

Young terrapin in nature or in confinement, unless kept warm, were not observed to eat; there is, then, no growth in size until the spring of the following year. It was found at the Beaufort Laboratory, however, that if the baby terrapin are kept in warmed nursing houses during the first winter, they would mostly remain active, feed and grow during the winter. By the following spring they were about the size of year-old terrapin and had thus been put forward about one year toward maturity. They could be kept from hibernating in following winters and fed as during the first winter, but the gain after the first winter was not considered sufficient to justify the expense.

In rearing terrapin in open pens, space requirements will depend in part upon the nature of the area, and especially upon the clearness of the water and the regularity of its change by tidal action or other cause. "The main consideration," says Hildebrand (1929, p. 66), "is the provision of sufficient room to furnish the necessary sanitation." He thought that under the conditions existing at Beaufort 100 animals could safely be grown to maturity in a pen 5 x 22 feet. This would allow about 1.6 square feet per terrapin.

The sexes are externally indistinguishable in the first few years of life, although adult males and females are markedly different in size and form. While females may attain a length on the lower shell of 7 or 8 or even nearly 9 inches, males rarely exceed 4½ inches in such measurement. They are thus quite diminutive in comparison with the larger females with which they may mate. Males are also flatter, and the top shell is rather more wedge-shaped behind. The heads are smaller and more pointed, and the tails are very much larger and heavier because of the included penis. It is only when males are about four years old, with an undershell more than three inches long, that they are readily distinguishable.

Males grow more slowly, but females are too variable in growth for size at a given early age to be a criterion of sex. In a particular brood, that of 1912, about one-eighth of the females had attained the "legal" length of 5 inches (125 mm.) in the sixth year, when the largest male was 4 inches. A little over 50 per cent of females had a 5-inch undershell in the eighth year and 82 per cent in the thirteenth year. The smallest female of the lot in that year was about 4⅗ inches (115 mm.). A length of 6 inches was first attained by a female in the thirteenth year. The gain in undershell length per year after the eighth year is measured in millimeters, one or two. Unless the rate of growth in nature is much more rapid than it is in confinement with regular feeding, it may be assumed that a 7-or 8-inch female, rare in nature, but of highest value in the market, is from 20 to 30 years old *at least*. It would seem to require 10 to 20 or more years to add an inch in length after about the tenth year (data gathered from tables in Hildebrand, 1929).

The results obtained with different yearly broods were variable, but generally not markedly different. In the case of the brood of 1910, however, a female (or, perhaps, more than one) was over 6 inches in the sixth year. Nine years later (1925) the largest female was 6⅗ inches (165 mm.), indicating a gain of 11 mm in 9 years. Probably North Carolina terrapin do not often attain an undershell length much exceeding 5½ inches. It is a well known fact that for many animals there is an inverse relation between size and temperature during development. Animals of the same species may attain larger sizes in more northern and colder waters.

On the other hand, among individuals of any given brood, the variability in growth is extreme. Coker (1906), Hildebrand and Hatsel (1926), Hildebrand (1929), and others, have remarked on the extraordinary variability of turtles in respect to rate of growth.

SUMMARY

1. The diamond-back terrapin, once the most valuable (per unit) food product of the coastal region, has depreciated greatly in value since the time of World War I but there are indications of continued esteem and perhaps of substantial recovery in market value.

2. Presumably in consequence of exhaustive fishery the populations have been seriously depleted in northern waters and in North Carolina. Production in the State is now negligible.

3. The waters of North Carolina in northern and southern parts are within the respective ranges of terrapin of the "Chesapeake" and "Carolina" types.

4. Cultural experiments have been conducted at the U. S. Fisheries Biological Station, Beaufort, N. C., since 1902, but chiefly from 1909 to 1948. Although over-all direction of the experiments has undergone many changes, and several scientists have contributed substantially to this development, great credit for continuity and success must be attributed to the late Captain Charles Hatsel of Beaufort for most efficient care from the beginning in 1902 until his retirement in 1947.

5. Terrapin are readily kept in confinement for breeding and rearing at relatively small expense for food. Data are available in various publications regarding space requirements, sex ratios, diseases and mortality, and rate of growth. Keeping newly hatched terrapin in warmed nursery houses and feeding them during the first winter, not only reduces mortality during the period of greatest helplessness, but also enables the terrapin to make two years growth in one year.

6. If a high market price can be depended upon, there is promise in the breeding and rearing of diamond-back terrapin in privately managed terrapin farms.

7. In spite of much scientific study, particularly under conditions of propagational experiments, there is still a paucity of information regarding the natural history of terrapin in the wild. There is particular need of fuller

quantitative studies of the natural food in different geographic areas and the relation of food to flavor.

BIBLIOGRAPHY

Anderson, A. W., and E. A. Power.

1949. Fishery Statistics of the United States, 1945. U. S. Fish & Wildlife Service, Statistical Digest No. 18 (1949), 372 p., (pictorial section, p. 355-372).

Barney, R. L.

1922. Further notes on the natural history and artificial propagation of the diamond-back terrapin. Bull. U. S. Bur. Fish., Vol. XXXVIII, 1921-22 (1923), p. 91-112. (Doc. 917, 1922).

Coker, Robert E.

1906. The natural history and cultivation of the diamond-back terrapin with notes on other forms of turtles. North Carolina Geol. Surv., Bull. No. 14, 1906, 69 p., 23 pls. Raleigh.

1920. The diamond-back terrapin, past, present and future. Scientific Monthly, Vol. 11, 1920, p. 171-186.

Hay, William Perry.

1905. A revision of *Malaclemmys,* a genus of turtles. Bull. U. S. Bur. Fish., Vol. XXIV, 1904 (1905), p. 1-19, 12 pls.

Hay, W. P., and H. D. Aller.

1913. Artificial propagation of the diamond-back terrapin. U. S. Bur. Fish., Econ. Circ. No. 5, 1913, 14 p., 3 figs.

1917. Artificial propagation of the diamond-back terrapin. U. S. Bur. Fish., Econ. Circ. No. 5, revised 1917, 27 p., 5 figs.

Hildebrand, Samuel F.

1929. Review of experiments on artificial culture of diamond-back terrapin. Bull. U. S. Bur. Fish., Vol. XLV, 1929 (1930), p. 25-70. (Doc. 1060, 1929).

1933. Hybridizing diamond-back terrapin. Journal of Heredity, Vol. 24, No. 6, p. 231-238. Washington.

Hildebrand, Samuel F., and Charles Hatsel.

1926. Diamond-back terrapin culture at Beaufort, N. C. U. S. Bur. Fish., Econ. Circ. No. 60, 1926, 20 p., 3 figs.

1927. On the growth, care and behavior of loggerhead turtles in captivity. Proc. Nat. Acad. Sci., Vol. 13, No. 6, p. 374-377. Washington.

Pope, Clifford H.

1939. Turtles of the United States and Canada. xviii + 343 p., pls., extensive bibliog. New York and London: A. A. Knopf, 1939.

THE SEAWEED RESOURCES OF NORTH CAROLINA

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CONTENTS

INTRODUCTION

Seaweeds or marine algae constitute several major groups (phyla) of plants that are the oldest on earth. It is believed that the ancestors of our modern seaweeds developed in oceans ages ago, probably before conditions on land permitted development of plants as we know them today. Seaweeds, which differ radically from land plants in structure and reproduction, are regarded as primitive in these respects.

The four major groups of seaweeds are commonly known as bluegreens, greens, reds, and browns. The classification is based in part on pigmentation, but the gross color of seaweeds is not always a reliable character for determining the proper phylum. The red algae are particularly variable. Although all red algae contain a red pigment in addition to chlorophyll (green), they are sometimes green or brown in color because the red pigment may be masked by chlorophyll or other pigments.

Marine algae, like all land plants having green leaves, must have light

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for growth. Accordingly, their distribution in the sea is limited to depths to which sufficient light penetrates, as the majority grow on the bottom attached to stones or shells. Most seaweeds are found along the shore wherever there is a substratum for attachment, from the intertidal zone to a depth of 300 feet or more in very clear water. In waters that are not clear, they may grow no deeper than one or two feet below low tide line. Coastal waters are relatively rich in nitrates, phosphates, and other nutrient salts that come from the land by drainage, a circumstance of benefit to seaweeds.

In general, brown algae are plants of colder waters, especially the giant kelps, abundant along New England and Pacific coasts. Green algae, though common in cold waters, exist in greater variety in warm waters such as those of Florida and the West Indies. Red algae are also of greater variety in the tropics, and are believed to be able to grow at lower light intensity, hence greater depth, than most browns and greens. In Florida, however, some green species grow well at nearly 300 feet.

Many seaweeds are seasonal or annual. Along the North Carolina coast, for example, many of those present during summer are of sub-tropical affinity and are replaced by a different flora with northern affinities during winter. A few species may be present only during spring or fall. As a result of the effect of Cape Hatteras as a temperature barrier, North Carolina is the southern known limit (in winter) for a number of species common in New England, and the northern known limit (in summer) for many species abundant in Florida.

Only the red and brown seaweeds are of economic importance. A few of the greens ("sea lettuce," for example) are eaten, but they are not a significant item of commerce. Bluegreen algae are not utilized as the individual plants are microscopic.

The principal economic uses of red and brown seaweeds and their extractives (phycocolloids) may be classified as follows: in foods, bacteriological media, pharmaceutical preparations, cosmetics, several industrial processes, dental and other molding compounds, fertilizers, and miscellaneous other fields. Seaweeds probably have been used for food since prehistoric times, while their use as medicine and fertilizer must have developed centuries ago, particularly in the Orient. The growth of science and industry during the past 100 years has led to many additional uses of seaweed extractives, especially in the more industrialized parts of the world. New uses and new types of seaweed products are frequently announced.

In America, dried seaweeds are eaten on a small scale in New England, mostly by people whose ancestors came from the British Isles; and along the Pacific coast, mostly by people of oriental origin. Powdered seaweed is often used in so-called health foods, in stock feed, and as a condiment.

The real economic value of seaweeds in America, however, lies with seaweed extractives, principally agar, algin, and agar-like phycocolloids such as carrageenin from "Irish moss."

BROWN ALGAE

The economic value of brown algae is limited to a subgroup known as kelps. The principal product is algin, usually sold as sodium alginate. It is a colloidal carbohydrate that forms very viscous aqueous solutions for which there is a wide variety of uses, particularly in foods. Algin does not have the gel-forming property of agar, hence its uses are somewhat different. Products of secondary importance obtained from kelps include the polysaccharide, laminarin, and the complex alcohol, mannitol. In addition, dried and pulverized kelps are used in health foods and stock feed as a source of essential trace elements.

In the past, kelps were widely used as a source of potash and iodine, obtained by burning the seaweed, and of acetone and calcium acetate, obtained by fermentation. Seaweeds are no longer used as raw material for these substances, as less costly sources have been discovered.

Since kelps are cold water species, the algin industry of the United States is located in New England and in the Pacific coast states of California, Oregon, and Washington. Along the Atlantic coast, kelps do not grow in abundance of commercial value south of Massachusetts. New Jersey is the southern known limit of the kelp group.

A genus of brown seaweeds that contains algin is *Sargassum* or "Gulf weed," that occurs off the coast of North Carolina and southwards. The algin content of *Sargassum* seems to be somewhat less than that of kelps, and its quality is said to be inferior. For these reasons and because of its irregular occurrence on beaches and thin distribution at sea, commercial collection for algin alone may be too costly.

The plant is characterized by an abundance of small, spherical, berry-like air bladders distributed along its branches that make it one of the few kinds of seaweeds that float. The species-groups of *Sargassum* indigenous to the Gulf Stream and Sargasso Sea are rarely found growing attached. Large quantities are washed ashore by east or southeast storms.

The value of *Sargassum* as a source of algin, trace elements, and other substances has not been investigated adequately. What appears at present to be an inferior grade of algin may prove to have characteristics of special value. It is conceivable that a North Carolina seaweed factory that uses other seaweeds might process *Sargassum* whenever sufficient raw material is available.

RED ALGAE

Agar and agar-like substances (agaroids) are the important extractives of red seaweeds. Agar is manufactured on both the Atlantic and Pacific coasts of the United States. The agaroid, carrageenin, is obtained from the seaweed, "Irish moss," along the coasts of the New England states and Canada. A potential source of another agaroid is the seaweed *Agardhiella,* abundant in the spring along the North Carolina coast.

Before World War II, Japan had almost a monopoly on agar of commerce, and 90 per cent of the agar consumed in the United States was imported from Japan. Consequently, Allied nations were without an adequate source of agar when hostilities began. Early in 1942, agar was classified by the War Production Board as a "critical war material" and its use restricted to bacteriological purposes. As a result, both governmental agencies and private institutions were stimulated to support a search for hitherto undiscovered sources of agar raw material and to look for agar substitutes. One outcome was the development of the agar industry in North Carolina.

CHEMICAL NATURE AND PHYSICAL PROPERTIES OF AGAR

Agar is the gel-forming extractive of *Gelidium, Gracilaria,* and certain other red seaweeds, a one per cent solution of which in water forms a firm gel. Chemically it is a complex carbohydrate described as the sulfuric acid ester of a linear galactan. In hot water (80° C. or above), dehydrated agar forms a colloidal solution. Gelation occurs at about 40° C., although some *Gracilaria* agar may gel as high as 63°. The gel strength of agar is about eight times that of gelatin so that in culture media where a 1.5 per cent concentration of agar forms an adequate gel, 12 per cent gelatin is needed to obtain a semi-solid medium of the same strength.

Agar is a cell wall constituent, along with cellulose, of the seaweeds in which it occurs, where it probably functions to control diffusion of solutes into and out of the cell, to reduce loss of water if the plant is exposed at low tide, and it may serve as a reserve food. It exists as the calcium (or other metal) salt of the polysaccharide galactan. By means of electrodialysis the metallic ions may be removed from agar leaving free agar acid which may then be neutralized with any base, forming a metallic or ammonium agarinate. When agar is hydrolyzed by heating with dilute acid, galactose is the principal sugar produced.

USES OF AGAR

The most important use of agar, with respect to human welfare, is in bacteriological culture media, although there are several other uses equally important from the standpoint of amount consumed, as shown in Table 1.

TABLE 1

Uses of Agar in the United States
(From Tseng, 1944)

	Tons *
Medicinal	50
Culture Media	50
Baked Goods	50
Confections	50
Dentistry	38
Canning (meat & fish)	25
Emulsifier	25
Cosmetics	13
Miscellaneous	25

* Figures are per annum consumption of a typical pre-war year.

The uses for agar may be classified as follows:

FOODS. In fruit cakes, fruit puddings, icings, pie fillings, meringues, and cheeses to control moisture content and to modify texture; in mayonnaise and salad dressings as a thickener and stabilizer; in confections, especially jelly candies and marshmallows; in aspic type salads to provide a gelatinous matrix; in place of pectin in jellies, jams, and preserves; in canned meats such as fish, poultry, and tongue to prevent the product from becoming mushy during transit; in casings for sausages and wieners.

PHARMACEUTICALS. Probably the best known use of agar is as "roughage" or bulk in constipation therapy. It is also used to stabilize emulsions; to solidify some glycerin suppositories; to make a formaldehyde gel for fumigation; in wound dressings to absorb moisture or provide a constant rate of release of antiseptics or antibiotics; as pill coating, especially to control time of release or rate of availability of a drug; as a vehicle in which a drug is incorporated so that there is a slow release of a therapeutic agent during its entire passage through the body.

MOLDING COMPOUND. Agar is the principal constituent of some of the best dental impression materials, as it is fluid at a temperature that does not burn the mouth, but will gel at a temperature slightly above that of the body. Its elasticity permits removal of the agar mold from undercuts without breaking or distortion. It is used in a similar manner for other types of molding work, such as the making of artificial hands.

INDUSTRIAL USES. Agar is used as a suspending agent for graphite lubricants of dies in drawing tungsten wire for light bulbs and electronic tubes; in place of gelatin as a vehicle for photographic emulsions; in hectograph duplicators; as an activator of nicotine sprays; in storage batteries for submarines; occasionally in tobacco to control moisture; to coat humus particles in marketing nitrogen-fixing, root nodule bacteria; it has been suggested as a constituent of the "mud" used in drilling oil wells.

COSMETICS. Greaseless ointments of various types often contain agar or agaroid; it serves to stabilize emulsions, as a moisture control agent or cream-former in tooth pastes, shaving creams, hand lotions, deodorants, sunburn creams, and other preparations.

MISCELLANEOUS. Agar is important in studies on the physics of hydrophilic, gel-forming colloids; it is a vehicle for plant hormones for *Avena* type tests; it is used in chemistry to flocculate barium sulfate precipitates; it is valuable as an embedding substance for small pieces of plant or animal tissue that might otherwise become lost in solutions, and for cutting material with a freezing microtome.

THE AGAR INDUSTRY OF CALIFORNIA

Agar was first manufactured in the United States in California in 1920. The seaweed *Gelidium cartilagineum* was used, a species similar to *G. amansii,* the principal agar source in Japan. The American industry barely managed to exist for the first 20 years because of competition from low-priced Japanese agar, a result of the cheapness of labor in Japan. Important labor-saving improvements in the manufacturing process and production of agar superior in purity and uniformity to that from Japan were factors that saved California's industry. The principal difficulty in California is the necessity of employing divers using a complete suit and pulling seaweed from the rocks by hand. Collecting is limited to summer months and then to days of good weather.

The California industry immediately expanded with the outbreak of war and within a year was producing enough agar to meet our domestic wartime requirements for bacteriological agar, with some for export to Allied nations. Since the war, California factories have again closed down.

THE AGAR INDUSTRY OF NORTH CAROLINA

Agar had never been produced along the Atlantic coast of the United States until 1943 when the Van Sant Company of Beaufort, N. C., undertook commercial production as a result of the discovery in 1942 at Duke University's marine laboratory that agar could be produced from *Gracilaria confervoides* of North Carolina, and that there was an abundance, of commercial importance, of this species near Beaufort. Pilot plant operations were carried on at the American Chlorophyll Co., Alexandria, Virginia. The Beaufort factory was originally built by Coca Cola interests for the purpose of extracting theobromine from cocao shells. War cut off sources of raw material and soon thereafter the factory was adapted to agar production.

In 1945, the Van Sant Company was sold to M. Wronker Stansfield and associates, who had previously held part interest in the firm. The name was changed to Beaufort Chemical Corporation. Production capacity was increased, methods improved, and strenuous efforts were made to obtain sufficient agar raw material to keep the factory in operation at full capacity the year around. A poor year for *Gracilaria confervoides* followed, possibly because of low salinities, and the factory could not operate continuously. In 1948, the property was purchased at a court sale by Sperti Foods, Inc. Subsequently, Mr. H. S. Leahy became manager of the factory. In 1948 and 1949 many additional improvements were made in production methods and equipment, and year-around operation was assured by stock-piling a supply of *Gracilaria foliifera* obtained at Sebastian, Florida, to be used whenever seaweed was not available from North Carolina waters.

SEAWEEDS UTILIZED

So far, three species of North Carolina seaweeds have been processed at Beaufort. *Gracilaria confervoides* has been the principal plant, but considerable quantities of *G. foliifera* (synonym: *G. multipartita*) have been used, especially in 1946. During 1946 and 1947, a new type of phycocolloid with unique properties was made from *Hypnea musciformis.* A patent has been granted the writer and assigned to Duke University relative to a method for preparing *Hypnea* extractive.

METHODS OF COLLECTION

All economic seaweeds in North Carolina grow in shallow water in sounds or bays where the depth is from one to six feet at low tide. Fishermen often load skiffs in shallow water by means of forks or rakes, a method that is rather slow. Greater efficiency in collection of seaweeds could be accomplished by specially designed nets or trawls. Shrimp trawls have been used to locate drifting *Gracilaria* in deeper water but are not entirely satisfactory for collecting, as a full trawl is too heavy to handle.

In some localities, nets are set across currents to catch drifting seaweed and the accumulation removed at frequent intervals. Nets are usually effective during one direction of tidal current only, and after north winds of fall have caused loose seaweed to move off shallow areas on which it grew.

Considerable quantities of seaweed are collected along the shore. Drifting seaweed in the fall usually washes ashore on a south-facing beach such as that of Harkers Island. If collected within a few days after reaching shore, it is of good quality although it may contain a quantity of foreign material such as eelgrass.

DRYING OF THE CRUDE SEAWEED

Boat loads of seaweed are towed to drying racks built along the shore or above shallow water. The racks are constructed of poles with poultry wire or fish net fastened to the tops. They are about 3 feet wide, 4 feet high, and of various lengths. Seaweed is spread on them in a layer about 6 inches thick. From 2 to 4 good drying days are needed for each batch. The seaweed is usually turned over at least once.

Since fishermen do not wash seaweed with fresh water to remove salt and mud, about 10 pounds fresh weight make 1 pound dry weight. If washed or thoroughly rained upon, from 15 to 20 pounds fresh weight are required to make 1 pound dry weight; thus seaweed bought from fishermen must be regarded as constituting less than 60 per cent by weight of agar-yielding material.

YIELD

A factory yield of 20 per cent agar, based on weight of raw material as purchased, is actually a yield of approximately double that amount because of the salt, mud, and moisture it contains. By laboratory methods, a yield of 45 per cent is commonplace, since clean, thoroughly dry seaweed is used.

ECONOMIC CONSIDERATIONS

Approximate total amounts of dry seaweed collected each year in North Carolina since processing began are given in Table 2. Fishermen received 10 cents per pound for this material.

In Table 2, figures for 1943 include some seaweed collected in 1942, when pilot plant production was first undertaken. The great abundance of seaweed that developed in North Carolina waters in 1942, 1943, and 1944 is not shown by Table 2 since collections during these years did not make a noticeable decrease in quantities present in the water. Countless tons washed ashore and decayed. Figures for 1945 and 1946, however, are representative of quantities available as fishermen were encouraged to gather all they could find, and factory production facilities were increased. Unfortunately, the crop was poor both years, probably because of excessive rainfall and low salinities. Oysters were killed in many localities.

As shown in Table 2, fishermen were paid about $67,200 for 672,000 pounds of seaweed during the first four years of the agar industry in North Carolina and over 100,000 pounds of agar were produced at a time when it was classified as a critical war material. Although the value of economic seaweeds in North Carolina does not compare with that of the more important fisheries, its collection, localized between Beaufort and Atlantic, has seasonal importance. Seaweed is collected during summer and fall. In addi-

TABLE 2

Approximate Total Dry Weight and Value of Each Species of Seaweed Collected in North Carolina from Inception of Agar Industry in 1943 through 1948. Only Small Quantities Were Gathered in 1947, When Change in Ownership Occurred

	1943		1944		1945		1946		1948	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Gracilaria confervoides	100,000	$10,000 *	275,000	$27,500	120,000	$12,000	20,000	$2,000	8,000	$800
Gracilaria foliifera	......	......	......	.....	6,000	600	120,000	12,000	83,325	8,332
Hypnea musciformis	......	......	......	......	4,000	400	27,000	2,700	.....	....

* Prices paid for seaweed vary with quality as determined by analysis at the factory, ranging from 6 to 10 cents per dry pound. Figures in Table 2 are lower than actual weight of material purchased, except for 1948 when only first quality material was accepted, hence they represent calculated weight of pure seawed for which price is 10 cents per pound.

tion to the supplementary employment offered to fishermen by the seaweed market, the work is often a family affair. Men gather seaweed while women and children spread it to dry. In some localities, women and children gather seaweed that washes ashore.

Since seaweed is a raw material for a more valuable product, its value to the State is not represented by the sum paid fishermen each year for raw material. Each ton of dry seaweed, assuming a yield of only 15 per cent, produces about 300 pounds of agar. With the market value of agar at about four dollars per pound (September, 1947), the value of the product derived from each ton was $1,200.

As long as the market price of agar exceeds $2.00 per pound, one agar factory can operate profitably in North Carolina under present economic conditions, assuming that supplementary raw material can be obtained elsewhere to permit year-around production. On the basis of quantities obtained in previous years, it would appear that from 150,000 to 300,000 pounds, dry weight, of seaweed can be gathered in North Carolina each year. However, reliable predictions of abundance of seaweed cannot yet be made for North Carolina. The total abundance of seaweed varies from year to year, and at the same time individual species vary independently of each other.

Of great importance to domestic agar producers is the future outlook on competition from Japanese agar. Prices paid in the United States for imported agar from 1925 through 1941 and for domestic agar from 1942 through 1946 are given in Table 3.

TABLE 3

Highest and Lowest Prices Paid in the United States for Japanese Agar Annually from 1925 through 1941 and for American Agar from 1941 through 1946

	Lowest	Highest		Lowest	Highest
1925	$1.25	$1.60	1936	$ .60	$ .95
1926	.73	1.32	1937	.55	1.20
1927	.53	1.10	1938	.63	1.05
1928	.59	1.12	1939	.90	1.50
1929	1.00	1.45	1940	1.40	1.50
1930	.87	1.35	1941	1.50	1.60
1931	.65	1.25	1942	3.50	4.75
1932	.39	1.15	1943	3.50	3.50
1933	.31	.52	1944	3.00	3.50
1934	.35	.56	1945	3.50	3.50
1935	.37	.70	1946	3.50	4.00

During the first four months of 1947, Japanese agar registered a low of $2.00 per pound, followed by a price rise in the summer to $3.85. During the first half of 1949, the price ranged substantially above $3.00. By mid-

1950, however, the price per pound had fallen to less than $1.00. Most Japanese factories are located in the cold, mountainous prefectures of northern Japan. Agar is manufactured only from December through February, when air temperatures will cause the agar gel to freeze, a vital step in the dehydration and purification process. Few factories have mechanical refrigeration equipment. In 1946, it was estimated that about 600 small agar factories would resume operations with an average of eight employees each. Virtually everything is done by hand.

Approximate consumption of agar on the principal continents for a typical pre-war year (1939) is shown in Table 4.

TABLE 4

Agar Consumed in 1939 on the Three Principal Continents

	Tons
North America	266
Europe	660
Asia	611

Since consumption of agar in Europe is more than double that used in the United States (or even in both North and South America), it would appear that there is still a great potential market for phycocolloids in the Americas that has not yet been served.

BIOLOGY OF NORTH CAROLINA SEAWEEDS

Economic seaweeds of North Carolina can be collected from about May first through December of a good year. The principal environmental factors which influence growth and variation in abundance from year to year are water temperature, salinity, and concentration of nitrogenous salts and phosphates. Factors that control individual species are not known.

Gracilaria foliifera reached commercial abundance in early May near Beaufort in 1945. The peak of abundance occurred in June, and in July it had begun to decline. In 1946 the species developed later, reached much greater abundance (Table 2), and was collected through September. It appears to be a species that grows well at lower average salinities than does *G. confervoides,* as salinities were unusually low during August, 1946, and *G. confervoides* failed to develop in quantity. *G. foliifera* is to be found farther up estuaries than *G. confervoides.* Although all plants of *G. foliifera* grow attached at first, large quantities may be found adrift at the peak of the season. The species is found along the entire Atlantic coast of the United States.

Hypnea musciformis overlaps the season of *G. foliifera* although the peaks of abundance of the two may not coincide. Collection near Beaufort usually begins in May and continues into July, or later. In August, 1947, large quantities developed in North River where salinities were favorable as rainfall had not been excessive. All plants grow attached at first but may drift free when large. The period of abundance is usually short, typically from six to eight weeks. Mature plants bear spores and then apparently degenerate, although occasional plants may be found in North Carolina waters throughout the year. The species occurs from Massachusetts to Florida and in the Gulf of Mexico.

Gracilaria confervoides is a fall species in the Beaufort area that rarely develops in quantity before August, although the earliest plants appear in April or May. The peak of abundance occurs in October and November with a rapid decline in December.

G. confervoides appears to be present in North Carolina waters as two separate phases. One phase is always attached at first to shells and stones, the plants developing in the spring from spores shed the previous fall. Mature plants that have shed their spores degenerate and disappear. In most parts of the world, the species is present only in this attached, spore-bearing phase. At Beaufort, plants of this phase have little economic value as they never reach great abundance, probably because the substratum to which they can attach is limited. Mature plants often break loose and drift about in late summer and fall, but should not be confused with the phase in which the plants are never attached.

The other phase is composed of loose, drifting, sterile plants that apparently never form spores of any kind. These plants survive the winter in the vegetative state, although in a semi-dormant condition in which fragments undergo partial decay. Plants of the attached, fruiting phase disappear completely in November or December. In the spring when water temperatures reach 16 to 18° C., portions of loose, drifting plants that have survived the winter begin to sprout and within two weeks are of fair size. As they become larger they offer more resistance to water currents and begin to drift. By July of a favorable year, large bushy plants are adrift throughout the sounds and they begin to accumulate in masses in areas where tidal currents and winds concentrate them. Growth continues at an increasing rate until the water temperature is about 27° C., and continues to be rapid through September at least.

North winds of fall often cause a general movement of summer accumulations so that large quantities wash ashore or drift out to sea. At times, shrimp trawlers obtain considerable quantities of *Gracilaria* in 20 to 50 feet of water in the ocean. Although growth continues in the ocean as long as light and temperature are favorable, the parent material of all the drifting phase found in the ocean comes from the sounds.

By December the general movement of loose *Gracilaria* has ceased. It has washed ashore, drifted out to sea, or come to rest in certain shallow, protected areas where it will remain throughout the winter. When the water temperature falls below 18° C., growth ceases and there is a slow decay of plants with fragmentation at decayed spots, and a general settling down of the entire mass. Part of this material survives the winter and grows the following spring.

CONSERVATION

The life history of sterile, unattached *Gracilaria confervoides* indicates that those areas where the plant survives the winter should be protected from collecting after growth has ceased in the fall, as this constitutes the only known "seed material" for the following year's crop. A good tentative rule is to cease collecting after January 1. Extensive collection of winter dormant *Gracilaria* by the Van Sant Company during January, February, and March, 1945, may have been partly responsible for the reduced abundance of the following fall, along with low salinities. Since most of the *Gracilaria* that is present in the fall ultimately washes ashore if not collected, it is doubtful whether commercial collecting in the fall reduces the next year's crop.

With *Gracilaria foliifera* and *Hypnea musciformis* conservation is a different problem. The abundance of the crop of any given year depends upon a favorable combination of environmental factors, but even with ideal conditions, the number of plants is limited by surface for attachment (shells and stones) for which they must compete with non-economic species. It is doubtful whether any degree of commercial collecting would reduce the spores shed to a point where the environment would not be "seeded" with more spores than it could support. By the time the abundance of these species makes collecting profitable, spores have been shed by countless millions.

POSSIBILITIES OF CULTIVATION

Cultivation of seaweeds involving the planting of "seed" material and later harvesting a crop has not yet been accomplished. With *Gracilaria confervoides,* the reason that the species does not grow in abundance in certain areas that appear to be suitable habitats may be determined and, if tide currents do not interfere, it might prove profitable to distribute chopped-up pieces of plants in June or July. If the absence of the species is due only to absence of "seed" material, the *Gracilaria* distributed should increase 100-fold within a month or two if conditions are favorable. With *G. folliifera* and *Hypnea,* cultivation efforts are most likely to be successful if shells or stones are distributed over an area when spores are being produced by naturally-occurring plants sometime during the summer. The material distributed would be expected to support plants the following year.

NORTH CAROLINA AGARS

Agars from *Gracilaria confervoides* and *G. foliifera* of North Carolina both meet U. S. Pharmacopoeia requirements. They are similar to but not identical with agar from *Gelidium cartilagineum* of California. Gel strength of *Gracilaria* agar is more variable than that of *Gelidium* agar. *Gracilaria* agar is somewhat more elastic and exhibits greater syneresis; its temperature of gelation, also variable, is between 45 and 63° C. as compared to 40 to 45° for *Gelidium* agar. The temperature of melting is about the same for both types of agar. Because of the higher temperature of gelation and greater syneresis, *Gracilaria* agar is less suitable than *Gelidium* agar for culture media. Table 5 presents comparative data on *Gracilaria* agars from various parts of the world and "Bacto" [1] agar from California *Gelidium*.

TABLE 5

Comparison of Properties of *Gracilaria confervoides* Agar from North Carolina and Other Parts of the World and California *Gelidium* Agar. (From Stoloff, 1943)

	Concen. percent	Temp. of gelation	Gel Strength grams
Grac. confervoides	0.5	..	113
from North Carolina	1.0	..	407
	1.5	43–59° C	650
Grac. confervoides	1.0	47	120
from California	1.5	..	190
Grac. confervoides	1.0	46	95
from Australia	1.5	..	167
Grac. confervoides	1.0	37	187
from South Africa	1.5	..	337
Difco "Bacto" agar	1.0	39	215
from Calif. *Gelidium*	1.5	..	350

The gel strength given for North Carolina *Gracilaria* agar in Table 5 represents an extreme. Most samples are nearer the figures given for "Bacto" agar; some are lower.

Gracilaria agar from North Carolina seaweeds appears to be composed of a mixture of "fractions," one or some of which gel at about 63° C. and others at about 42°. *Gracilaria* agar usually forms an incipient gel at the higher temperature but complete gelation does not occur until the tempera-

1. A trade name.

ture falls below 42°. Since temperature of gelation is related to rate of cooling, agar cooled rapidly forms a gel at a lower temperature than that cooled slowly. *Gracilaria* agar cooled rapidly may not gel above 50° whereas the same sample will often gel if placed in a constant temperature oven at 63°. Samples of *Gracilaria* agar have been observed that did not begin to gel, even with slow cooling, above 45°. These came from seaweed collected before September.

Slight differences have been noted between agar from *G. confervoides* and *G. foliifera* of North Carolina, but a detailed comparative study has not been made. *Foliifera* agar has a decidedly higher viscosity when liquid than does *confervoides* agar.

Agar from *Gracilaria* collected late in the season has a higher gel strength, higher temperature of gelation, absorbs less water when soaked, and is extracted from the seaweed with greater difficulty than that from material collected early in the season (June, July, August). As the season progresses, there is a slight decline in agar yield.

The extractive from *Hypnea musciformis* differs from that of other seaweeds in that there must be a solute present that serves as a gelling agent. Pure *Hypnea* extractive in distilled water apparently will not gel, but if a salt or other solute is present, a gel is formed with properties related to the nature and amount of solute or mixture of solutes. Thus important properties of *Hypnea* agar, namely, gel strength, temperatures of gelation and melting, and viscosity of melted solutions can be controlled. Salts have been used for many years to increase gel strength of Irish moss extractive, and are also essential, apparently, to the formation of a gel.

Since the properties of *Hypnea* agar can be controlled independently of each other by varying both concentration of agar and concentration and nature of solute, it can be adapted to almost any conceivable use in which the presence of a solute is not objectionable. (Agar is rarely used in distilled water.) Under certain circumstances, *Hypnea* agar meets U. S. P. specifications. With *Gelidium, Gracilaria,* and other agars, physical properties are fixed within a narrow range.

Hypnea agar in a concentration of one per cent, for example, can be made to have a gel strength double that of any other known agar in the same concentration. By virtue of its controllable physical properties, a long list of new uses for *Hypnea* agar should be forthcoming, particularly uses for which no other agar is suited. A more detailed discussion of *Hypnea* extractive is given in Bulletin 3 of the Duke Marine Station, and by Humm and Williams (1948).

THE MANUFACTURING PROCESS

Dried seaweed is thoroughly washed in a washing machine with a rotating inner cylinder such as is used in laundries. Washed seaweed is conveyed to a cooker to which is added about 10 times as much water, by weight, as weight of the dry seaweed. Cooking is done at a temperature near boiling for one to two hours by means of perforated steam pipes in the bottom of the tank. The resulting agar solution is drawn off the residue and pumped to another tank from where it goes through a filter press, while very hot, containing a diatomaceous filter aid. The clear agar solution, about 1.2 per cent concentration, is then run into ice cans, allowed to cool and gel, and then is frozen. The agar ice is shaved into small pieces and conveyed into a tank of circulating water. As thawing occurs, the agar loses most of its water, holding only about as much as dry agar would absorb if soaked in warm water. Along with water lost, go most of the soluble impurities such as salts and pigments. Freezing and thawing are steps in dehydration and purification of agar. After thawing and washing is completed, water is drained from the thawing tank and the wet agar flakes pumped to the dehydrating room where they are spread evenly on screens and dried in hot air. The resulting rough sheets of dry, purified agar are hammermilled to obtain a soluble, granular form, or pulverized to a fine, white powder. The product is then ready for market.

RESEARCH FOR THE FUTURE

Volumes have been written on taxonomy and morphology of marine algae but only a few papers on their physiology and ecology. Research in the latter fields is badly needed and will help to expand utilization and to establish sound conservation measures of seaweed resources.

Further investigations are needed on the ecology of the vegetative phase of *Gracilaria confervoides*. Efforts should be made to cultivate it in experimental plots and to transplant it to other parts of the State where it does not grow at present. With *G. foliifera* and *Hypnea musciformis* there is need for data on season of spore shedding and germination of spores that results in the spring and summer growth of these species.

Transplantation of economic seaweeds to North Carolina waters from parts of the world having a similar marine environment should be tried. There may be valuable seaweeds in India, Australia, South Africa, or South America that will thrive in North Carolina waters.

Seaweeds of North Carolina should be studied to determine their vitamin content. Six out of seven seaweeds tested on the Pacific coast (Norris, Simeon, and Williams, 1937) were found to be good sources of vitamin B, and a few species were found equal to lemons in vitamin C content. It is possible also that seaweeds, if pulverized and added to fertilizers, would supply essential trace elements to depleted soils.

The uses and value of agar from North Carolina seaweeds will probably be increased when further technological data are available. *Gracilaria* and *Hypnea* agar should be electrodialyzed to obtain the free agar acid and then neutralized with various bases to obtain a variety of agarinates. The properties of each should be studied and compared with various agars already on the market.

Study of the carbohydrate portion of North Carolina phycocolloids is needed in order to determine the nature and structural formula of the carbohydrate units. Such studies might lead to methods of preparation of synthetic agar, or to methods of altering the properties of *Gracilaria* and *Gelidium* agar.

The unique properties of *Hypnea* agar suggest other fields of study. Additional data are needed on the remarkable effect of various solutes, both electrolytes and non-electrolytes, on the behavior of *Hypnea* extractive. The nature of the ash of *Hypnea* extractive has never been studied, and the amount has been only roughly determined. The slight seasonal variation of *Hypnea* extractive has just been realized; nothing is known of its nature or significance.

Further work on the discovery by DeLoach [2] that agar precipitated with ethyl alcohol can be re-dissolved in cold water, if the precipitate is not permitted to dry, might lead to a special use for this phenomenon. Valuable data in the field of colloidal chemistry and physics might result from a comparative study of the swelling of *Gracilaria* and *Gelidium* agar in the presence of various electrolytes and other solutes.

The necessity of the investigator's preparing his own agar from carefully selected and identified seaweed for which date and place of collection are known cannot be over-emphasized. Much work on chemistry and physics of agar was done on that from Japan, which was almost always a mixture of extractives from several species of seaweeds. Thus the results are of very limited value and are scarcely capable of duplication. Even American commercial agar producers cannot avoid contaminating seaweeds that might affect chemical and physical properties of the product.

In addition to the three species of seaweeds already of economic importance in North Carolina, there are others of potential value. Only preliminary studies (unpublished) have been made on the algin from *Sargassum* often available in quantity in North Carolina. Among red algae known to yield a phycocolloid are *Agardhiella tenera, Laurencia tuberculosa, Chondria*

2. Bull. 3, Duke Marine Lab., 1946.

spp., Gigartina acicularis, Gelidium crinale and *G. coerulescens. Agardhiella,* often abundant in early spring, yields a phycocolloid similar to that from Irish moss. Probably none of the others is of sufficient abundance in North Carolina to have economic value, although all should be studied. Agar from the two species of North Carolina *Gelidium* is of exceptionally high gel strength and clarity.

SUMMARY

Scarcity of agar during World War II led to the establishment in 1943 of an agar factory for the first time on the Atlantic coast of the United States near Beaufort, N. C. Three species of seaweeds from Core and Bogue sounds have been utilized: *Gracilaria confervoides, G. foliifera,* and *Hypnea musciformis.* Agar from all three species meets U.S.P. requirements and is similar but not identical to *Gelidium* agar from California and Japan. *Hypnea* agar is a new type in which such important properties as gel strength and temperature of gelation can be controlled over a wide range by addition of various salts, sugars, or other solutes.

North Carolina's only seaweed factory at the present time requires about 600,000 pounds of dry seaweed per year to operate at capacity. Apparently no more than half this quantity can now be obtained annually in North Carolina so that the factory must secure part of its raw material elsewhere. North Carolina fishermen collect and dry seaweed and receive 10 cents per pound for material of good quality. *Gracilaria foliifera* and *Hypnea* are collected usually from May through July; *G. confervoides,* the most abundant species, from August through December. Over 763,000 pounds of dry seaweed, for which fishermen received about $76,300 and from which about 120,000 pounds of agar were made, were collected and processed between 1942 and the end of 1946 in North Carolina.

Methods of collection, drying, and processing have been described; conservation, possibilities of cultivation, and research for the future have been discussed.

BIBLIOGRAPHY

Adams, C. M.

1947. The Japanese Agar Industry. U. S. Fish & Wildlife Serv., Fishery Leaflet 263, 24 p., 13 figs., 2 maps, 8 tables, frontisp., Chicago 54. Sept., 1947.

Duke University Marine Station.

1946. Utilization of seaweeds from the south Atlantic and Gulf coasts for agar and its decomposition by bacteria. Bull. 3 (7 papers, various authors, comprehensive bibliog., 14 illustrations), 80 p., Duke Univ. Press, Durham.

Fox, F. W. and E. Stephens.

1943. Agar from South African seaweeds. S. African Jour. Sci., Vol. 39, 1943, p. 147-149.

Hoyt, W. D.

1920. Marine Algae of Beaufort, N. C., and adjacent regions. Bull. U. S. Bur. Fish., Vol. XXXVI, 1917-18 (1921), p. 367-566, 3 maps, 47 figs., 46 pls., gloss., extensive bibliog. (Doc. 886, 1920).

Humm, H. J.

1942. Seaweeds at Beaufort, N. C., as a source of agar. Science, N. S., Vol. 96, 1942, p. 230-231.

1947. Agar—a pre-war Japanese monopoly. Econ. Bot., Vol. 1, 1947, p. 317-329, 4 figs.

Humm, H. J. and L. G. Williams.

1948. A study of agar from two Brazilian seaweeds. Amer. Jour. Bot. Vol. 35, 1948, p. 287-292, 8 figs.

Jones, W. G. M. and S. Peat.

1942. Constitution of agar. Chem. Soc. Jour., Vol. 1942, p. 225-231.

Kylin, J.

1915. Untersuchungen ueber die Biochemie der Meersalgen. Zeitsch. f. physiol. Chemie, Vol. 94, p. 337-425.

Moore, Lucy B.

1944. New Zealand seaweed for agar manufacture. New Zealand Jour. Sci. and Technol., Vol. 25 (Sec. B), p. 183-209, 16 figs., 7 tables. Botany Div. Publ. No. 9, New Zealand Dept. of Sci. and Indus. Research.

Norris, E. R., Mary K. Simeon and H. B. Williams.

1937. The vitamin B and vitamin C content of marine algae. Jour. Nutrition, Vol. 13, 1937, p. 425-433.

Okamura, K.

1933. Uses of algae in Japan. Proc. Fifth Pacific Sci. Cong., Vol. 4, 1933, p. 3153-3161.

Percival, E. G. V.

1939. Chemical constitution of agar. Pharm. Jour., Vol. 142, 1939, p. 189.

Robertson, G. R.

1930. The agar industry in California. Jour. Ind. & Engin. Chem. Vol. 22, 1930, p. 1074-1077.

Sauvageau, C.

1920. Utilisation des Algues Marines. 394 p. Paris. 1920.

Smith, H. M.

1905. The seaweed industries of Japan. Bull. U. S. Bur. Fish., Vol. XXIV, 1904 (1905), p. 133-165, figs., 1 pl.

Stoloff, L.

1943. The agar situation. Fishery Market News, Vol. 5, p. 1-5.

Tressler, D. K.

1940. Marine Products of Commerce. 762 p. (Chapters 4-7 on seaweed products, 19 tables, 16 figs., references) New York. Reinhold. 1923. (Second printing, 1940; revised edition in press, 1950.)

Tseng, C. K.

1944. Agar: a valuable seaweed product. Sci. Monthly, Vol. LVIII, 1944, p. 24-32, 7 figs.

1944a. Utilization of seaweeds. Sci. Monthly, Vol. LIX, 1944, p. 37-46, 10 figs.

1946. Phycocolloids: useful seaweed polysaccharides. Colloid Chemistry, Theoretical and Applied, edit. by J. Alexander, Vol. VI, General Principles and Specific Industries, Synthetic Polymers and Plastics. 1946, p. 629-734, 31 tables, 29 figs., extensive bibliog. New York. Reinhold.

Wood, E. J. F.

1946. Agar in Australia. Bull. No. 203. Council for Sci. & Indus. Research of Australia, Div. of Fish., Report No. 12, Appendix I, 43 p., 3 figs., 4 pls., 1946. Melbourne.

A PRELIMINARY SURVEY OF MARINE ANGLING IN NORTH CAROLINA

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American Museum of Natural History and The International Game Fish Association

CONTENTS

INTRODUCTION

The purpose of this survey is to summarize the present status and future potentialities of marine angling in North Carolina, with a view to increasing the recreational facilities and income of the coastal population.

My observations are based on material gathered personally on these and other angling grounds, or supplied me either by letter or in the small amount of literature concerning game fishing off this coast. I have also made use of scientific literature dealing with the fishes under discussion, and the files of the International Game Fish Association.

Hydrographic, economic, legal, and commercial material, contained elsewhere in this Survey, is not duplicated here. Data on sizes of fish, unless otherwise stated, refer only to sizes of interest to anglers. Anadromous fishes, when chiefly fished by anglers in fresh water, are omitted. The absence of certain fishes from angling grounds does not necessarily imply their absence from the coast in deeper or farther offshore waters, or in seasons or under some other circumstances preventing angling.

At present there are no laws covering marine fishing in North Carolina, except when such fishing may infringe upon riparian rights. Beaches are posted so infrequently that this is a community problem only.

The terms "sports fishing," "angling," and "game fishing" are generally understood to refer to rod and reel fishing only. As we are here concerned with a potential source of income and recreation and not with angling rules, these terms are here understood to refer to rod and reel fishing, "table" angling when not in commercial quantity, and recreational handlining. "Big game fishing" is generally applied to angling for large offshore fishes, such as marlin, tuna, swordfish, and, usually, sailfish.

ANGLING AS RECREATION AND ECONOMIC ASSET

Angling is universally accepted as a healthy and inexpensive form of recreation, and needs no discussion to support this fact. It is at present the most popular sport in America and, without much doubt, in the world. Construction of more bridges and piers for fishing, and cooperation from North Carolina's public schools, both for white and colored people, might be worth while. The formation of more angling clubs and of clubs in connection with schools or other educational or public projects will aid materially in furthering the sport.

A few of the people, industries, and businesses profiting by the presence of visiting anglers on North Carolina's coast are listed here under the particular phase of sports fishing with which they are concerned:

BOATS. Carpenters, masons, metal workers, architects, construction workers of all kinds. Workers and equipment for shipyards, docks, slips, and filling stations. The necessary purchase, repair and renewal of tools and materials involved. Fishing cabins and their equipment in personnel and materials. Bathing beaches and equipment. Oil, gas, food, ice, soft drinks for provisioning boats.

Guide captains and mates and their clothing, living, and equipment. Tackle and scales: Tackle shop keepers and workers and equipment; tackle manufacturers and material involved (wood, metal, flax, nylon, feathers, etc.)

PHOTOGRAPHY. Camera and camera supply and processing shops and equipment.

ACCOMMODATION. Hotels, tourist accommodations of all kinds, restaurants, food stands and shops, drug stores, liquor stores. The more anglers arriving, the more renewal of all supplies will be necessary, much of which can be purchased locally, such as renewal of hotel furniture, linen, china, etc., etc.

GARAGES AND FILLING AND REPAIR STATIONS and workers and equipment involved.

TRANSPORTATION. Public and private, including local and out of state with stations, air fields, taxis, garages, train sheds, bus stops, and docks and all their workers and equipment.

MISCELLANEOUS. Clothing, luggage, drug supplies; entertainment places, special attractions of the State; special products of the State.

Practically all the above necessitate office personnel and equipment. If the State produces and processes any of the basic materials involved, such as flax, cotton, wood, etc., there will of course be additional profit.

An outstanding example of what anglers can bring to a community is the village—population 1,500—of Wedgeport, near Yarmouth, Nova Scotia. Before 1935, this small French Canadian village derived its meagre income from commercial tuna and lobster fishing. Its general appearance was of a self-respecting, but not very prosperous community. It had no accommodation for visitors.

In 1935 one of the world's best-known marine anglers determined to try fishing tuna off the now famous Rip, and against the auguries of the commercial men, he set out in an old lobster boat with a hand-made swivel chair. One day's fishing showed everyone just how fine a sport was there. A few more adventurous anglers followed his trail, but in 1936, the town still had no inns or other places for anglers to stay. They had to live in Yarmouth, drive over to Wedgeport, and keep the car waiting while they got a few hours fishing. However, Wedgeport had secured a professional guide who had set up headquarters on one of the docks and was training some local men; there was a guides association; some tackle was available, and a boat or two. A thin line of cars was to be seen at the dock and a well-known taxidermist had arrived in town. Meanwhile, in Yarmouth, a very active Government Bureau of Information man had started publicizing Wedgeport with whatever help he could enlist and with all the push he could summon. Dominion and local government agencies were with him in the effort, and so was the whole of Wedgeport. In 1937 Wedgeport was really launched as a fishing center when the first of the International Cup Matches (for tuna) was held there.

By 1946 Wedgeport had fifteen angling boats, fifteen captains, thirty guides, a guides association, an angling club, a good dock with attested scales, a hotel, and much excellent publicity. In this year, 1949, Wedgeport is building more boats; has three hotels and several private tourist homes, and Roy Cann of the Yarmouth office of the Nova Scotia Bureau of Information wires me that the "angling last season aided the community to extent of about one hundred thousand dollars." The International Matches this September in Wedgeport will bring teams from the United States, Great Britain, Cuba, Argentina, and Brazil, with a crowd of anglers from other sections who have come along as audience or press or to try their luck independently. This, it must be remembered, was a very small community with no tourist trade of any sort, for the most part not on maps, not on a railroad, chiefly French-speaking but in no way "quaint," and without bathing beaches or any other possible attraction for visitors. It had only the fish and, after its initial push, the enormous and concerted will to become the famous tuna fishing grounds it now is. In the case of Wedgeport, the information and publicity service goes on without pause, and this is extremely necessary. I have in mind two other small communities, perhaps in themselves more potentially attractive to tourists, where fish are even more plentiful and the season longer, but where no information service was maintained, and no concerted effort made. Eventually what visitors' accommodations had been available were closed; their few boats were taken elsewhere. The fish are still there but only very seldom is an angler able to afford the luxury of a yacht there on which he can live and from which he can fish.

North Carolina, with her beautiful long coast line; with fresh-water fishing, salt-water fishing, and bathing so close together; with a good all year round climate, a long fishing season, and good hotels and inns, should surely be able to attract increasing numbers of anglers from those who fish from piers to those who try for marlin off Hatteras.

GEOGRAPHICAL DISCUSSION

Off nearly the full length of North Carolina's coast, and separated from it by sounds, are long, low "banks" of sand. The sounds communicate with the ocean through other sounds or through inlets.

Currituck, the most northern sound, is fresh, and Albemarle into which it discharges is nearly fresh water. Roanoke and Croatan sounds are separated by Roanoke Island. Pamlico Sound, into which these four others discharge, is separated from the ocean by Hatteras and Ocracoke islands which are broken by Oregon, New, Hatteras, and Ocracoke inlets. To the south of Pamlico Sound is Core Sound running south to Beaufort, where Bogue Sound begins. There are numerous smaller sounds to the south.

A general impression that in North Carolina the faunas of the north and south meet is true to some extent, but is not always, as generally assumed, to the angler's advantage, as tropical fauna and northern fauna may appear here only as stragglers. Nor is Cape Hatteras as sharp a barrier as customarily indicated in angling literature. In summer, the water temperatures south of there are more or less constant with that of the Florida Straits. In the region of the Cape they begin to cool, but this is very gradual and a sharply colder barrier is not achieved until Cape Cod. Therefore in summer there is no real barrier for southern forms at Hatteras, although tropical stenothermal[1] forms would find one in the cooling water. In winter there is more of a barrier caused by the cooling of the North and Middle Atlantic Bights at that time, in addition to the presence of the warmer water of the near-by Gulf Stream in the region of Hatteras. These matters are discussed in detail by Dr. Nelson Marshall.[2]

For many years anglers have believed that the Gulf Stream off North Carolina was the haunt of some of the more spectacular game fishes, particularly the blue marlin and the bluefin tuna. This idea appears to be based on the capture of two blue marlin off Diamond Shoals, and on an impression that the bluefin tuna must pass North Carolina in migration. No account has been taken of the fact that such fishes may be part of population units and may touch this coast only rarely and as stragglers, or that if they pass on a migratory route, they may do so either at a depth or a distance offshore entirely inaccessible to anglers.

Dr. Marshall has discussed another prevalent idea that the Gulf Stream is moving closer to shore.[3]

FACILITIES FOR SPORT FISHING

North Carolina has a number of features which should make her coastal area particularly appealing to anglers. The main roads, rail, plane, and public transportation services are all good, although some long stretches of lonely road are in need of service stations. It would also be advantageous to facilitate transportation from mountain area to shore area in order to attract to the coast some of the visitors who now go only to the mountainous section of the State.

Hotels, guest houses, and anglers' cottages are fairly numerous, above average in comfort and below in cost.

The State could well advertise its coast as an ideal section for learning to fish. On its reasonably priced party boats, from its piers and bridges, and in

1. I. e., animals which can tolerate or live only within a narrow range of temperatures.

2. For maps, charts, tables, etc., and other geographical and meteorological data of the North Carolina coast, see Part I of this Survey, by Dr. Nelson Marshall.

3. *Loc. cit.*

its protected sounds, bights, and inlets, one can learn and practice all sorts of angling from handlining to surf casting and offshore rod and reel fishing. There is a great deal of fine angling for which no boats are necessary, and much for which small skiffs, with or without guides, may be used. There is also fine fresh-water fishing and hunting near many of the marine grounds.

Good offshore angling weather averages about three days out of six; the average is higher for inshore and inside waters.

Although the long, sandy beaches and banks are ideal vacation spots, the present average stay for anglers is from two days to two weeks. Efforts could be made to increase this stay by publicizing the less expensive and less strenuous methods of angling and featuring this coast as suitable for family vacations.

A number of small improvements are advisable at the moment: further marking of the wrecks which are a popular haunt of many game fishes; further lighting of channels in which night approach is at present difficult; cutting inlets to give quicker access to the ocean from some already fine harbors; improvement of some of the yacht basins; more facilities for boat repair.

Mr. W. A. Ellison, Jr., Director of the Institute of Fisheries Research at Morehead City, calls my attention to the Coast and Geodetic Survey Charts No. 1109-A and No. 1110-A. "These are," he writes, "the so-called wreck charts, issued by the Coast and Geodetic Survey which locate and identify each wreck, giving the complete history of the wreck. By means of these charts any competent navigator with an adjusted compass and a knowledge of currents and winds should be able to locate the wrecks without too much trouble. I mention this because I think it is important that the sports fishermen know about these charts."

Boats taking anglers offshore should certainly be equipped either with twin engines, ship-to-ship or ship-to-shore radio or, preferably, both.

Available repair facilities are mentioned under their appropriate sections. There is one, however, which should be spoken of despite its distance inland. This is the yacht basin now under improvement at New Bern, which will be a convenience for those who have to go into the shipyard for repair work.

BOATS

There are few dock charges and when they exist they average three cents per foot per day; less after one month.

The bulk of angling boats in the State are primarily commercials, available to anglers in off season or on single days when they happen to be free. The uncertainty of this arrangement is irritating to prospective anglers. Because of it, and because of the fact that it is basically due to unpredictable natural phenomena, no figures can give more than a general picture of the situation. The establishment of an information center or centers would be helpful.

Menhaden boats, winter trawlers, and deep sea draggers are not suitable for angling use. The majority of North Carolina shrimpers—which might be used for angling—follow the shrimp run the year round. They may fish any day but Sunday between 4 A.M. and 8 P.M., and in any place. Some of them even go out of the State in the slow season, although this may be changed by possible future laws regarding the taxation of out-of-state boats.

Boats used in oyster dredging are fully in use from October through March. The smaller oyster boats are unsuitable for many offshore grounds. Large boats used for flounder fishing are chiefly from out of the State.

The supply of skiffs and small motor boats is at present large enough to supply both commercial and angling needs for them.

The terms "charter boat" and "party boat" are used arbitrarily in this discussion. The charter boat, a very important feature in sports fishing, here indicates a boat used only for angling and equipped for outside, offshore, and Gulf Stream fishing. Such a boat should be at least 38 feet long, equipped with twin engines and with ship-to-shore radio. It should have a fishing chair with rod holders, adjustable foot-rest and movable gimbal for rod butt, or at least a stool to which rod sockets have been attached. Various other luxuries adding to its value to anglers would be sleeping accommodations for at least four people, steering from more than one place, double rudders, and Diesel motors. Just as important as the boat is the fishing guide, who must know how to handle the boat, care for the tackle and equipment, rig baits, and instruct the inexperienced angler.

Some of the finest pioneer fishing for the largest game fishes, such as tuna and swordfish, has been done from dories which are equipped with an outboard motor and into which seats and supports have been built, or from launches seemingly more suitable for harbor fishing. However, I must add that such fishing was done by expert big game anglers accompanied by equally expert guide captains.

The expense of owning a charter boat is often prohibitive unless there can be a more than fair assurance of both charter and a sufficient number of fishing days. Because of the uncertainty of weather for the offshore fishing for which such a boat would ordinarily be chartered, it might be more practical for such boats in North Carolina to be owned by a guides association instead of by individuals. Charter boats seldom take more than four anglers and usually carry a guide captain and mate.

The term "party boat" is here used to indicate boats other than charter boats taking more than one or two anglers, but it does not include small motor boats or skiffs. Some party boats are anchored for still fishing; some take out thirty or more anglers; some provide overnight sleeping arrangements; some make more than one trip a day. In North Carolina such boats have seldom been built or purchased for anglers' use.

Because of physical and faunal conditions which vary with the grounds, it is probable that uniform boat charges throughout the State would be unfair. The present (1946-1947) charges run in general as follows:

Charter boats: $60 to $80 per day, often depending on the distance offshore.

Commercial boats used for individual anglers or not more than six people: $35 to $60 per day. Many of these boats will not go more than a few miles offshore.

Party boats: $25 to $80 per day (inshore, $25 to $50), or $3.50 to $8.00 per person per trip; higher prices may include gear, food, or sleeping quarters.

Small boats for fishing or hunting, with guide, about $15 per person per day.

Skiffs or rowboats without guide: about $1.50; with guide, $7 per person per day.

Boat owners are managing to keep their prices to anglers fairly reasonable by varying them with locality, seasons, and grounds, but in the great majority of cases they are unable to produce any printed statement either of current prices or of types of boats available. These inevitably vary from year to year, and the post-war years will see substantial increase in the number of angling boats. Many boat owners are planning to get charter boats, or more charter boats, if possible. Whatever the situation, they should have available in print the information I have mentioned above.

REGIONAL DISCUSSION

It must be remembered in connection with the following material that the boat situation is a shifting one, from year to year and even from week to week; therefore figures can only be approximate.

For purposes of discussion, fishing areas may be roughly divided into the Nags Head–Roanoke Island–Portsmouth section; the Morehead City–Swansboro section, and the Wilmington–Shallotte section. These sections are understood to include intervening angling grounds of which there are many. There are a few communities, like Swanquarter, which although distant from the ocean have marine fishing and boats available to anglers. Such places have no boats for outside fishing.

NAGS HEAD–ROANOKE ISLAND–PORTSMOUTH

The most famous offshore fishing grounds for this section is Diamond Shoals, lying about 19 miles from Hatteras Inlet and 32½ miles from Ocracoke Inlet.

This section has bank, sound, inlet and wreck, and offshore fishing. Spring is a trolling and fall a surf casting season.

ROANOKE ISLAND. There are here about 20 local commercial boats, chiefly suitable for inlet fishing. Their average length is 35 feet. Some Virginia boats come down on charter or with their anglers. There is little offshore fishing.

HATTERAS. The local commercials are suitable for angling use. They are about 40 feet long and single-engined. One regular charter boat is available. There are insufficient boats for the double use of commercial and sports fishing, especially as Ocracoke has to call on Hatteras boats for offshore anglers. There is no skiff fishing.

OCRACOKE. Skiffs and smaller boats for inside and inlet fishing and fishing less than five miles offshore are available in adequate number and two twin-screw boats are available. Although all the Ocracoke boats can be used commercially, from two to four are kept for anglers during the height of the commercial season. There are fourteen small boats for hunting and angling, each taking not more than four anglers. Plenty of guides are available. The average price per boat at Ocracoke is $20 to $30 per day, and at Hatteras $20 to $25. "Deep" fishing comes higher: $45 to $50.

There was some alarm when I was in the Roanoke Island–Hatteras–Ocracoke region at the large number of channel bass of all sizes being netted for a cannery at Wanchese. Channel bass is the chief attraction for anglers in that region. This fish sometimes runs as early as mid-March, through the spring, and again in the fall. Sea trout are caught here from mid-August into October; the rather rare cabio is taken in- and offshore, and the amberjack and dolphin are outside around wrecks.

The local commercial boats are most in use in the spring. Winter trawling in this region is largely by out-of-state boats although recently some local boats have been engaging in it. A large commercial fishery for croaker operates from spring into July, when there follows a dead period lasting from one to two months, during which some of the commercial boats are freed for angling use. There are not enough boats for anglers in this whole region, particularly for offshore fishing. The seasons are a fairly long one in spring and, because of weather and the hunting season limits, a shorter one in fall.

Additional attractions of the section are the unspoiled beaches and banks, duck shooting, and the Lake Mattamuskeat Federal Waterfowl Refuge.

MOREHEAD CITY–SWANSBORO

Here there is bank, inlet, and wreck fishing. Popular grounds are Core and Shackleford banks, Drum Inlet, and Lookout Bight which is deep and is well protected from northeasters. There is also some surf casting.

There are some thirty-five boats available for Gulf Stream angling to anglers in this whole section. These are 40 to 50 feet long and equipped with ship-to-shore radio. Most of them are twin screw. Half of these take on parties for overnight—a special feature of this section. The charge for a party of six is $75. If the boat supplies gear, the price is higher, as it is per person for parties of more than six. There are ten boats for inside fishing and seven or eight commercials licensed to take parties but uncertainly available for anglers' use. Some Florida boats come up in late spring or summer. There are several marine filling stations and two good machine shops in this section. The Morehead City Yacht Basin offers good facilities for both transient and permanent docking.

Most boats here are equipped for the less expert angler and for large parties. This is a safer outside fishing section than the more northern regions but, on the other hand, it is in general much less attractive scenically, and much less unspoiled.

The best fishing season commercially is September through December, but due to weather conditions the best angling months are September and October. A small amount of the game fish fauna here could be fished into November. There are sea bass, channel bass, some sailfish, and the usual amberjack and dolphin, as well as both sea trout and spotted trout. This area reports that the taking of indiscriminate sizes in the commercial nets is potentially detrimental to the supply.

Additional attractions in the region are the very near-by fresh-water fishing grounds; the two marine laboratories at Beaufort and the Institute of Fisheries Research at Morehead City.

The people of the section are enthusiastic on the subject of angling, and have made some attempt at record keeping.

WILMINGTON–WRIGHTSVILLE BEACH–SOUTHPORT–SHALLOTTE

This section has pier and inlet fishing, some surf casting, and offshore fishing, particularly on Frying Pan Shoals, which lie some 30 miles off the point of Cape Fear.

The supply of boats appears to be good here, but is locally reported as insufficient to meet demands. There are three or four two-engined charter boats; eight other boats, running up to 60 feet in length and reserved for anglers; 20 to 25 others usually available; five boats which can go out to the Gulf Stream (this includes the charter boats above), and many small boats and skiffs. Most communities can summon boats from others, and some Florida boats come up in summer. There is an additional although uneven supply of commercial boats. There is pier fishing all winter, and a little surf casting, usually for the common mullet. The fauna is plentiful and varied. The best season is September and October when the fish run largest. Frying Pan Shoals is a concentration spot for dolphin, amberjack, and some sailfishes. The population of this section are enthusiastic and well informed about angling and are doing everything possible to publicize their grounds. The section could easily offer a longer fishing season as it has a good winter climate. Pier fishing is a feature here. Pier admission is thirty-five cents in the season; in the winter the admission booths are closed, but there is still pier fishing.

Local anglers report that the rock shelf outside Wilmington, although lying deep, should be buoyed. They also feel that if an inlet could be cut at Carolina Beach, which already has a fine harbor, boats could have easy access to the twenty-two-mile-distant Gulf Stream.

There are four single screw, 30 to 40-foot party boats at Carolina Beach. Wrightsville Beach is particularly well equipped as a vacation spot for anglers. It has five 40 to 50-foot, and nine 30 to 40-foot party boats. The majority of these are twin screw and equipped for Gulf Stream fishing. Most of them have radio. There are good local facilities for repair.

Southport, a very popular spot with anglers, has four single screw and one twin screw boats, the largest 60 feet, the smallest 30 feet. These boats can go to the Gulf Stream, although considerable good fishing is done from 15 to 20 miles out. One of these boats is in use commercially when there is a bluefish run. Southport needs improvement of its natural yacht basin and could well utilize more facilities for boat repair and for living quarters for anglers.

This whole section has a long fishing season, both marine and fresh water, and, in addition, some hunting. It is additionally attractive to anglers because of its annual fishing rodeo, and to tourists because of beautiful Orton Plantation between Wilmington and Southport.

SEASONAL DISCUSSION, BY MONTHS

This section is included to show conflict or lack of it between use of boats for commercial purposes and use of boats for angling; also to indicate what and where fish are present off North Carolina.

JANUARY. Present: channel bass (offshore), sea bass, striped bass, bluefish, croaker, flounder, sea mullet, pigfish, spotted sea trout.

Shrimpers and oyster boats are in use; there are minor inshore pound nets and sink nets taking croakers; occasional seines for flounders and some gill nets for spotted trout.

There is a negligible amount of angling, almost entirely in inside waters, for striped bass, bluefish and spotted trout. Some puppy drum are on the beaches.

FEBRUARY. Present: channel bass (offshore), sea bass, striped bass, bluefish, croaker, flounder, sea mullet, pigfish, spotted trout.

Shrimpers and oyster boats are in use; nets and lines are out for channel bass; sink nets for croakers. There is a completely negligible amount of angling and only in the southern part of the State.

MARCH. Present: channel bass (offshore), sea bass, striped bass, bluefish, croaker, flounder, sea mullet, pigfish, sea trout.

Shrimpers and oyster boats are in use; pound and gill nets are fishing channel bass, chiefly in the area south of Cape Hatteras; there is line fishing for sea bass; pound and sink nets inshore are fishing croaker; flounder spearing is going on.

The spring angling season often begins in March, with trolling and surf casting, especially in the Roanoke Island section.

APRIL. Present: channel bass, sea bass, striped bass, bluefish, croaker, flounder, sea mullet, sea trout.

Shrimpers and oyster boats are in use. Commercially, there is flounder spearing, net and line fishing for channel bass, striped bass, bluefish, croaker, sea mullet and sea trout.

Anglers are trolling for channel bass off the banks in the north, and there is a little surf casting for this and for sea mullet. Anglers need motor boats for bass and sea trout fishing.

MAY. Present: amberjack, channel bass, sea bass, striped bass, bluefish, cabio, croaker, dolphin, flounder, spanish mackerel, common mullet, sea mullet, sheepshead, tarpon, sea trout.

Shrimpers are in use. Oyster boats are available. Nets and lines are getting channel bass, striped bass, croaker, spanish mackerel, sea mullet, sea trout and sheepshead. Beach seines and runaround gill nets are fishing mullet.

There is outside angling for amberjack and dolphin off New Hanover County; sea bass off Carteret County, cabio off Brunswick County. Trolling for channel bass and bluefish is going on in all areas, and there is a small amount of surf casting, particularly in the Roanoke Island-Hatteras section.

JUNE. Present: amberjack, barracuda, channel bass, sea bass, striped bass, bluefish, bonito, cabio, cero, croaker, dolphin, flounder, spanish mackerel, blue marlin (reported), common mullet, sea mullet, pigfish, sailfish, tarpon, sea trout, wahoo.

Most shrimpers are in use; oyster boats are available. Commercial nets and lines are out for channel bass, striped bass, bluefish, croaker, sea mullet, sea trout, spanish mackerel, flounder and pigfish. Beach seines and runaround nets are catching mullet.

Anglers can fish outside for amberjack, barracuda (sometimes inshore also), sea bass, bonito, cero, cabio (sometimes coming inshore), dolphin, sailfish, blue marlin (?), and wahoo (rare). There is inside and inshore angling for channel bass, striped bass, sea trout, croaker, sea mullet, tarpon (rarely hooked), and wahoo (very rare).

JULY. Present: amberjack, barracuda, channel bass, sea bass, striped bass, bluefish, bonito, cabio, cero (a few), croaker, dolphin, flounder, blue marlin (very rare), white marlin (reported as present), common mullet sea mullet, pigfish, sailfish, sea trout, wahoo (rare).

Shrimpers are in use; oyster boats are available. There is commercial netting for channel bass, bluefish, sea mullet, pigfish, sea trout, croaker, and beach seines and runaround gill nets for the common mullet.

There should be outside and offshore angling for amberjack, barracuda, sea bass, larger bluefish, bonito, cabio, dolphin, sailfish, wahoo, and perhaps blue marlin. Inside and inshore there is angling for the smaller bluefish, sea mullet, and occasionally, a wahoo.

AUGUST. Present: amberjack, barracuda, channel bass, sea bass, striped bass, bluefish, bonito, cabio, cero (?), croaker (not plentiful), dolphin, flounder, common mullet, sea mullet, pompano, sailfish, sea trout, wahoo (very rare); blue marlin is questionably present; white marlin is reported to be present.

Shrimpers are in use; oyster boats are available. Most of the commercial gear used at this season requires only the services of small boats which at this season of outside and offshore angling are in less demand than in some other months. This is one of the best months for offshore angling in the northern section and one that could use a larger supply of offshore boats down the whole coast.

There is outside and offshore angling for amberjack, barracuda, sea bass, the larger bluefish, bonito, cero, cabio, dolphin, sea mullet, sailfish and wahoo (rare), and anglers are trying for blue marlin. Inshore angling is for channel bass, sea trout, smaller bluefish, pompano, and an occasional wahoo.

SEPTEMBER. Present: amberjack, barracuda, channel bass, sea bass, striped bass, bluefish, bonito, cabio, cero, croaker, dolphin, flounder, blue marlin (questionably present), spanish mackerel, white marlin (reported), common mullet, sea mullet, permit (occasionally), pompano, sailfish, sheepshead, tarpon, wahoo (rare).

The shrimp boats are in use. There are small net and line fisheries for channel bass, striped bass, bluefish, sheepshead, flounders, pompano, sea trout, and common mullet.

Outside angling is for amberjack, barracuda, sea bass, channel bass, larger bluefish, bonito, an occasional wahoo, a few cero, cabio, dolphin, sea trout, sailfish. White marlin angling is reported, and there are the inevitable tries for blue marlin.

This is a fine month for angling in the Ocracoke section. Boats in all sections are insufficient.

OCTOBER. Present: amberjack, channel bass, sea bass, striped bass, bluefish, bonito, cabio, cero, croaker, dolphin, flounder, common mullet, sea mullet, pompano, sailfish, sheepshead, spot, tarpon, spotted sea trout, wahoo (rare). Anglers are vainly trying for blue marlin and bluefin tuna. White marlin are said to be present.

Shrimpers and oyster boats are in use. Net and line fishing is going on for sea bass, channel bass, striped bass, bluefish (using small boats), sea mullet, pompano, spotted trout, spot, sheepshead. Motor boats are servicing the mullet fisheries. There is flounder spearing. When good, this is probably the finest angling month for the whole coast, but the weather is beginning to be tricky.

It is also one of the months in which commercial boats are in very full use. Outside, offshore angling includes amberjack, sea bass, bluefish, bonito, cero, cabio, dolphin, sailfish, wahoo. Inshore and surf angling is excellent for channel bass, striped bass, some bluefish, sea mullet, pompano and sea trout. Tarpon are present but seldom take the hook.

NOVEMBER. Present: channel bass, sea bass, striped bass, bluefish, cero, croaker, flounder, common mullet, sea mullet, sailfish, spot, spotted sea trout. Sailfish and white marlin are said to be present in the early part of the month, in the southern area.

Shrimpers and oyster boats are in use. The sea bass fishery is serviced by motor vessels and power boats. Some winter trawling, chiefly by out-of-state boats, is going on for channel bass, bluefish, flounder, croaker, sea mullet, spotted trout. There is also a pound net fishery for channel bass, and seining for the common mullet.

When weather permits, there is outside angling for sea bass, cero, and sailfish. Channel bass and striped bass are the principal inshore and inside fish. Because of the weather, this is a poor month for anglers, although the early part of it is sometimes fairly good, particularly in the more southern areas. There are sufficient boats available for the amount of angling done in this month.

DECEMBER. Present: channel bass (offshore), sea bass, striped bass, bluefish, croaker, flounder, common mullet, sheepshead, spotted sea trout.

Shrimpers and oyster boats are in use. There is a winter trawl as in November, net fisheries for channel bass, and seines for the common mullet.

A very small amount of angling is available, chiefly for striped bass, and more usually inland than marine.

Spring and fall are the best angling seasons in the State, particularly the months of April, May, early June, September and October. Given favorable weather, November may also be a good month in the more southern areas.

Good angling on the northern part of the coast is fairly definitely limited to the April–June, September–October seasons.

FAUNAL DISCUSSION[4]

AMBERJACK
(Genus *Seriola*)

At least two, and probably three, species of *Seriola* have been identified from North Carolina, but to anglers they are all amberjack.

The adults of this southern fish occur from at least as far south as Brazil to Cape Cod, where they are found as stragglers. Species of this genus are also found on our own Pacific coast, off Europe, Africa, and Australia. On our Atlantic coast it is most numerous off Key West in winter and is there fished commercially. Off North Carolina it is found from May to October on the grounds with dolphin, feeding on small fishes and crustaceans and congregating around wrecks and buoys.

Fifty-pound amberjack are fairly common around Key West, but the average weight off North Carolina is 12 pounds. The maximum recorded size for the genus is 134 pounds, and the record rod and reel catch, taken off Florida, 106 pounds.

Young amberjack have been taken off Beaufort from June through September. Hildebrand and Cable (1930) state that the fry in the vicinity of Beaufort "occur chiefly at sea where spawning no doubt takes place during the summer." They further note a female of thirteen inches with somewhat distended ovaries, showing that the fish may be sexually mature at this length.

Anglers rate this fish very high as a hard fighter of great strength. It is one of the most numerous and important game fishes in North Carolina, especially around the wrecks off Cape Lookout, Cape Hatteras, and Cape Fear.

BARRACUDA
(Genus *Sphyraena*)

Here again there is confusion about species. For many years both the great barracuda, *S. barracuda* (Shaw) and the northern barracuda, *S. borealis* (DeKay), were reported off North Carolina. However, Hildebrand and Schroeder (1928) reported that the only two species of *Sphyraena* recorded from waters north of Florida were *borealis* and *guachancho*. This limits *barracuda*, a typically West Indian species, to a more tropical range.

Barracuda are present in warm offshore waters all over the world and

4. Species marked by an asterisk are further discussed by Dr. Roelofs in the chapter in Part II on "The Edible Finfishes of North Carolina," beginning on p. 109.

often run up estuaries for short distances. They are not commercially taken although their flesh is edible.

Due to confusion of species, the only weight record is for a rod and reel catch of great barracuda—103¼ pounds, caught off the Bahama Islands. *S. guachancho* seldom runs over two feet; *borealis* seldom over one foot. The U. S. Fish & Wildlife Laboratory at Beaufort reports many barracuda from six to eight inches long, at which size they are mature, off the Beaufort–Morehead City section, and large schools are reported off Frying Pan Shoals from June through September, with an average weight of 5 to 10 pounds. The bulk of the North Carolina run seems to be in this locality.

Barracuda are fearless, hard fighters. Although their angling rating is high, their swift, direct approach to swimmers and boats, combined with a formidable array of long sharp teeth, makes them less popular than other game fishes. Anglers seldom go out deliberately for barracuda.

CHANNEL BASS OR RED DRUM
Sciaenops ocellatus (Linnaeus)

The channel bass runs from Texas to New Jersey, occasionally straggling farther north. Centers of abundance are Chesapeake Bay, the Gulf of Mexico, and North Carolina. The fish moves in large schools; is present all year round off North Carolina, but more plentifully and more accessibly in spring and fall, and is the object of large commercial fisheries. It averages 15 to 30 pounds and seldom weighs above 50. Anglers fish for both adult and young (puppy drum), which are abundant on the beaches. The rod and reel record, caught off Cape Charles, Virginia, on August 5, 1949, weighed 83 pounds.

Hildebrand and Schroeder (1928) say this fish probably spawns in Chesapeake Bay somewhat earlier than off Texas (October). It probably does not spawn north of Chesapeake Bay.

Channel bass is one of North Carolina's outstanding game fishes. The regular angling cycle for it in the northern part of the State is trolling and some surf casting March 15 to June 15; it is then present in quantities and runs 17 to 55 pounds. At Ocracoke the drum begin to come in the middle of April and are fished at night April through June. By mid-April, they are off the bank; by May, at the inlet and in the sound; by September, they are good on the beach but not in the sound. In October, they are on the bank again. Hatteras reports them all year, and large loads were coming in there commercially in January (1947). Reports from commercial fishermen at Ocracoke say that none of the channel bass brought in there contain roe. Carteret County reports the fish on Core Banks and in Drum Inlet through November, averaging 25 pounds and present in other months but running somewhat smaller. Wilmington reports big ones taken from Wrightsville Beach to New River Inlet, and much surf casting. There they come into the inlets at night, close to the shore, and are also caught from boats anchored in the inlet. Shallotte reports them both inside and in the surf. An unconfirmed report from the Wilmington region states that channel bass there often contain roe weighing as much as five pounds.

Whether these fish are spawning off North Carolina or whether North Carolina is getting the results of the Chesapeake Bay spawning, or both, it is probable that netting of females with ripe eggs and of indiscriminate sizes of young will ultimately deplete the supply.

* SEA BASS. ALSO CALLED BLACK BASS OR BLACKFISH
Genus *Centropristes*

Fishermen and anglers do not distinguish *C. striatus* from *C. philadelphicus,* both of which are present off this coast. *C. striatus* is concentrated around Cape May, where it spawns, and runs down to Cape Hatteras, probably straggling farther south. *C. philadelphicus* is concentrated in the northern part of Florida and its spawning grounds are not known. It apparently runs north to Cape Hatteras and probably farther. The fact that we are here dealing with two species accounts for the lack of agreement in reports of angling seasons. The Manteo–Hatteras section reports the fish as present from July through December. It is known that commercial fisheries for sea bass are going on in January and February off Cape Hatteras by out-of-state boats with out-of-state landings.

The fish averages ½ pound, and some of greater weight have been infrequently taken. The ancient rod and reel record, caught off New York, weighed 8 pounds 2 ounces and is suspect in the two most important ways —manner of catch and weight!

C. striatus is said to be mature at a length of about five inches. This is not one of the most popular game fishes, due to its small size and the customary presence of more popular game fishes on its grounds. It is generally found around wrecks and over rocky bottom where it feeds on the bottom on small fish, squid, and crabs.

* STRIPED BASS, ROCK, OR ROCKFISH
Roccus saxatilis (Walbaum)

This anadromous fish is so widely distributed that its presence would hardly lure anglers from any distance. It is, nevertheless, a very popular game fish from Canada to the Gulf of Mexico and from Oregon to the southern part of California. In North Carolina it is present all year, and although sometimes taken in salt water, it is more often trolled in the Inland Waterway or tidewater streams. The rod and reel record catch weighed 73 pounds. It was taken in Vineyard Sound, Massachusetts, on August 17, 1913.

* BLUEFISH

Pomatomus saltatrix (Linnaeus)

Like the striped bass, this fish is a very widely distributed and very popular game fish. It occurs in nearly all temperate and tropical waters, moving in large schools and appearing erratically. It is highly carnivorous and eats quantities of fishes, crustaceans and worms. The larger individuals run in outside waters; the smaller enter sounds and run up rivers.

The bluefish is taken by trolling and still fishing and is very popular with pier anglers. It is also caught by surf casting. It will bite savagely at any bait and will include in the bite as much of the tackle as possible. Van Campen Heilner recommends its fishing off any resort between New England and Florida where one can get offshore, or in any inlet. He considers July, August, and September the best months. Off North Carolina the fish is present all year, but in some months the specimens available to anglers are small. The larger fish usually run in spring and fall. Mr. Heilner reports fine fishing at Cape Hatteras in May. The average size is from two to four pounds. The "rod and reel record," a very old one, is 25 pounds and in all probability was a handline catch. Popular as this fish is, the International Game Fish Association seldom receives any claims for record size, showing that there is seldom any great variation.

Spawning is assumed by most ichthyologists to take place offshore in spring and summer. The fish is known to spawn between May and July off New York and southern New England.

"BONITO"

Sarda sarda (Bloch). Common bonito

Euthynnus alletteratus (Rafinesque). False albacore; little tuna

Auxis thazard (Lacépède). Frigate mackerel.

Anglers and commercial fishermen are usually capable of distinguishing among these three fishes, but in speaking and writing of them, both classes of fishermen are apt to use the term "bonito" for all three. *Euthynnus alletteratus* is also referred to as "school tuna." Therefore information on the bonito is extremely difficult to assign to any one of the three genera. It appears to apply most often to *Sarda sarda*. All three fishes are gamey fighters, and are also valued as bait.

Bonitos (probably *S. sarda*) occur offshore off North Carolina in summer and fall, coming in from the ocean to feed. They congregate around wrecks, and are reported in quantity off Pea Island feeding on minnows, and about five miles out of Ocracoke. The Ocracoke boats are too small to go out for them, but the larger Hatteras boats do so.

This fish is widely distributed in the Atlantic and Mediterranean, off Europe, Africa, and North America. There is another species in the Pacific off the United States, South America, and in the Indo-Pacific region. On our Atlantic coast *Sarda sarda* runs from Cape Ann south to Florida which seems to be about the southern limit for the Americas. It is believed to come inshore to spawn and is abundant in summer from Massachusetts south. The average weight is four pounds and it is reported to attain twelve. There is no rod and reel record.

Euthynnus alletteratus runs larger than *Sarda sarda,* averaging around 30 pounds. This fish has been taken in some quantity off Roanoke Island where it is called bonito. Unlike *Sarda,* it is not very edible.

Auxis thazard is occasionally taken around Beaufort. It runs around two pounds and is not good eating.

The three fishes are easily distinguishable from each other. The conspicuous front teeth on the lower jaw of *Sarda sarda,* the oblique wavy bands and spots on the posterior part of the upper sides of *Euthynnus,* and the wide separation of the two dorsals of the frigate mackerel should serve as distinguishing characters to any fisherman.

The bonitos are confused with the bluefin tuna only in name, as all fishermen and anglers know the bluefin by sight.

CABIO, ALSO CALLED COBIA, BLACK BONITO, AND SERGEANT-FISH
Rachycentron canadus (Linnaeus)

The cabio is a very popular gamefish of no commercial value, although it is edible and marketable when taken. The genus contains only this species. It is widely distributed in tropical and temperate offshore waters and runs into bays, inlets, and channels. The fish occurs at least as far south as Brazil and straggles north to Massachusetts. It is found in summer in the Gulf of Mexico, where young a few inches long, obviously of a local population unit, have been taken in July and August. It has been reported off the East Indies and Japan, although not present on our own Pacific coast.

Although cabio may be found among schools of bluefish or kingfish, they are generally solitary and erratic wanderers and are nowhere common. On our Atlantic coast, they occur most frequently from the Chesapeake Bay region, in or near which they spawn in summer, southward down the whole length of North Carolina. Occasionally, large catches are made, such as the sixteen individuals caught on June 1, 1945, off Wanchese, Roanoke Island. They are plentiful off Mississippi.

The cabio is a voracious feeder on fishes and crustaceans and a hard fighter when hooked. It is fished by bait casting, trolling, and still fishing.

In outside waters light tackle is frequently used for it, but closer inshore heavier tackle is necessary because of the danger of fouling the line on the rocks or wreckage about which the fish is often found.

The rod and reel record catch weighed 113 pounds; the average weight is from 10 to 25, but 40 pounds is not uncommon.

CERO, ALSO CALLED KINGFISH AND KING MACKEREL
Scomberomorus cavalla (Cuvier & Valenciennes)

This popular anglers' fish is chiefly taken by trolling. It averages around seven pounds and is said to reach a weight of 75. The rod and reel record taken off Bimini, B.W.I., in February, 1935, weighed 73½ pounds. The fish is often present among schools of spanish mackerel (*S. maculatus* (Mitchill) and spotted cero (*S. regalis* [Bloch]), but commercial fishermen distinguish easily between the commercially profitable spanish mackerel and the commercially unpopular cero whose sharp teeth are destructive to nets. Reports of the cero's edible quality are conflicting.

The cero is a southern fish whose northern limit on our coast is about North Carolina although it straggles up as far as Cape Cod. It runs south to the Gulf of Mexico and to Brazil and is reported off Africa. Other *Scomberomorus* species are plentiful in the Pacific. Concentration points are from South Carolina to Key West and the Gulf coast. In winter the cero is absent north of Florida where it is very abundant. It occurs all along the North Carolina coast but is most frequently caught off the Beaufort-Cape Lookout section in spring and fall. Records at Morehead City show a number of cero taken in October and November and weighing between 15 and 30 pounds. They are said to average about 10 pounds in July in this region, and about 20 pounds in October. Large runs of them are reported for the Wilmington-Southport area in October, where it is suggested by various anglers experienced with Cero fishing in Florida that the North Carolina anglers are not fishing deep enough for them.

* CROAKER
Micropogon undulatus (Linnaeus)

The croaker is so abundant off North Carolina for such an extended season that its commercial value is based not so much on its abundance but on the lack of it; during slack seasons if caught it brings higher prices. This is a smallish fish, marketable at a weight of ½ pound and reaching slightly over five pounds. It occurs from Cape Cod to Texas and is most abundant from Maryland south. It spawns from August to December in the northern parts of its range and probably later farther south. Fish with well developed roe have been found in Chesapeake Bay during October and early November. The croaker frequents bays and shallow water over grassy bottom, feeding on small fishes, crustaceans and mollusks.

The most productive commercial fishing grounds for this fish are off Maryland, Virginia, and North Carolina in spring and fall. It is not popular enough as a game fish to attract anglers from any distance whatever.

DOLPHIN

Coryphaena hippurus (Linnaeus)

The dolphin is one of North Carolina's most important game fishes. It is a Gulf Stream fish, occurring on the same grounds with the amberjack and in sufficiently large and certain numbers to attract offshore anglers. It is variously reported as good and poor eating, but has no commercial value. It is particularly abundant on the flying fish grounds off Diamond Shoals.

Although this fish is common in so many places all over the world that an angler has a wide choice, its presence, combined with other attractions, is sufficient to attract anglers from a distance. There is also always the alluring chance of snaring a marlin or a sailfish on dolphin grounds, as well as the certainty of getting as many amberjack as anyone could want. The dolphin is very widely distributed all over the world. On our Atlantic coast we find it running north to Cape Cod, and on our Pacific, north to Oregon. There are concentrations in Florida and Mexico. It is definitely an outside, offshore fish, partial to blue water. Light or medium tackle is used in trolling for it. It averages in general under 25 pounds, but the rod and reel record, taken off Oahu, T.H., weighed 67½ pounds. Off North Carolina its usual weight is about 12 pounds. Its food consists of flying fishes, mullet, and other small fishes.

Young dolphin differ greatly in appearance from the adult. Lütken (1880) figures a series of young. C. M. Breder (1929) reports that dolphin spawn in spring in the West Indies; Ocean City, Maryland, reports numerous dolphin in July and August and numerous large schools of small ones; Beaufort reports young of about 12 inches as plentiful in late summer. In general, they are present from June to October the length of the coast. Both *C. hippurus* and a smaller species, *C. equisetis* (Linnaeus) have been recorded from the State; the latter off Cape Lookout.

The dolphin exhibits great speed when chasing its favorite food, the flying fish, and great strength and fighting ability when hooked.

* SPANISH MACKEREL

Scomberomorus maculatus (Mitchill)

This fish is caught only incidentally as an angler's fish in North Carolina and quite frequently confused with the cero, from which it is easily distinguished by the relative position of the dorsal and anal fins, and by its teeth. The fish is found on both coasts of America; on the Atlantic from Maine to Brazil. Other species occur in Europe, Africa, and the Pacific. It is a schooling, warm-water, surface fish going north in the spring and south in the winter. It spawns in Chesapeake Bay in late spring and early summer and is there from May to September, and in quantity in Florida from November to March. The fish is said to reach a weight of 20 pounds but is more usually about 1½ to four pounds. There is no rod and reel record.

BLUE MARLIN
Makaira nigricans ampla (Poey)

The blue marlin, one of the two species of *Makaira* known to occur in the Atlantic, is one of the most famous big game fishes in the world. It runs larger than the white marlin, and averages 200 pounds or more. The rod and reel record, taken in June, 1949, off Bimini, weighed 742 pounds. There is no detailed record of its occurrence in other than Bahaman and United States waters. Although it has been identified as far south as the Leeward and Windward Islands, its southern limit has not been established. Its actual northern limit appears to be Bimini, B.W.I., but stragglers appear with some regularity off Miami and Palm Beach, and, in very small numbers and irregularly, are sighted off Bermuda, Maryland, Montauk, Block Island and Georges Bank. The seasons and places of its occurrence as far as determined are:

Windward and Leeward Islands: sometime between January and June.

Cuba: April through October, particularly August and September; rumored to be present all year on both north and south coasts.

Bimini: January through August, especially June and July.

Florida: January through April, increasing in number toward the end of the season.

Maryland: July and August.

North Carolina: Two blue marlin taken off Cape Hatteras; one in July 1938; one in July 1939, in the Gulf Stream. Other reports unconfirmed.

The blue marlin is known to spawn off or very near the north coast of Cuba, where females with eggs about to rupture the membrane are frequently taken in August and September. There is a commercial fishery for it in Cuba.

The blue marlin seems to be concentrated in the deep column of warm temperature water between Cuba and the western edge of the Great Bahamas bank. This column may at times streak to the north, accounting for stragglers. At any rate, the contrast between the numbers of blue marlin present in it, and the small number ever taken or sighted out of it, is too marked to be ignored. Nor is this a question of where anglers have happened to fish with bait that appeals to this fastidious fish. Florida waters and northern waters have been thoroughly explored for it by expert anglers.

Several well-known anglers believe that the blue marlin is off Hatteras in numbers sufficient to attract anglers. This idea appears to be based on the theory that the fish is migratory and passes that point as it goes north in the Gulf Stream—a theory not in accord with the ideas above. However, the theory may have been an effort to explain the not infrequently correct instinct developed by many anglers. At this time, however, it would seem unwise to advocate the expenditure of much effort or money in trying to prove the blue marlin's presence in numbers in the waters off Cape Hatteras.

WHITE MARLIN
Makaira albida (Poey)

The white marlin runs farther north in greater numbers than the blue. It has been reported off Cape Hatteras and at the edge of the shoals off Southport in September, although there is no confirmation of its presence in any quantity.

This fish occurs off Cuba in great quantity. Ernest Hemingway says that it spawns there in May, heading inshore in pairs—the typical spawning behavior of the speared fishes. He states that in May he has found female fish full of roe. The fish is plentiful in Cuba as early as March in some years and usually from April through May. It occurs there as a straggler in September, one of the most plentiful months for the blue marlin. The white marlin are in Bimini from December through July; the best month is May. They are caught off Palm Beach and Miami in March and April; off Ocean City, Maryland, in quantity in late August and early September. They are off New York and southern New England around the beginning of July. The grounds off Maryland are stretches of shoal water, only fifty or sixty feet deep. Marlin taken there weigh an average of seventy pounds, although one of 130 has been reported. The record, taken off Miami, weighed 161 pounds. No free eggs and no young of this fish have ever been recorded although there are constant rumors of young being seen. With this gap in its life history, no theories as to its distribution can be very tenable.

This fish is a very popular big game fish which provides spectacular jumping when hooked.

* SEA MULLET, ALSO CALLED KINGFISH, KING WHITING, ROUNDHEAD, VIRGINIA MULLET, SEA MINK
Genus *Menticirrhus*

Three species of *Menticirrhus* are present in North Carolina waters. The most numerous, *M. americanus* (Linnaeus), is a southern form ranging from

Texas to New Jersey but not common north of Chesapeake Bay. *M. saxatilis* (Bloch) runs from Massachusetts as far south as Florida, but is not common south of Chesapeake Bay. *M. littoralis* (Holbrook) ranges from Chesapeake Bay south to the Gulf coast, but not as far north as either of the other two. There are other species in the West Indies, South America and the Pacific

The species are all lumped under the name sea mullet by commercial fishermen. They average about the same size—one-half pound to three pounds.

The sea mullet has never been a very well known or popular game fish and there are no rod and reel records. Its presence would not act as a special attraction to anglers, although it is popular where taken and is good eating. In January, 1947, sea mullet were being taken on rod and reel off Morehead City; the more usual season for them in Carteret County, however, is September and October. Angling is possible there from April through October. Although taken commercially throughout the year, the fish becomes more scarce in cold weather.

POMPANO

Trachinotus carolinus (Linnaeus), and others

At least four species of pompano occur off North Carolina. It is found in the ocean, close to banks, inlets, etc., and is said to come in with the breakers. *T. carolinus,* whose range is Texas to Massachusetts, is the most frequent of the species in this section. The permit, *T. goodei,* is only occasionally present and in negligible quantity, chiefly in the Morehead City section in the fall. There seems to be no rod and reel fishing for the pompano in this section, chiefly because the largest run is after the sports fishing season has almost entirely stopped. Commercial and angling fishermen rate the fish high and it is fine eating. The average size is from one to 1½ pounds.

The other species present are *T. falcatus,* the round pompano, a West Indian form straggling to Massachusetts but uncommon anywhere in the northern part of its range, and *T. glaucus,* the gaff-topsail pompano, or palometa, occurring from Chesapeake Bay to the Caribbean and not uncommon in Florida. This has been reported in quantity from Beaufort in the past. We have reports of the presence of this fish off the Ocracoke section and off Cape Lookout from mid-June to August, but no reports of its being captured by sportsmen. All the pompanos are very popular game fishes farther south.

ATLANTIC SAILFISH

Istiophorus americanus (Cuvier & Valenciennes)

The genus *Istiophorus* is world-wide in distribution and one of our most popular offshore game fishes. It ranks as a big game fish although by no means as large or as difficult to catch as some of the others, particularly in the Atlantic where it averages smaller than in the Pacific. It has no commercial value, is not very edible, and is often thrown back when caught.

The Atlantic sailfish is present from Brazil to as far north as Woods Hole; it occurs in quantity off Florida and the Bahamas and is suspected of spawning off Miami during May and June. It is known to spawn off Port Isabel, Texas. The early stages of this fish are known and have been figured and described by Lütken and others. Like other fishes whose eggs are pelagic and therefore drift to considerable distances, spawning areas are difficult to locate as young are quite often found at considerable distance from them.

The sailfish does not seem to be plentiful off North Carolina, but neither does it seem to have been tried for very often or with any persistence. It would appear to be present in sufficient quantity to attract anglers. It is fished off Hatteras from June to October and off Morehead City and the vicinity, from July through September from ten to fifteen miles offshore. Small ones are sometimes taken in late summer in the Morehead City section. A few sailfish have been sighted within twelve miles off Wrightsville Beach, and some taken about forty miles off Southport, between September and November.

The Atlantic sailfish averages around 35 pounds with a usual topweight of 60 pounds, but the rod and reel record, taken off Miami Beach weighed 106.

TARPON

Tarpon atlanticus (Cuvier & Valenciennes)

If this very popular game fish could be persuaded to take the hook in North Carolina waters, it would undoubtedly attract many anglers to its grounds. North Carolinians are inclined to attribute its refusal of bait to inexpert angling, but the same situation is true in Bimini, B.W.I., which is a center for expert anglers. It is possible that the fish will not take bait in clear water.

The tarpon is a coastwise fish going well up into fresh water and able to stand considerable temperature variations. It occurs from Nova Scotia to Brazil and is also found in Queensland, and, in enormous numbers, off Nigeria and the Gold Coast of Africa. Concentration points are the Gulf coast of Florida, Texas, and Louisiana; the Rio Encantado, Cuba; the Pánuco River, Mexico; the Chagres River at Gatun Spillway; Lagos, Nigeria, and the mouth of the Volta River, Gold Coast, West Africa.

The fish travels in schools and there is no evidence of migration other than a spring drift northward and movement in and out of streams. It is a voracious fish, feeding on fishes and crustaceans.

Both adult and young are fished for sport; the best season for them is supposed to be at the time of the first spawning—usually April through July. Young up to 25 pounds are fished by fly casting; larger ones by still fishing or cork fishing from a small boat. Adult tarpon average between 40 and 60 pounds; the rod and reel record, taken in the Pánuco River in March, 1938, weighed 247 pounds.

Most tarpon caught off North Carolina have been netted by chance. They have been caught off Roanoke Island in September and October and sighted in the surf there in May and June. They have also been seen in the Inlet at Hatteras in the fall. In the Wilmington section, two tarpon of about 35 pounds have been caught by surf casting, and several netted. On August 1, 1927, a 57-pound tarpon was taken in surf fishing in New River Inlet. Other reports say that the fish is fairly common along the North Carolina beaches in the fall, schooling in or near the surf. Mr. Aycock Brown reports that many tarpon are caught in menhaden nets.

* SEA TROUT, ALSO CALLED GRAY TROUT AND WEAKFISH
Cynoscion regalis (Bloch & Schneider)

This game fish occurs from Florida to Massachusetts and occasionally as far north as the Gulf of Maine. It is found in large quantity in tide rips, channels, inlets and the surf almost all year from North Carolina south; north of that it is seasonal. There are big runs from May to October off Long Island and New Jersey. It is a profitable commercial catch and the object of large fisheries. Probably more than one species is found off North Carolina but the only differentiation by fishermen is between this and the spotted trout, whose winter season somewhat overlaps the tag end of the sea trout's season.

The fish is known to spawn in Chesapeake Bay.

The average size of sea trout is from two to five pounds, but it often runs larger. The rod and reel record, taken in September, 1944, in Mullica River, New Jersey, weighed 17 pounds 8 ounces.

In the Roanoke Island section angling is best for this fish in spring and fall; April and October are the best months for it in the Morehead City section and south.

* SPOTTED TROUT, ALSO CALLED SPECKLED SEA TROUT OR SPECKLED WEAKFISH
Cynoscion nebulosus (Cuvier & Valenciennes)

This fish occurs from New York to Texas but is uncommon north of Delaware. It runs somewhat smaller than the sea trout, with which fishermen and anglers confuse it. "Sea trout" taken from September on, are apt to be this fish, although in September some of both kinds are present.

Spotted trout is commercially important from Virginia south and on the Gulf coast. It is particularly important in North Carolina in the winter months when other fishing is scarce, and is present in quantity particularly in the Beaufort section.

As with other fishes, commercial catches are often possible when angling is not. In this case, the reason is the cold: spotted trout often become numbed by cold and can be easily caught in nets, whereas they would not take bait.

BLUEFIN TUNA
Thunnus thynnus (Linnaeus)

This fish occurs all over the world, in the Atlantic and Pacific oceans and the Mediterranean and Black seas. On our Atlantic coast, its presence has been substantiated from various points between the northern Bahama Islands and Newfoundland but this does not mean that it necessarily occurs without gap along that entire coast. Concentration points are the Bimini-Cat Cay section of the Bahama Islands; New Jersey; Long Island; the Gulf of Maine; the Wedgeport–Liverpool section of Nova Scotia. It is uncommon off Florida and Bermuda and is reported as formerly common off Ocean City, Maryland, but not present there in recent years. There are two records of bluefins near Beaufort; one in 1885 and one in the early 1900's.

The prevailing impression is that the bluefins appear from somewhere south of Bimini, passing that island in great numbers and very swiftly, in May and June, and on a northbound migration which finally lands them in Nova Scotia or the southern part of Newfoundland. The fish are off New Jersey in August and September; in the Gulf of Maine from June to September, with the height of the run in July. The rod and reel record of 927 pounds was taken on August 25, 1940 in Ipswich Bay, Massachusetts. The average size of the fish varies with locality from 60 pounds to over 200.

The bluefin is known to be very dependent on temperature and salinity conditions; the run in some localities extends for some time and in others only a very short time; in some the presence of the fish is irregular and in others regular enough to warrant a profitable commercial fishery in stationary nets, as off Sicily, Sardinia, and Tunis. There are constant rumors of its presence off North Carolina, probably based on the assumption that it is migratory and must pass there. It is possible that there is no run of bluefin there at all, but that this is a case of circumscribed population units. It is also possible that the fish do pass there but too far out or too deep—or both—to be noted by fishermen or anglers.

The breeding habits of this fish have been studied on various European grounds and work on sex and growth rates has been done off Long Island.

The fish referred to in North Carolina as "school tuna" does not mean, as it does elsewhere, bluefin tuna under 60 pounds. It refers to a different genus, *Euthynnus,* which, in turn, is much confused with *Sarda sarda* and sometimes with *Auxis thazard.*

WAHOO

Acanthocybium solandri (Cuvier & Valenciennes)

This highly rated sports fish does not occur in large numbers anywhere. Its known range is from British Guiana north to Cape Hatteras. It also occurs in the Pacific where it has been taken by anglers off the Hawaiian and the Philippine Islands. During the Cuban winter, trolling for wahoo along the hundred fathom curve is a popular sport, and it is also reported off Cuba in deep cool waters in summer. The fish occurs both in open ocean and in bays and inlets, frequenting wrecks and pilings. It spawns off Cuba and is also said to spawn off Bermuda. Like the swordfish, the male and female swim together at the spawning season but not otherwise. It does not school.

The wahoo is fished off the east coast of Florida and the Bahamas from January through May. Off North Carolina, it has been taken off Hatteras from June to October and, but very rarely, off Southport in the fall.

The fish averages between 15 and 20 pounds, but many larger ones have been taken by anglers. The rod and reel record, caught in the Bahamas in April 1943, weighed 133½ pounds.

INCIDENTAL GAME FISHES

North Carolina offers a number of fishes, which, while not among the most popular or famous, are good enough fishing to provide pleasant recreation during vacations. Most of them are also taken commercially. Flounder, spot, pigfish, sheepshead, scup, and the common mullet fall into this category. The common mullet, although sometimes taken on rod and line, is not usually considered a game fish, but is very frequently used as bait. There are usually quantities of mullet in the Beaufort section in September; the season of most abundance is April to November. The flounder, of great commercial importance, is present all year although not always accessible to anglers. The sheepshead is usually taken by accident while angling for sea trout; the larger ones are found off the northern part of the coast. The spot is not usually considered a sports fish although a prize was given for a 14½ ounce spot in the 1946 tournament. It occurs in quantity in the Ocracoke section. The scup and the pigfish are usually only accidentally taken by anglers. This January (1947) we have had reports of rod and reel fishing for pigfish off Morehead City.

American anglers differ on whether or not to place any sharks in the game fish category. In other parts of the world, however, there is no doubt. The hammerhead shark, *Sphyrna zygaena* (Linnaeus) is known to occur off Beaufort. There is no rod and reel record. Other "game" sharks reported to be off the North Carolina coast are the following:

The thresher shark, *Alopias vulpinus* (Bonnaterre). The record, caught off New Zealand, weighed 922 pounds.

The tiger shark, *Galeocerdo arcticus* (Faber). The record, caught off Australia, weighed 1382 pounds.

The three sharks belonging to the mackerel shark family: the porbeagle shark, *Lamna nasus* (Bonnaterre), the record of which was caught off Florida and weighed 1009 pounds; the man-eater shark, *Carcharodon carcharias* (Linnaeus) the rod and reel record for which was caught off Australia and weighed 1919 pounds. The third shark in this group, the mackerel shark, is classified by anglers with the mako, which has been put into a separate genus by some ichthyologists. Our mackerel shark is *Isurus tigris* (Atwood). The record mako weighed 1000 pounds and was caught off New Zealand by a young flying officer in 1943. It was the first fish he had ever caught.

SUMMARY

North Carolina offers anglers good spring and fall, some summer, and a small amount of winter angling for a large number of inside, surf, inshore, and offshore fishes.

The small number of so-called big game fishes ever taken off this coast, combined with the expense and difficulties of fishing their grounds, does not warrant exploitation of these fishes, although their presence or absence could be profitably investigated by ichthyologists. On the other hand, the State has fine angling quantities and good seasons for dolphin, amberjack, cabio and sailfish, channel bass, striped bass, sea trout, and bluefish, all of which are first class game fishes, as well as many others.

Facilities in the State are excellent in standard, but lacking in number and certainty. This is particularly true of boats, the great majority of which are commercial craft used for anglers only when there is no commercial run. There is insufficient information on fishes, exact seasons, localities and quantities of non-commercial fishes, and prices.

While the profit ultimately to be derived from a long-term scientific survey of game fishes only would not balance the expense of such an enterprise, the marked absence of any coherent records and the small amount of reliable information available is a definite deterrent to prospective anglers. Even so, the general prospects of angling well warrant promotion of North Carolina's entire coast as an angling-vacation spot for a long season, from May to November, and, to some extent, as a winter resort. Recommendations follow with a view to immediate improvement of several conditions now hindering game fishing in the State.

RECOMMENDATIONS

1. A system should be devised to make angling boats available when needed. This could be done by the establishment of information pools. Charter boats, more of which are needed, might be joint purchases. Boat owners should make available printed information regarding their current prices and the types of boats they are able to supply. Standardization of prices is not recommended, due to the variance of conditions in different localities.

2. Known data on the game fishes of the coast should be accurately compiled at once into an illustrated pamphlet for laymen, to be published by an unbiased source. Failing such a source book, inaccurate statements, mistaken identifications, and unsubstantiated guesses will continue to get into rod and gun columns, club yearbooks, and other publications and from these will eventually seep into scientific publications and go down through the years as authoritative statements.

3. Collection of further data is suggested in one of the two following ways:

A. Undoubtedly the most efficient way to collect reliable data on game fishing possibilities in North Carolina would be a survey of at least three years by one or two trained men. Such investigators would travel sufficiently to keep their information up to date; when necessary they would have at their disposal boats and gear for investigation of grounds and for the accumulation of pertinent oceanographic data. At the end of the survey, time would be allowed for drawing up reports which would be widely distributed. To such reports supplements would be added from time to time. As commercial grounds are often completely unsuitable for game fishing, data taken from commercial fishery statistics are very seldom of more than the most general use to anglers. This survey would be done entirely from the point of view of angling.

B. In the absence of funds to support such work, there is an alternative which would yield some valuable if not very complete information. First, a small grant might be made to have printed and distributed a layman's pamphlet as I have mentioned above. Simultaneously record books for anglers, containing spaces for the data as on the sample sheet on page 281 could be made up and distributed to hotels, docks, restaurants and boat owners in the marine fishing areas, to be kept in their headquarters, not given to the angler. Arrangements could then be made for volunteers to pick up these data at specific times, say every four months. The records should include the individual angler's entire fishing record, not just his successful days. If such records could be systematically filed for at least three years, a fine general picture of the situation could be drawn from it. Such work

SUGGESTION FOR ANGLING RECORD BOOK

ANGLING RECORD—Kept by Pageant Inn, Manteo

Mo. Day Year	Weather	Location	Hour of catch, strike or sight or hours fished (if no catch, strike or sight)	Sighted only	Strike only	Boated	Fish	Weight	Kind of boat	Angling method	Signature or identification mark (if you do not care to sign, please use an identifying mark so that catches by the same angler may be recognized.)	Check of official recorder (please initial and date) ANGLERS: Do not write in this column.
May 15 1950	Fair, calm	Ocracoke, in inlet	3 P.M.			√	Channel bass	5 lbs.	Skiff	Trolling	J. A. Brown, Richmond, Va.	√
June 20 1950	Calm	Wreck near Hatteras Light	2:35 P.M.		√		Amberjack	? 5-6 lbs.	30′ cabin cruiser	Trolling	A B C	Aug. 1, √ 1950 B. Doe, Raleigh
June 21 1950	Unsettled	Ocracoke, inlet	2-4:15 P.M.							Still fishing	John Doe, New York City	

Above much condensed form indicates information needed; actual forms should be expanded.

would serve as further accurate source for more professional investigators as well as for the laymen for whom the first pamphlet would be a temporary source. Cooperation from clubs, and the formation of more angling clubs would greatly aid such an enterprise.

4. Competitive angling and publicity: Competitive angling, which is on the increase all over the world, is a splendid publicity method and of great help to the sport in general. It should, however, be held to the financial level of an amateur sport. If too great sums of money become involved, either in the expense of entering such tournaments or in prize money, it can become a burden to a community and a menace to the ethics of the sport. This is particularly true in North Carolina where advancement of angling as a source of profit and recreation to her people depends so largely on keeping the prices for all facilities involved below the level of adjacent coastal areas with longer seasons and already highly developed angling facilities.

5. Other recommendations suggested in the body of this text are: more bridges and fishing piers; more marking of wrecks; improvement of some of the channels and yacht basins; service stations on some of the long stretches of road in sparsely inhabited sections; improvement of inland to shore transportation, and the cooperation of anglers, angling clubs and educational institutions in furthering angling as a recreation.

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FRANCESCA LAMONTE

SELECTED BIBLIOGRAPHY

Anderson, A. W., and E. A. Power.

1949. Fishery Statistics of the United States, 1945. U. S. Fish & Wildlife Service, Statistical Digest No. 18, 1949, 372 p. (pictorial section, p. 355-372).
(*Statistics of all important commercial U. S. fishes, by species, regions, gear, etc., numbers of fishermen, common and scientific names, etc. Published annually under above title and authors from 1942* (*No. 11*), *and earlier* (*without illustrations*) *for many years annually as "Fishery Industries of the United States," by various authors, as appendices to the Annual Reports of the U. S. Commissioner of Fisheries.*)

Beebe, William.

1941. A study of young sailfish (Istiophorus). Zoologica: Scientific Contributions of the New York Zoological Society, 1941, Vol. XXVI, No. 20. p. 209-227, 9 figs., 5 pls.

Bigelow, Henry B., and William W. Welsh.

1925. Fishes of the Gulf of Maine. Bull. U. S. Bur. Fish., Vol. XL, Part I, 1924 (1925), 567 p., 278 figs. (Doc. 965).

Breder, C. M., Jr.

1929. Field Book of Marine Fishes of the Atlantic Coast. New York: G. P. Putnam's Sons, 1929, 332 p., 403 figs., 8 color pls.

1944. Material for the study of the life history of *Tarpon atlanticus*. Zoologica: Scientific Contributions of the New York Zoological Society, Vol. XXIX, Part 4, 1944, No. 19, p. 217-252, 9 figs.

Brown, H. H.

1945?. The fisheries of the Windward and Leeward Islands. Development and Welfare in the West Indies, undated (1945?), Bull. 20, 97 p., tables, maps.

Caine, L. S.

1935. Game Fish of the South. Boston: Houghton Mifflin Company, 1935, 259 p., figs.

Camp, Raymond R.

1939. All Seasons Afield with Rod and Gun. New York: Whittlesey House, 1939, 352 p., figs., photos.

Carson, Rachel.

1944. Fish and shellfish of the South Atlantic and Gulf coasts. U. S. Dept. of the Interior, Office of the Coordinator of Fisheries. Conservation Bull. 37, 1944, 45 p., 21 figs.

Earle, Swepson.

1940. The white marlin fishery of Ocean City, Maryland. U. S. Bur. Fish., Spec. Rept., 1940, 15 p., 4 figs., maps.

Evermann, Barton Warren, and Millard Caleb Marsh.

1902. The fisheries of Porto Rico. Bull. U. S. Fish Comm., Vol. XX, Part I, 1900 (1902), p. 49-350, 112 figs., 49 color plates.

Farrington, S. Kip, Jr.

1943. Salt water fishing from Maine to Cape Hatteras, North Carolina. Yearbook International Game Fish Association, New York, 1943, p. 90-93, 5 photos.

Ginsberg, Isaac.

1929. Review of the weakfishes (*Cynoscion*) of the Atlantic and Gulf coasts of the United States with a description of a new species. Bull. U. S. Bur. Fish., Vol. XLV, 1929 (1930), p. 71-85, 7 figs. (Doc. 1058, 1929).

Heilner, Van Campen.

1937. Salt Water Fishing. Philadelphia: The Penn Publishing Company, 1937, 450 p., pls., photos., figs.

Hildebrand, Samuel F., and Louella E. Cable.

1930. Development and life history of fourteen teleostean fishes at Beaufort, North Carolina. Bull. U. S. Bur. Fish., Vol. XLVI, 1930 (1931), p. 383-488, 101 figs. (Doc. 1093, 1930).

1934. Reproduction and development of whitings or kingfishes, drums, spot, croaker, and weakfishes or sea trout, family Sciaenidae, of the Atlantic coast of the United States. Bull. U. S. Bur. Fish., Vol. XLVIII, 1940, p. 41-117, 44 figs. (Bull. No. 16, 1934).

1938. Further notes on the development and life history of some teleosts at Beaufort, North Carolina. Bull. U. S. Bur. Fish., Vol. XLVIII, 1940, No. 24, p. 505-642, 159 figs. (Bull. No. 24, 1938).

Hildebrand, Samuel F., and William C. Schroeder.

1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish., Vol. XLIII, Pt. I, 1927 (1928), 366 p., 211 figs. (Doc. 1021).

International Game Fish Association.

1945. Organization and rules of the International Game Fish Association, New York, 1945.

Iselin, C. O'D.

1936. A study of the circulation of the western North Atlantic. Papers in physical oceanography and meteorology, published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institution (in continuation of Mass. Inst. Tech., Meteorological papers), Vol. IV, 1936, No. 4, 101 p., 58 figs.

Kaplan, M. N.

1937. Big Game Anglers' Paradise. New York: Liveright Publishing Corporation, 1937, 400 p., photos., figs.

LaMonte, Francesca.

1945. North American Game Fishes. New York: Doubleday, Doran & Company. 1945, 202 p., 72 plates, figs.

1944. Note on breeding grounds of blue marlin and swordfish off Cuba. Copeia, 1944, No. 4, p. 258.

LaMonte, Francesca, and D. E. Marcy.

1941. Swordfish, sailfish, marlin and spearfish. Ichthyological Contributions of the International Game Fish Association, Vol. 1, 1941, No. 2, 24 p., 4 pls., 1 fig.

Longley, W. H. [edited and completed by Samuel F. Hildebrand.]

1941. Systematic Catalogue of the Fishes of Tortugas, Florida. Carnegie Institution of Washington. Papers from Tortugas Laboratory, Vol. XXXIV, Publ. 535, 1941, 331 p., 33 photos., pls.

Lütken, C. F.

1880. Spolia Atlantica. Bidrag til Kundskab om Formforandringer hos Fiske under deres Væxt og Udvikling særligt hos nogle af Atlanterhavets Høsjøfiske. Det Kongelige Danske Videnskabernes Selskabs Skrifter, Kjøbenhavn, 1880, 5te Række, Naturvidenskabelig og Mathematisk Afdeling, 12te Bind, p. 413-610, 5 plates. (French summary incomplete; Pl. III incorrectly referred to as Pl. IV).

Munro, Ian S. R.

1943. Revision of Australian species of *Scomberomorus*. Memoirs of the Queensland Museum, Vol. XII, 1943, Pt. II, p. 65-95, 8 pls., 4 figs.

Nichols, J. T., and C. M. Breder, Jr.

1926. The marine fishes of New York and southern New England. Zoologica: Scientific Contributions of the New York Zoological Society, Vol. IX, 1926, No. 1, 192 p., figs.

Nichols, J. T., and Francesca LaMonte.

1935. How many marlins are there? Natural History: Journal of The American Museum of Natural History, Vol. XXXVI, 1935, p. 327-330, 5 photos.

Pearson, John C.

1929. Natural history and conservation of the redfish and other commercial sciaenids on the Texas coast. Bull. U. S. Bur. Fish., Vol. XLIV, 1928 (1929), p. 129-214, 44 figs. (Doc. 1046, 1929.)

1931. Sport fishing in Chesapeake Bay. U. S. Bur. Fish., Fishery Circular No. 1, 1931, 19 p., 11 figs.

1932. Winter trawl fishery off the Virginia and North Carolina coasts. U. S. Bur. Fish., Investigational Report No. 10, Vol. 1, 1932, 31 p.

Sanzo, L.

1929. Contributo alla conoscenza dello sviluppo nei Carancidi: *Seriola dumerili* Risso. Bollettino di Zoologia, Anno I, 1929, No. 1, p. 33-34.

1933. Uova, larve e stadi giovanili di *Seriola dumerili* Risso. Memoria R. Comitato Talassografico Italiano, Venezia, 1933, 12 p., pls., 12 figs.

Schroeder, W. C.

1924. Fisheries of Key West and the clam industry of southern Florida. Appendix XII, Rept. U. S. Comm'r. Fish., 1923 (1924), 74 p., 29 figs. (Doc. 962, 1924.)

Smith, Hugh M.

1907. The fishes of North Carolina. North Carolina Geol. and Econ. Surv., 1907, Vol. II, 449 p., 188 figs., 21 pls. Raleigh.

Truitt, R. V.

Sport fishing in Maryland. The Conservation Department of Maryland, 16 p., photos. (not dated).

Walford, Lionel A.

1937. Marine game fishes of the Pacific Coast from Alaska to the Equator. Berkeley, The University of California Press (A contribution from the Santa Barbara Museum), 205 p., figs., 69 pls.

Westman, J. R., and W. C. Neville.

1942. The tuna fishery of Long Island, New York. A survey conducted by the United States Department of the Interior, Fish & Wildlife Service, in cooperation with the County Executive and the Board of Supervisors, Nassau County, L. I., New York. Issued May, 1942, 31 p., 12 figs.

Whiteleather, R. T., and H. H. Brown.
1945. An experimental fishery survey in Trinidad, Tobago and British Guiana with recommended improvements in methods and gear. Anglo-American Caribbean Commission, Washington, 1945, 130 p., 42 figs.

Wylie, Philip.
1943. Florida fishing. New York: Yearbook International Game Fish Association, 1943, p. 94-96.

PART III

ECONOMICS OF THE FISHERIES OF NORTH CAROLINA

BY Harden F. Taylor

CONTENTS

INTRODUCTION

It became clear early in this inquiry that any treatment of the economics of the fisheries of North Carolina, a small part of those of the whole country, was bound to be superficial and of little value. Viewed in small scale, locally, and for short periods of time, and dominated by the uncertainties of weather, erratic markets, and fisherman's luck, the fisheries appear to be capricious and unpredictable. Yet when viewed statistically in larger perspective of time and place, regularities or patterns of economic behavior might be expected to appear, as they do in such other fields as insurance, trade and commerce, wherein "large scale order rests on small scale disorder."

Public thinking and official policy-making in the fisheries are usually based on the assumption that purely biological factors of abundance of fish, or even of particular species of fish, are the main if not the only determinant of the welfare of the fishing community. Since the sole motive of all persons engaged in the commercial fisheries is self-interest in making a living and making money, and the magnitude of production and sales is determined by how much fish the public will buy, of what kind and at what price, and since demand by consumers, expressed by prices, must inevitably react on fishermen in their choices of what to catch, or try to catch, when and where, it seems obvious that economic determinants have an importance and deserve consideration at least equal to those of biological nature. The two sets of determinants, economic and biological, act, react, and interact upon each other so as to set the pattern of the whole, and a picture based solely on biological considerations is bound to be one-sided and often erroneous.

As example, the decrease in abundance of Great Lakes fishes as indicated by the statistics of catch of all and of particular fishes over a series of years has created the impression in the United States and Canada that the Great Lakes fisheries are in a serious state of depletion and threaten to become worse, or exhausted, and to somebody's disadvantage, if measures of control are not put into effect—an impression which seems well justified if biological factors alone are considered and such economic factors as money values, cost of catching, prices, numbers of fishermen engaged, etc., are disregarded.

Quite a different picture is presented when economic factors are considered. Our analysis of the data indicates, to the extent that the primary data used can be relied upon, the following facts: that while the total catch by United States fisheries in the Lakes is somewhat (15 per cent) less now (avg. 1921-1940) than formerly (avg. 1887-1908), the number of fishermen declined less than it did in the whole United States; that prices advanced to such an extent that the percentage increase in gross money value of food fish was a third greater in the Lakes than it was in the whole United States; that the gross value per fisherman increased by a percentage greater than that of the whole, or of any other statistical region, of the United States; and that per fisherman the exchange value of fish for other goods increased in the Lakes region more than it did anywhere else in the country. Scarcity in this case does not appear to have been a calamity to the fisherman. Under the operation of purely automatic economic forces the Lakes fisheries adjusted and regulated themselves in these and several other respects and had far-reaching reaction in stimulating the production of other fishes both in salt water of both oceans and fresh water as far away as Lake Okeechobee, Florida, as will be seen in the details of this report.

What is needed is a clear understanding of the pattern of economic behavior generally which must be sought in the study of the fisheries of the whole country and even of foreign countries. Such a study should try to identify and measure the factors which fix the magnitude and determine the internal and external competitive position of the fisheries as a source of wealth and livelihood; it should try to discover the characteristics of the market and their influence on the many local fisheries, and reveal sensitive points at which action can bring about improvement. Above all, it should try to find general and persistent regularities of behavior which will make it possible to foresee in some measure the economic as well as biological effects of whatever actions are taken in the making of public policy or in private business.

Strange as it may seem, the literature appears to contain few if any such studies of fisheries economics. The Reports and Bulletins of the U. S. Fish Commission founded in 1871, and its successor agencies, the Bureau of Fisheries and the Fish & Wildlife Service, contain much useful descriptive material on the catching, preparation, and marketing of fishery products, and also the main body of available statistics; but no economic studies of the kind above referred to are found therein or, so far as we know, anywhere else.

Accordingly we have felt it advisable, at the risk of appearing to go far beyond the terms of our undertaking in this Survey of the Marine Fisheries of North Carolina, to make a beginning of such a study and to go as far with it as our resources permit, and in the light of our findings to present what economic data we have been able to assemble on North Carolina fisheries.

This study of general fishery economics is, of course, based mostly on the United States fisheries, with corroboration of some points by data on certain foreign countries, and with emphasis on the smaller and more localized fisheries. It consists of two main divisions, the first devoted to the description, mostly qualitative, of the economic nature and characteristics of the fisheries; the second, to a quantitative consideration of the subject with somewhat special emphasis on the oyster and the shrimp because of their local importance to North Carolina. The qualitative division is based largely on the writer's personal observations, experience, and general reading.

The quantitative division on fish production and values of the United States, both state and national, is based on the statistical data of the U. S. Fish & Wildlife Service, and its predecessor agencies. This is done in order to obtain the maximum of consistency, comparability, and uniformity. For foreign countries, the data are taken from official sources. General economic data, not on fisheries, are derived from standard sources, all of which are cited.

The Government record of fisheries statistics is indispensable, of course, but much more could be desired of it, both qualitative and quantitative. It is perhaps idle now to say that data collected without specific purpose in view, as they were, are almost certain to omit facts that the analyst will need to answer critical questions, and that economic analysis should run concurrently with collection of data. It is not now possible to separate seed oysters from market oysters prior to 1902, nor to arrive at the total production and value of particular fishes that were included in "all other" in some regions, and shown separately in others half a century ago; nor is it possible to convert menhaden oil and scrap to fresh menhaden with any accuracy. We must make the most of the record as it stands.

The statistical record is defective principally in its failure in many cases to explain sufficiently what was done and to make clear exactly what the figures represent, and in the discontinuity of the record. Some of the doubts arising from insufficient explanation were resolved by correspondence with the officers of the Fish & Wildlife Service, who upon reexamination of the record were able to supply some of the missing information. Especial thanks are due to Mr. Andrew W. Anderson, Chief of the Division of Commercial Fisheries, Mr. Fred F. Johnson, and Mr. E. A. Power, for their generous and painstaking compliance with many requests for assistance of this and many other kinds.

The Government data are all annual totals. It is therefore not possible to analyze the short-term behavior of production and prices, and, from the nature of the canvasses as we understand them, it appears that values were oftener estimates than actual records of sales by fishermen and dealers; prices shown herein are these values, whatever they are, divided by the reported quantities.

To overcome the defect of discontinuity of the record it was necessary to fill in the years of missing statistics by interpolation as the only means of arriving at a continuous series and at totals for the whole country or large parts of it. Further details of the manipulative procedure and tests of validity of what was done are given in the statistical section.

Although the actual statistical record begins in 1880 and extends to 1945, the data prior to 1887 were found to be of unsatisfactory comparability with those of subsequent years. It was decided to end the study with 1940, not only because of the impact of war-time price regulations and black markets, but also because data of a general nature for comparative purposes were obtained from the Census, the last one of which was in 1940. During the First World War the field data are too sparse to be of much use even by interpolation. It is therefore unfortunate that the economic behavior of the fisheries in the upheavals of war are not presentable. The period 1887-1940 is considered adequate to the purposes of this study in the search for the behavior pattern and determinants rather than for the appraisal of the immediate economic position of the fisheries.

Field data of North Carolina in the coastal region were collected by Mr. Josiah W. Bailey, Jr., and in the interior by Dr. C. A. Kirkpatrick; consumer market studies were made in Greensboro by Miss Margaret Edwards, Home Economics Department, The Woman's College, Greensboro, assisted by Miss Evelyn Sharpe; in Greenville by Mrs. A. E. Bloxton, East Carolina Teachers College; in Raleigh by Miss Ellen Brewer of Meredith College. Miss Mavis W. Gibbs generously cooperated with Dr. Kirkpatrick in furnishing him information on the marketing of fish in North Carolina, and Professor Dudley J. Cowden and Mr. Warren W. Webb computed the effective buying income of the coastal counties for 1939. Miss Minerva C. Billard, in addition to typing the manuscript and the voluminous statistical tables, performed much of the tedious work of their compilation and calculation and of proofreading the manuscript. To all of these grateful acknowledgment for their generous assistance is here made.

I. ECONOMIC STATUS AND STANDARD OF LIVING OF THE COASTAL REGION OF NORTH CAROLINA

Since we are especially concerned in this Survey with the economic welfare of the coastal region of North Carolina, certain quantitative data concerning the twenty-one seaboard counties have been assembled from various sources and are presented in Tables 63 to 67, Appendix. They reflect some of the economic conditions and standard of living as a background for our more detailed consideration of the fisheries.

Population. North Carolina has been for many years among the States having most rapid increase in population, by reason of its high birth rate and low death rate. The rate of increase in the 21 coastal counties has been slower in recent years than that of the State as a whole, the population being 12.4 per cent of that of the whole State in 1920, 10.8 per cent in 1930 and 10.2 per cent in 1940. From 1920 to 1940 the population of the United States increased 24.5 per cent, that of North Carolina as a whole 39.6 per cent, that of the 79 non-coastal counties 43.1 per cent, that of the 21 coastal counties increased only 14.5 per cent, and four of the coastal counties declined in population, including Hyde, which is sixth in value of fish production, while four others increased less than 10 per cent including Pamlico, which stands fourth in value of fish production. In the intervening decades, between 1920 and 1930, the population of the coastal counties increased 7.8 per cent, while that of the remaining 79 counties of the State increased 26.1 per cent, and between 1930 and 1940 the coastal counties increased 6.2 per cent, the rest of the State 13.5 per cent. These figures of population consistently indicate a general failure of the seaboard counties to hold their increment of population as does the State as a whole, and suggest a general social unattractiveness of the coastal region. This fact is especially true of some of the counties which are actually or potentially among the best for fishing operations. The rural-farm population in 1940 was 48.5 per cent of the whole population of the twenty-one counties and 10.6 per cent of the rural-farm population of the State. The density of population per square mile in 1940 in the twenty-one counties was 36.4; in the whole State, 72.7.

Agriculture. The main source of livelihood of the region is agriculture, in which the figures of comparison are more favorable to the coastal counties than are those of population. In comparison with the ratio of population of the coastal counties of around 10 per cent of that of the whole State (10.2 per cent in 1940), the number of farms is 10.3 per cent, the number of farmers and farm managers 11.3 per cent, and the gross farm income 12.9 per cent; the average size of farms is a little larger than that of the whole State (75.1 vs. 67.7 acres) and the average value per farm in all the counties is slightly more than that of the whole State; the amount of mechanization in farm autos and of trucks and tractors per 100 farms is of the same general magnitude as that of the whole State, but less than that of the whole United States, possibly by reason of the generally smaller farms and special nature of the crops (tobacco, peanuts, potatoes, etc.). The percentage of farm tenancy is about the same as that of the whole State, which is slightly more than that of the whole United States; however, North Carolina ranks thirteenth highest among the States in percentage of farms operated by tenants or thirty-fifth in percentage operated by owners. The per cent of farms mortgaged is not far from the State and national averages. Considering that the coastal counties account for their share of agricultural values in proportion to their percentage part of the whole population and rural farm population of the whole State, some deductions can be made by examining the agricultural ranking of North Carolina among the forty-eight States.

In the cash marketings of farm crops North Carolina stands third, being exceeded by California and Texas; in cash marketings of livestock it stands twenty-eighth; in the value of crops consumed at home the State stands in first position, and in the value of livestock products consumed at home it stands second among all the States. Also, in the combined value of cash marketings and home consumption of crops, North Carolina stands third, and in livestock products, twenty-second. In total value of all products, plant and animal, sold for cash and consumed at home, including Government payments, North Carolina stands thirteenth among the States (eleventh in population). In the percentage of the State total value of farm produce, both crops and livestock, consumed at home, North Carolina stands eighth in rank among the States, West Virginia being first and the southeastern cotton States as a group standing at the top. From all these points of view, North Carolina *as a State* ranks agriculturally high among all the States.

However, the States vary greatly in size and population. When, therefore, we divide the total of all annual farm values, crops and livestock, sold for cash and consumed at home, plus Government payments, by the rural-farm populations, North Carolina stands thirty-eighth among the States, with $380 per capita of rural farm population. The States with the highest percentage of home consumption are the lowest in per capita total farm income, West Virginia being forty-eighth and the southeastern cotton States occupying positions from thirty-seven to forty-seven. (Texas is thirty-fifth.) From this point of view, North Carolina, though largely agricultural, was in 1940 a relatively poor State in agricultural income, and the coastal region has its proportional share of this poor showing.

Some indication was obtained that the region buys more and produces less of its own food requirements than it needs to, in view of its own possibilities in kitchen gardens, cows, pigs, chickens, and fisheries, but we were unable to find quantitative data with which to measure this factor.

Manufacturing. The region is not considered a manufacturing region, but has in number 9.1 per cent of the State's establishments, does about 2 per cent of the business, and employs 3.8 per cent of the wage earners. Sawmilling is the chief manufacture of the region outside of New Hanover County, and menhaden oil, meal, and scrap in Carteret County.

Standard of Living. The standard of living in the coastal region, as measured by a few selected categories of material comforts, conveniences, facilities, services, and buying power, is generally somewhat below that of the remainder of the State, though the comparison is not seriously unfavorable. Outside the towns, the dwellings are mostly without conveniences of plumbing, central heating, and gas; a smaller percentage have been built since 1929, and more are in need of major repair (as of 1940) than those of the whole State. In effective buying power the coastal counties increased from 9.4 per cent of that of the whole State in 1939 to 9.6 per cent in 1944. Most of this buying power had its origin in agriculture and lumbering. Educational facilities and services are to a large extent provided by the State and cannot be used as a local criterion of comparison. The number of hospital beds (for white and colored) is slightly larger in proportion to the total of the State than is the population. Hospital facilities and public health services, however, are also regarded more as a State than a local responsibility, and were dealt with by the legislature of 1947.

Taxes. The 21 counties of the coastal region, having 10.2 per cent of the population of the State in 1940, accounted in that year for 7.24 per cent of the individual and 6.95 per cent of the domestic corporation State income tax returns, and paid 5.29 per cent of the individual and 2.77 per cent of the domestic corporation income taxes. The individual taxes paid per 100 of population in the 21 coastal counties were only 56.9 per cent of those of the State as a whole.

In these comparisons, the coastal region is set against the 100 counties of the State, including not only the 21 coastal counties themselves but the mountain counties and certain others of low economic status. If the comparison were made between the 21 coastal and the 79 non-coastal counties, the contrast would be even greater. In some of the counties, including the fishing counties of Hyde, Pamlico, Onslow, Tyrrell, and Brunswick, the revenue derived by the State from income taxes is negligible.

Fisheries. The average value of the fish production for the five-year period,

TABLE 1

Comparison of Fisheries with Agriculture, Forestry and Manufacturing in Coastal Counties

Counties	Value of fish, Average 1936 to 1940 incl. $(000)	Gross farm income 1940 $(000)	Value of lumber 1942 (est.) $(000)	Value added by mf'r 1939 $(000)	Wages paid 1939 $(000)	Effective buying income per capita 1939-40 $	Number of fishermen Average 1936-40 incl.	Number of farmers 1940	Number wage earners 1939
Carteret	913	785	207	645	244	260	2,605	538	463
Dare	297	32	...	27	15	235	771	15	26
Brunswick	172	1,229	298	949	304	205	660	1,590	531
Pamlico	145	1,163	188	37	7	203	391	736	17
Beaufort	93	4,463	1,641	966	342	285	393	3,220	650
Hyde	66	634	63	...	...	210	187	883	...
Chowan	49	1,456	261	381	179	267	156	862	368
New Hanover	47	758	66	9,121	1,775	494	415	268	2,606
Onslow	46	1,969	204	153	84	206	325	2,440	148
Bertie	39	3,470	1,380	378	212	220	69	3,430	507
Pasquotank	32	1,271	794	2,407	1,001	350	57	757	1,639
Pender	31	1,545	458	186	94	199	165	1,826	226
Currituck	25	843	87	...	...	217	156	691	...
Perquimans	18	1,139	435	364	132	232	77	1,028	230
Tyrrell	13	623	367	57	27	205	97	466	80
Washington	10	1,077	299	285	161	233	93	904	277
Craven	7	2,738	900	1,554	674	298	80	2,210	1,121
Hertford	7	2,410	389	669	307	225	39	1,956	601
Martin	6	4,261	736	1,346	474	254	101	2,360	559
Gates	2	1,255	115	29	20	211	16	1,228	42
Camden	1	781	13	...	...	219	15	583	...
Total	2,020	33,900	8,901	19,553	6,052	280	6,909	27,991	10,091

1936 to 1940, inclusive, was $2,019,632, which may be compared with farm income of $33,900,000 in 1940. The average number of fishermen was 6,909 (of whom about 1,500 were employed casually) which may be compared with 27,991 farmers and farm managers. While the region is not considered a manufacturing community, it furnished in 1939 employment to 10,131 wage earners who received $6,052,000 in wages and added a value of $19,553,000 by manufacture. Thus the fisheries employed (full or part time) 24.7 per cent as many persons, and produced 6.0 per cent as much value as agriculture, and employed 69.0 per cent as many persons as received wages in manufacturing while producing only 32.3 per cent as much in gross value as were paid in wages in manufacturing and 10.2 per cent as much as the value added by manufacture. In 1942, the 21 counties produced 317,678,000 board feet of lumber which at an estimated value of $28 per M. would amount to $8,-896,000, or 4.2 times the average value of fish production of 1936-40 (4.8 times the 1940 value, $1,865,000, Table 24).

Figures of capital investment are not available, but it is probable that the wealth produced by agriculture, forestry, and manufacture results from the employment of both labor and a substantial amount of capital, while that produced by the fisheries is mainly produced by labor. It is not possible from the data at our disposal to make a more rigorous comparison of the fisheries with agriculture, forestry, and manufacturing as sources of wealth. The cost of operations and the employment of shore labor and the amount of wages paid in the fisheries on the one hand, and the secondary sales values of fish and farm, forest, or manufactured products on the other, are not ascertainable so as to make possible an over-all comparison of values to the region with any satisfactory degree of accuracy.

Even though wealth produced locally may diffuse throughout the coastal region, it is misleading to apply the fishery figures to all the twenty-one counties, many of which are so situated that they cannot be fishing communities more than incidentally. If we set up the counties in descending order of value of fish product as they are in Table 1, the comparisons are more illuminating.

Here we see that the greater part of the value of fish production is in four counties, Carteret, Dare, Brunswick, and Pamlico. In only two of these, namely, Carteret and Dare, are the fisheries the leading source of income from natural resources or manufacturing, and only in Dare is the value of fish greater than farm income and manufacturing combined. It may be that the new income from "The Lost Colony" pageant will be an important item in Dare County, though of doubtful permanency. No figures are available for the revenue brought into the coastal counties by sports fishermen, which may be an important item in Currituck, Dare, Hyde, Carteret, and possibly Brunswick.

Recapitulation. An attempt is made in Table 2 to set up an over-all comparison of the twenty-one coastal counties. In this table the ranks of the counties in fourteen categories of measurement are arranged, those of a favorable nature in descending order, and those of an unfavorable nature (per cent of farm mortgages, of farm tenancy, of houses in need of major repair, and population per dwelling unit) in ascending order, so that "best" is No. 1 and "worst" is No. 21 in each column. Since the quantities ranked are not absolutes, but relatives, i.e., per cents and per capitas, they are not affected by size or population of counties. No attempt is made here to weight the various indices for relative importance; the averages may be distorted by the inclusion of so much data on housing and other characteristics, and the

TABLE 2

Ranking or Relative Positions in Welfare and Standard of Living of the Coastal Counties of North Carolina as of 1939-40

						All dwelling units				Occupied dwelling units						
	Average value fish 1936-40 incl.	Increase in population 1920 to 1940	Percent farms mortgaged	Percent farm tenancy	Value added by manufacture per wage earner.	Percent electric lights	Percent running water	Percent need major repairs	Percent built since 1929	Percent occupied by owner	Population per unit	Percent with radio	Effective buying income per capita * 1939-40	Retail trade per capita 1940	State income tax, individual per capita, 1940	Average rank not including fish
Carteret	1	5	2	5	8	3	3	3	5	2	6	4	6	7	7	4.7
Dare	2	7	1	1	18	4	5	7	1	1	3	2	8	8	15	5.8
Brunswick	3	11	3	3	6	15	12	10	2	3	13	18	18	15	14	10.2
Pamlico	4	16	8	4	16	10	18	4	7	4	9	21	20	20	20	12.6
Beaufort	5	9	14	9	5	6	7	15	8	10	8	9	4	4	4	8.0
Hyde	6	19	9	14	—	14	21	19	19	7	11	19	16	19	21	16.0
Chowan	7	14	21	17	9	5	6	5	17	16	10	7	5	6	5	10.2
New Hanover	8	8	16	2	1	1	1	1	6	18	1	1	1	1	1	4.2
Onslow	9	3	7	15	14	21	17	11	4	9	17	16	17	13	19	14.1
Bertie	10	13	11	20	10	11	14	12	10	19	20	13	12	12	13	13.6
Pasquotank	11	10	20	10	2	2	2	14	20	17	4	3	2	2	2	7.9
Pender	12	4	4	6	13	12	13	16	3	5	14	20	21	16	12	11.4
Currituck	13	20	5	8	—	17	16	13	15	11	2	15	14	17	17	13.1
Perquimans	14	21	15	16	11	16	9	20	21	14	7	12	10	10	11	13.8
Tyrrell	15	12	19	7	15	20	15	17	9	6	12	6	19	14	18	13.5
Washington	16	15	10	12	12	8	10	18	16	12	15	10	9	11	9	11.9
Craven	17	1	6	18	3	13	4	2	11	13	18	11	3	3	3	7.8
Hertford	18	6	18	21	7	9	8	6	13	20	19	8	11	9	6	11.3
Martin	19	2	17	19	4	7	11	9	12	21	21	14	7	5	8	11.2
Gates	20	18	13	11	17	19	20	8	18	8	16	17	15	18	10	14.9
Camden	21	17	12	13	—	18	19	21	14	15	5	5	13	21	16	14.5

* Effective buying income in 1939 per capita of 1940 population.

omission of others, such as property taxes, public debt, etc., but they probably reflect the over-all relative economic status of these counties.

The average of all the ranks for each county is shown in the last column. These averages are themselves ranked in Table 3.

TABLE 3

Comparative Welfare of Twenty-one Coastal Counties of North Carolina; Over-all and Average Rank in 14 Categories of Measurement and in Value of Fish Production

Economic welfare			Value of fish Average of 1936-1940 inclusive	
Over-all rank	County	Average rank in 14 categories	County	Rank
1	New Hanover	4.2	Carteret	1
2	Carteret	4.7	Dare	2
3	Dare	5.8	Brunswick	3
4	Craven	7.8	Pamlico	4
5	Pasquotank	7.9	Beaufort	5
6	Beaufort	8.0	Hyde	6
7	Brunswick	10.2	Chowan	7
8	Chowan	10.2	New Hanover	8
9	Martin	11.2	Onslow	9
10	Hertford	11.3	Bertie	10
11	Pender	11.4	Pasquotank	11
12	Washington	11.9	Pender	12
13	Pamlico	12.6	Currituck	13
14	Currituck	13.1	Perquimans	14
15	Tyrrell	13.5	Tyrrell	15
16	Bertie	13.6	Washington	16
17	Perquimans	13.8	Craven	17
18	Onslow	14.1	Hertford	18
19	Camden	14.5	Martin	19
20	Gates	14.9	Gates	20
21	Hyde	16.0	Camden	21

This analysis indicates that the fisheries in their present state of development serve to put Carteret and Dare counties near the top in rank in economic welfare, and to lift Pamlico slightly from a place near the bottom of the list. In commercial fisheries it appears that the counties with best access to the source are Carteret, Pamlico, Brunswick, Dare, and Onslow, while Pasquotank, Beaufort, and Craven are well situated as possible primary market centers. Considering both opportunity in geographical access to the fisheries, and need of economic betterment, Brunswick, Hyde, Onslow, and Pamlico call for especial effort to improve the fisheries.

Conclusion. The coastal region may be considered a community of mild climate and simple life, where essential physical wants are provided without great effort or hardship; the facilities in the country and seaside villages are primitive, but sufficient if wants are few and ambition is low. Judged by sophisticated standards, life might appear to be unexciting and the region unable to offer its young people generally sufficient inducement to hold them in large numbers. It is too easy to seek greener pastures elsewhere. We made no survey of social conditions. It is now fashionable to assume that crime, dereliction, juvenile delinquency and general degradation commonly go along with poverty and overcrowding, especially in large cities. In the region we are considering there is certainly no overcrowding (density of population 36.8 per sq. mi.). In some of the counties the density of population itself appears to be too low for economic vigor. There may be poverty in the sense of deficiency of cash income and subsistence farming, but apparently not to the extent of destitution, since, as has been pointed out, the natural conditions make simple subsistence relatively easy to find. If there is malnutrition it can be ascribed not to lack of food or the opportunity to obtain it, but rather to lack of interest in and knowledge of good food as the basis of health and a source of enjoyment. There is a noticeable lack of man-made beauty or signs of pride in habitation, clothes, or surroundings. We made no survey of the state of health or prevalence of disease of the inhabitants.

The region as a whole has rich natural resources in its farm land, forests, and fisheries but contents itself mainly with the production and sale of bulk commodities in agriculture and fisheries, and to some extent the first step of manufacture, as in rough sawed lumber, without pursuit of the many opportunities for further enrichment by more advanced manufacture of finished consumer goods, alertness in the adoption of the many technical improvements in the production of wealth, or even adequate exploitation of the natural resources. It can hardly be doubted that the main impediment to what we call progress is that the human qualities of creative enterprise and desire and ambition for more and better things have not had adequate stimulation. Whether the spirit of enterprise can be engendered or stimulated by action from without the region, or whether it must necessarily arise spontaneously from within, cannot be decided by any data at hand, but since it has not already spontaneously arisen to any marked extent, whatever action is undertaken must proceed in the faith that it can be engendered by some form of intervention, such as a program of scientific research and promotion.

II. ECONOMICS OF THE FISHERIES GENERALLY

General and Qualitative

PRODUCTION

The Ultimate Sources of Production of Fisheries and Agriculture. Nearly all of the food and raw materials of the earth have been derived from the 29 per cent of its surface occupied by land. Only a small amount by comparison is supplied by the remaining 71 per cent occupied by the ocean, although it contains the great bulk of the world's accessible soluble minerals, including the fertilizers on which plants and animals subsist. The fisheries deplete no natural resources, they automatically replenish themselves, and what they produce is a net return of wealth to the land from which it was originally lost. As the world's human populations continue to increase, demanding about 2½ acres of agricultural land for the support of each person and with the possibility that agricultural land may in future have to be used to grow raw materials for the manufacture of liquid fuels, the need becomes greater to determine what the resources of the sea are and how to use them.

The first fact of economic significance is that in contrast with agricultural soil a few inches thick which must be maintained, protected from erosion and fertilized,[1] the *ultimate source of the fisheries, the ocean and its content of chemical fertility and its photosynthetic production of basic vegetation, is inexhaustible* and requires no fertilization or maintenance. The sea is so vast and its water is in such continuous circulation that man can do nothing by way of addition or subtraction to affect in the slightest detectable degree the chemical fertility or the production of basic vegetation except locally and temporarily and on a very small scale. This assertion applies also, with perhaps slightly more qualification, to the large inland seas and lakes, and exception must of course be made for smaller lakes, ponds, etc. The word *inexhaustible* here does not mean that the supply of fish, even at sea, is limitless. There is undoubtedly some limit, as yet unknown, to the possible yield of fish as natural wildlife even at sea, both

1. 815,000 tons of nitrogen and 1,850,000 tons of phosphorus were used to fertilize the soil in the United States in 1948. Lodge, F. S. Fertilizers in 1947-48. Chemical and Engineering News, Vol. 26, p. 18-19, 1948.

locally and generally. Such limit as there is, is in the amount of basic vegetation that is converted into useful fishes and other animals. There is, however, no evidence that the ultimate potentials of production are affected by exploitation even if carried to the point of diminishing returns; there appears to be no reason to doubt that once the pressure of exploitation is relieved in heavily fished areas the fisheries would return to their original state.

Agriculture, the source of most of the world's food and much of its raw materials, is at its best and most efficient in the production of vegetable crops; in feeding these crops to animals and in converting them into animal protein and fat as meat, milk, and eggs, only a small percentage of the food content is recovered (in terms of calories of energy), varying from 4 to 5 per cent as beef, lamb and poultry meat, 7 per cent as eggs, 15 per cent as milk, and 20 per cent as pork. (Maynard, 1946.) In addition to this economic loss, a great deal of labor and expense is devoted to cultivating the crops and feeding and tending animals.

The fisheries are at their best in the production of animal proteins and fats, the most expensive and most needed classes of food. Nearly all the vegetation in the sea and larger lakes is microscopic and not now directly useful to man; it must be transformed into animals large enough to be useful; in this transformation (often in several steps) there are also large losses as yet not accurately known, but apparently smaller at each step than those in land animals.[2] Whatever may be the biological efficiency or inefficiency in the production of aquatic vegetation and its transformation into animal substance as fish, it may be disregarded for our purposes here since it involves no labor or expense; from the economic point of view all the factors of production of the fisheries are provided by nature; we need only harvest the crop.

Comparative Costs of Fishery and Agricultural Products. We have only fragmentary data for direct comparison of the over-all costs of production of meat and fish. In order that a comparison can be made, we assume that first selling prices are comparably related to costs of production in the two classes of products. Table 4 shows, for the United States in 1938-39-40, the primary prices of fish and domestic animals.

The National Research Council[3] estimated the cost of production in man-years for the lowest cost domestic animal food, i.e., growing corn and feeding pigs in the most productive regions. The figures show 50,000 pounds of pigs on the hoof, or 32,600 pounds of edible pork and lard per man-year. The exact figures for the most productive fisheries (North Atlantic

2. For critical exposition and review of literature on efficiency of food conversion in fishes, see Lindeman (1942), and Ricker (1946).

3. Unpublished MS. See Food & Agriculture Organization, (1945).

TABLE 4

Average Prices in Cents per Pound of Fish (Total U. S. Production) at Ports of Landing and of Domestic Animals at Local Markets in the United States, 1938-39-40

YEAR	FISH *			ANIMALS †						
	Fin	Shell ‡	All ‡	Beef Cattle	Calves, Veal	Sheep	Lambs	Hogs	Chicken	Eggs
1938	1.78	5.72	2.20	6.54	7.90	3.58	7.05	7.74	—	12.9
1939	1.80	5.54	2.17	7.14	8.40	3.90	7.78	6.23	13.5	11.8
1940	2.00	5.98	2.44	7.55	8.86	3.95	8.10	5.39	13.3	11.8

Sources:
* Calculated from statistical reports U. S. Bureau of Fisheries and Fish & Wildlife Service.
† Statistical Abstract of the United States, No. 66, 1944-45, Tables 727 and 740.
‡ Oysters, clams, and scallops included in this column are net meats exclusive of shells.

and Alaska herring, menhaden, and California pilchard) are not available, but the estimate was made of 500,000 pounds of pilchard per man-year, or 10 times the yield of the corn-pig combination (in the period 1940-41). A more exact comparison can be made with the somewhat more costly (but still very efficient) New England trawler fishery for cod, haddock, flounder, etc., in which a trawler with 20 men in crew produces 4 million pounds whole fish or 200,000 pounds per man-year—four times the yield of pigs. At 42 per cent yield of edible portions from the whole fish, the produce would be 84,000 pounds per man-year, or 2.57 times the production of edible pork and fat in pigs, which ratio is about the same as that of the base prices. This comparison is superficial, since it takes no account of capital investment or supplies and services purchased by either farmers or fishermen. Certainly agricultural livestock production has nothing to approach the low cost of the 5½ billion pounds of herring, pilchard, and menhaden valued at ½ cent per pound in the three years, 1938-39-40 combined.

Even though the comparisons now possible are superficial, and more study is needed, the differences are so great that there can be no doubt that the *bulk fisheries yield food values in protein and fat at far lower cost at the point of production than that of land animals.*

In the search for cheap sources of food protein and fat, the cultivation of yeast has been proposed and to some extent practiced. A recent report[4] on conversion by yeast of sugars prepared from by-product or waste wood cellulose to protein indicated a yield of about 25 per cent, as compared with about 5 per cent if the same sugar is fed to pigs. In order to do even this, nitrogen, phosphorus, and potassium had to be added and "assuming

4. Chemical and Engineering News, Staff Report, "Yeast Hailed as Aid in World Food Supply Problem," Vol. 26, p. 3487, Nov. 22, 1948.

no charge for the by-product wood sugar other than preparation expenses, raw materials and power costs for wood yeast were estimated . . . at about 1.5 cents per pound. Plant, labor and overhead costs would be added to this figure depending upon the type of installation." Even this hoped-for source of food does not compare with fish in edible value and cost. Sixteen countries of Northern Europe in 1938 produced 3,580,000,000 pounds of herring which were sold in the markets at average price equivalent to 1.02 cents per pound.

In nutritive value fish proteins and fats can be taken as approximately equal to those of domestic animals; fish generally are at least equal or perhaps superior to land animals in content of vitamins and calcium, and certainly superior in "trace" elements, iodine, copper, manganese, fluorine, and several others, but inferior in fats and higher in water content.[5] It can scarcely be doubted that fish contain all the ten essential amino acids, those which contain sulphur, viz., cystine and methionine, being especially noteworthy. Recent works which we cannot review here indicate that fish flesh is of high biological value as food, and that *from the point of view of national or world nutrition fish could serve as the equivalent, in every way, of meat.*

Earning Power of the Fisheries. With all the advantages of indestructible source and fundamentally lower cost, *fishing does not have the reputation of being a very profitable business or the source of large fortunes for individual persons;* even moderate fortunes are few and generally made by dealing in rather than catching fish, and the industry remains small. Such wealth as the fisheries produce is mostly diffused as livelihood for the fishermen, dealers, and workers in coastal communities and as a valuable food for the whole population. Since the fisheries do not offer much opportunity for ready profit they have never been attractive to large amounts of venture capital and the enterprise, research, and inventiveness that go with venture capital on a large scale. They are therefore a relatively backward industry. The explanation for the low earning power of the fishing business is to be found not in one but in many of its industrial characteristics, which are of the nature of handicaps at the source and throughout the distributive mechanism.

Fisheries an Extractive Commodity Industry. The fisheries are, along with agriculture, forestry, and mining, an extractive commodity industry. Manufacturing industries generally have protections of various kinds which limit competition, such as patents, secret processes, well known brands and

5. For data on food values of fish, see Atwater, (1892); Clark and Almy, (1918) *; Dill, (1921); Manning, (1931) *; McCance and Shipp, (1933) *; Taylor, (1932) *; U. S. Bureau of Fisheries (several authors) (1926) * (Those marked * contain bibliographies and further citations of literature).

trade-marks, public acceptance promoted by advertising, ownership of sources of materials, easy accessibility of capital and credit, and numerous others, which make it difficult for newcomers to establish effective competition.

The extractive industries generally have fewer protections; they extract the products of nature from the earth, soil, and water; the products are usually not identified with any particular producer, are sold in bulk with little or no advertising or special good will, and without benefit of patents, brands and trade-marks. Generally, one man's produce of a given grade is as good as another's; the quantity produced is in equilibrium with demand at prices, which yield small margins of profit, if any, per unit—often no more than a wage for those engaged.

Yet in all the three extractive industries other than fisheries there is at least the protective advantage of private ownership of the sources. Property rights in farms, forest lands, and mines are widely respected and protected from trespass by public authority. The requirement of an amount of capital at least equal to the value of the land is a further limitation on the amount of competition, which makes possible a profit on capital investment.

Fishery Sources not Privately Owned. The sources of fish are not privately owned or controlled but, subject to public regulation, are free for all with a few exceptions where, as in leased oyster bottoms, the lessee's rights are often little respected and public authority often fails to protect them adequately. The compensation of labor in fishing is generally not wages but a share in the catch. *The main characteristic which distinguishes fishing from all other producing industries, both manufacturing and extractive, is its communistic nature, that is, the common- or non-ownership of the source and a sharing of the catch.*

The effects of this determinant run through the entire structure of the fishing industry. We deal here briefly with the more important of them in the catching of fish.

a. *Minimal Requirement of Capital. Capital investment corresponding to the ownership of agricultural land is not required in the fisheries.* The fisherman is not tied by investment in, ownership of, and residence on, the ultimate source of his product as the farmer is tied to his land. Where the farmer is under practical necessity to plant his acres regardless of prospects for a slow-growing annual crop which must be planned long in advance of the market, the fisherman with relatively small investment in movable boats and gear is free to make quick decisions to fish more or less or not at all where he is, or to go elsewhere. He is also free to make quick changes in tools and methods and to seek different fishes. Fisheries production is therefore highly mobile and elastic in contrast with the rigidity of agriculture. As a consequence of this fact, *the fisheries are highly sensitive and quickly* *responsive to the forces of supply and demand,* inflation and deflation, as will be seen in the Section on quantitative economics.

b. *Free Enterprise and Unlimited Competition.* Most fishing operations requiring little of capital, skill, or experience are to a large extent the enterprise of individuals or very small groups of people who are free to go fishing. The fisheries therefore attract as many fishermen as can economically survive, and competition is at the maximum. A profit to fishermen may be realized from an occasional coincidence of a number of favorable circumstances that give the fishermen a greater return than wages. Such a coincidence occurred in the late World War II, when the scarcity of meat caused a sudden demand for fish which could not be met with the number of fishing boats available, the building of additional boats was restricted, and fishermen were drafted into the armed services. Prices rose sharply before OPA could apply controls and fishermen profited handsomely, i.e., their income was temporarily far in excess of prevailing wages of skilled labor. This condition, though without price control, continues to some extent in the postwar period because of the demand for all foods for export. In normal times, when competitive forces are free and in equilibrium, the rewards to the fishermen (the catch or a share in it) have some of the characteristics of wages, but, unlike wages they are not measured alone by the time or effort expended but in large part by chance both in catching and in the state of the market.

c. *Restrictive Legislation.* Until recent years public interest in the United States has not concerned itself greatly in dictating the use of farm, forest, or mineral lands. It has rather promoted and assisted at public expense the exploitation of them as basic sources of wealth, and while the more recent public policies in agriculture are somewhat concerned with soil conservation, their general design is to make the land and farm labor more productive of wealth and to promote the economic welfare of farmers. The fisheries, however, being public, are in the circumstances above described the subject of rivalries, fears, and jealousies which give rise to the belief, deeply and historically implanted in the public mind and not minimized by political interest and the demands of sportsmen, that the fisheries are to be regarded less as a source of wealth to be promoted than a limited natural resource in danger of being exhausted or "depleted." The fisheries are therefore the subject of all manner of restrictive legislation, much of which is illogical and contradictory, and which enforces inefficiency and generally interferes with the free play of economic forces to the disadvantage of the commercial fisheries in competition with agriculture.

Fisheries literature from the earliest times is replete with recorded beliefs of which hundreds could be quoted that (1) the yield of the fisheries is declining; (2) the declines are caused by excessive fishing or by destructive methods, and at the wrong times and places; (3) legislation would halt the declines and restore productivity. For a time (about 1872 to 1915) there was also great confidence in the efficacy of fish culture.

In Massachusetts 359 legislative acts were passed between 1623 and 1857 involving directly the protection of food fishes.[6] Running throughout the Reports (from 1872) and Bulletins (from 1881) of the U. S. Fish Commission is a continuous stream of alarms at the diminution and even "approaching exhaustion" that threatened the fisheries, and every improvement and innovation of more efficient methods of capture (trawl lines in New England, pound nets, use of purse seine for food fish, paranzella net in California, beam- and later otter-trawl, etc.) were met with opposition, often violent, much of which expressed itself in prohibitory laws.

Implicit in the early literature is the belief that the amount of fish available is the sole determinant of the number and welfare of the fishermen, and the belief that fishermen can and will continue to exploit to exhaustion a fishery after it has reached a point of unprofitable yield. There is apparently no thought of how prices would behave in the event of a scarcity of fish in general or of particular species. While some skepticism was occasionally expressed in legislative hearings, the consensus of general and official opinion from 1872 to 1900 was that to perpetuate the fisheries there were needed more restrictive legislation and extensive fish culture by hatching eggs. A great program of hatching was carried out over the succeeding fifty or sixty years (from the 1870's), but hatching seems now fairly well discredited except for stocking lakes, streams, and ponds with game fishes. While some of the more vulnerable anadromous species have indeed declined in abundance notwithstanding both hatching and restrictive measures (their habitats in the fresh water streams having been made largely unsuitable), the sea fisheries have continued to increase in yield. The catch even of the Great Lakes fisheries was greater in 1940, 1945, and 1946 than it was in 1879; New England fisheries have doubled, as have those of the old Atlantic-Gulf fishery regions as a whole.

It is not possible to determine how the tangle of restrictive legislation has affected the yield of the fisheries, whether or not it has, in fact, preserved the supply from "depletion," or whether it has helped to keep the fisheries industry small by keeping its costs unnecessarily high. In any event the demand for laws (originating to some extent among the fishermen themselves) continues. We have made no survey of legislation in the several States. The commercial fisheries regulations of North Carolina (1948) (apparently not including the basic law), contain, on casual count, 148 prohibitions. Instead of permitting the fisherman to sell his produce, whatever it is, for the best price obtainable, and the market to say, through price,

6. Rept. U. S. Fish Comm., Part II, for 1872-73, p. 20.

for what purpose the fish is most needed, "food" fish cannot lawfully be caught, bought, sold, or possessed for any purpose other than human consumption, nor can food fish be caught by the purse seine (one of the most efficient implements); California limits the percentage of sardine catch that can be manufactured into fish meal and oil; trawlers are (or were, pre-war) limited, as being "too destructive," to four in Nova Scotia, one in Newfoundland, and none in Norway; power dredges for oysters were forbidden in North Carolina until recently; there are many restrictions in all the fishing States applying to kind, size, mode, and place of operation of nets, traps, purse seines, etc., prohibitions of night and Sunday fishing, regardless of the natural movements of fish, size limits, closed days and seasons, limits on the amount of catch, hindrances to commerce into and out of States, prohibitions of export of seed oysters, and a great number of others.

The commercial fisheries are also generally opposed in legislation by anglers and sportsmen. The commercial fisheries are concerned with what they can take out of the water; the sportsman is more concerned with maintaining a dense population of fish in the water so as to increase his chance of catching something; the sportsman is interested only in "game" fishes, i.e., the predators or killers, which, from the point of view of biological efficiency of aquatic life as a whole, might in some cases better be exterminated than conserved if it is within our power to do either.

Some public supervision of the fisheries in public waters is doubtless necessary, certainly more than is necessary for operations on privately owned farms. It is our purpose here only to point out that the existence of unnecessary and hampering legislation, whatever its origin or motive, is, to the extent to which it is enforced, an economic factor which must be taken seriously into account. Regulatory measures, necessary or not, which forbid the use of efficient methods and compel the employment of excessive labor for a given amount of production merely suppress the utilization of aquatic resources. However, human nature being what it is, rational and scientific legislation is hardly to be expected in a resource which is not subject to private ownership.

Technical and Industrial Progress of Fisheries and Agriculture. The increase in efficiency of agricultural production of food and raw materials in the United States is briefly summarized by Cooper, Barton, and Brodell (1947) from the summary abstract of which a quotation will here suffice:

> In all farm production, each farm worker in wartime in 1945 produced enough agricultural products to support himself and more than 13 others, whereas in 1920 one farm worker had supported himself and 9 other persons and in 1820, himself and only a little more than 3 other persons.[7]

7. Call (1929) points out that in colonial times 95 per cent of all producers were farmers, and that in the first census (1790) 96 per cent of the population was rural (places of 2500 or fewer).

Each man-hour of farm labor meant 44 per cent more gross production in 1945 than it did in 1917-21. Half of these savings in hours per unit of product resulted from mechanization. Other technological developments, primarily increases in yields of crops and livestock, were responsible for the other half.

Change in pattern of mechanization has been outstanding. Farm horses and mules have been rapidly replaced by tractors, trucks and automobiles during the last third of a century. Combines, tractor-plows, tractor-cultivators, mechanical corn-pickers, milking machines and other modern farming equipment are continuing to replace horse-drawn equipment and hand work. A modern tractor and its associated equipment now saves 850 hours of man labor compared with the time required with the animal power and equipment used a generation ago.

Thirty per cent of the increase in food supplies for feeding an increasing population from 1920 to 1942 came from acreages released by the decline in horses and mules; 70 per cent came from increased crop and livestock yields and from decreased exports. Crop production per acre has increased about one-fourth, and livestock production per unit of breeding stock has increased about one-third during the last quarter century. But crop averages in 1944 were about the same as the 1917-21 average.

These improvements have been effected by a great variety of scientific advances in addition to mechanization, such as those of soil conservation and management, genetics, acclimatization of species, combating enemies and pests, nutrition of livestock, incubation of eggs and battery production of poultry, and preservation of produce. Agricultural colleges, government agencies, and industry have all contributed to these advances through scientific research and technical improvements, and have disseminated widely a knowledge of agricultural science.

While the fisheries have made progress, too, the improvement is not spectacular. In terms of man-power, agriculture has in the past fifty years met more abundantly the needs of a rapidly growing population with nearly the same number (–7.8 per cent) of persons in the labor force.[8] In the fisheries, the catch of all fishery products per fisherman for most of the United States about tripled since 1890, but with a *decrease* of about 30 per cent in the number of fishermen supported by fishing. (See Table 39, Appendix.)

The larger part of the improvements in the fisheries industries has been on land in processing, transporting, and marketing. In the *production* of fish, while the over-all yield per unit of man power has increased, adequate study would probably show (if the historical data were adequate) that the improvement has not been general but to a large extent in the exploitation

8. In 1890, agricultural labor force, 9,938,373, population 62,947,714; 1940, agricultural labor force, 9,162,547, population, 131,669,275. Cooper, Barton, and Brodell, work cited, p. 4.

of a few very abundant species such as menhaden and pilchard, with mass-methods of capture requiring few men.

In the catching of fish, however, some improvements have been made; steam and diesel power have replaced sail, ice has replaced salt (with a saving of man power at sea), and the otter trawl introduced in 1905, and the V. D. modification in the '30's, have increased the efficiency, in terms of man power, of the ground or bottom fishery in the North Atlantic and practically created the shrimp fishery of the South Atlantic and Gulf (after 1908). The fathometer has aided the finding of fish, radio communication has improved navigation and marketing, and some experimental work has been done on the finding of fish with the aid of sonic echoes. With the decline of hook and line fishing, the use of man power to produce bait has greatly decreased.

These improvements, however, are not what they might be. The capture of fish has had little attention from trained engineers and scientists. A perusal of *History and Methods of the Fisheries* (Goode et al., 1887, Sec. V., Plates) reveals that almost all the methods then employed are still in use now, with little change.

Nets are still mere physical barriers or sieves made of vegetable fibres such as have been in use for hundreds or perhaps thousands of years, and depend on overtaking the fish by chance, as in trawling and seining, or on the fish's wandering unawares into a trap or accidentally encountering a gill net or biting a baited hook. Little exploration has been made of the possibilities of the new highly resistant plastic materials, some of which are transparent (nylon, vinylite, cellulose, acetate, etc.), as fibers or sheets from which nets or other barriers might be made. Nor has extensive or thorough study been made of the sense-reactions and behavior of fishes; nor anything more than casual or occasional scientific attempt made to take advantage of them as positive means of compelling or directing the mass movement of fish into capture, such as submarine lights and lures, chemical attractants, under-water sound waves and vibrations, electric fields (which numerous fishes themselves use both offensively and defensively) to shock, drive, or kill them; nor any biological studies of the habits and behavior of fishes with the specific view to devising better ways of following, finding, and catching them. Indeed the observation could be made with some plausibility that the use of such improvements if made would be forbidden by law or labor unions so that there is a general lack of confidence on the part of inventors that their efforts would be fairly rewarded even if successful.[9]

9. Since the above was written, nylon gill nets have come into use, furnishing a typical example, as indicated by the following news item from the New York Herald Tribune, August 16, 1949: "Alarm. Fishermen continue to be impressed and supervisory authorities are reported to be worried about the superior catching qualities of the new nylon nets, marketed under the name

Technical methods of handling the catch on boats are generally inadequate for products as delicate as fish are. As now caught, fish usually die in a state of extreme fatigue resulting from the struggle in a net or on a hook and their flesh is therefore acid (which is known to hasten deterioration); good sanitation, cleanliness and care of the fish are not practiced as carefully as they should be; pitchforks are still used for handling fresh fish in New England trawlers, and general rough handling of fish aboard vessels results often in serious damage and loss of weight by shrinkage, so that a considerable part of what is caught is so inferior as to injure the standing of fish in public esteem, rather than to promote it. Colleges or other institutions of instruction and research in the fisheries are exceedingly few.

These are all evidences of an unprogressive industry which has been deficient in capacity to generate improvements of its own and slow to take advantage of opportunities generated elsewhere. The slowness of the fisheries industry to improve its methods of pursuit and capture is undoubtedly due in large part to poor economic incentives and legal hindrances, and, in addition, to the fact that life for a scientist or engineer is not very attractive at sea on a fishing boat, where he must be—in order to learn about the problems and conduct experiments—as compared to a comfortable laboratory on shore. In another part this backwardness of the fisheries industry may well be explainable by its odd nature, in which it stands alone, as an incongruous mixture of communism[10] and capitalism. It is communistic in the non-private or public ownership and political control and regulation of the source, but capitalistic in the ownership of the tools of production and freedom of enterprise, and individualistic in the detached and isolated lives that rival fishermen live, much of the time at sea. Even when capitalistic in form of enterprise, as when fishermen operate boats and gear owned by investors not fishing, the actual fishing operations are communistic, in that labor does not work for hire but for a share of the proceeds, and operations are remote from control by, and little subject to, owners, but the product once caught becomes private property. *In its communistic aspects the fishing industry is deficient in the incentive of profits,* and being subject to the political power of regulation, it lacks the votes to assert itself. With only 125,000 fishermen in the United States,

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of "Nylock." Great Lakes conservation officials recently held a conference at Erie, Pa., and solicited testimony of commercial fishermen who said they are catching three to twelve times more fish with the new equipment. There is speculation that with wider distribution of the new nets, it may become necessary to place some restriction on total catches. Conservationists, already concerned with fish destruction in the Lakes by lampreys, apparently view progress with alarm."

10. The word communism is here used, not in the current ideological and political controversial sense, but as defined by Webster: "Any . . . system of social organization involving common ownership of the agents of production, and some approach to equal distribution of the products of industry." In this case, the source of supply, rather than "agents."

their voting power, even if concentrated in one State, would be small; diffused as it is over thousands of miles of coast and in thirty-odd States, it is negligible.

Natural Characteristics of the Supply of Fish. Although the biological basis of the fisheries of North Carolina is treated in another Part of the Survey, a brief sketch of the biological foundation is offered here to facilitate an understanding of the economics of the fisheries.

The totality of living things collectively on land and at sea begins, as said earlier, with plants which collect the chemical fertilizers, nitrates, phosphates, potash, carbon dioxide, water, and several other components and organize them into the substance of plants which are food for vegetarian animals; these vegetarians are prey for somewhat larger carnivorous animals some of which are prey to still larger ones. In these respects the web of life at sea is similar to that on land. There are important differences, however, between land and sea bio-economics. On land nearly all of our production, i.e., agriculture and animal husbandry, based on life is managed, regulated, and cultivated. *The produce of the sea is derived from wild life under natural conditions to which our operations must conform with little or no control or management of the productive factors.* Since man does not consume carnivorous land animals for food, the process of agricultural production is carried only one step from plant crops to vegetarian animals which are consumed as food by man. This two-step production is possible because land plants are relatively large, and are consumed by man as such or converted as food directly at one step into large animals, such as cattle, sheep, and pigs. Marine plants are microscopic or nearly so in size, and their conversion into animals usually consists of several carnivorous steps after the microscopic plants have been consumed by very small vegetarians and some larger fishes. Practically all fishes are to some extent carnivorous, some of them exclusively so.

The mass of living things collectively at sea on which the fisheries depend is almost inconceivably complex, multifarious and mutually destructive and interdependent. Nearly all marine animals, large and small, reproduce by laying prodigious numbers of eggs. The eggs which hatch and survive to maturity to produce another generation are not the rule, but exceedingly rare exceptions, which have escaped the hazards of existence—perhaps one in ten thousand or a million. At sea there are no holes or caves, and few hiding places; life of marine animals is a continuous round of killing and being killed and consuming and being consumed. The fishes, starfishes, jellyfishes, sponges, squids, shrimps, crabs, oysters, clams which we see and myriads of others which we do not see, all consume, one way or another, the same basic microscopic vegetation; they eat the vegetation itself or they eat the small quarter-inch vegetarian animals, they eat each other's eggs, they eat each other's young, they eat their own young, they eat one another. As each animal grows to larger size in most cases its diet changes accordingly, and itself becomes diet for different animals according to their sizes. Relative size determines, in many cases, which is consumer and which consumed.

Of the five species, cod, haddock, rosefish, pollock, and whiting, which together constitute more than half (58 per cent in 1945) of the total fishery of the New England States, fishery biologists say of each, in effect, that a catalogue of its direct food would include practically the entire fauna of the region, and each of the five includes the other four as well as the young of its own kind, in its diet.[11]

A striking example of the way of life of fishes is given by Peck (1896):

> The food of the squeteague [12] (*Cynoscion regale* [*regalis*]) may be characterized perhaps most clearly by a concrete instance. On the morning of July 23 there was taken a large specimen whose stomach contained an adult herring, in the stomach of the herring were found two young scup (besides many small crustacea), and in the stomach of one of these young scup were found copepods, while in the alimentary tract of these last one could identify one or two of the diatoms and an infusorian test among the mass of triturated material which formed its food. This is an instance of the universal rule of this kind of food; the squeteague captures the butter-fish or squid, which in turn have fed on young fish, which in their turn have fed upon the more minute crustacea, which finally utilize a microscopic food supply. And the food of the squeteague must be regarded as a complex of all these factors, a resultant of several life-histories to the given environment. Moreover, circumstances arising to modify any of the separate factors cause correlative changes throughout the whole series.

Contemplation of this internecine web of life should reveal the widespread fallacy in the prevalent thinking about fisheries that each species of fish can be singled out and protected, cultivated, conserved, or exploited and marketed, and treated as an economic and biological unit as if it stood alone and apart on its own nutritional foundation. It seems obvious that this can be true to only a slight extent, and for a few such specific feeders as the oyster. The catching of competitive finfish of one species removes some of the competition for other species and for other individuals of the same species which remain; and also some of itself as food for other species. The totality of all kinds of fish in a water community should and apparently does tend to be a constant in accordance with a Malthusian law of subsistence, or perhaps to vary with the over-all production of basic vegetable food in the region which might be affected by changes of tem-

11. See, Bigelow and Welsh (1925), feeding habits under the headings of the above named and other species.

12. The gray trout of North Carolina.

perature or circulation of the water. This integrated total of fish is a complex network of many equilibria. Many, perhaps all, of these equilibria are not constant but pulsating. The relative abundance of different species rises and falls, one being up while another is down.

The whole complex system of life at sea has been represented as a pyramid, the base of microscopic life being the most abundant, the successive consumers being less abundant but larger in (adult) size, the apex being the very large but not numerous sharks, swordfish, tunas, etc. There is reason to believe that removal of fishes high up on the pyramid improves the efficiency of the whole by reducing the average number of transformations of food with their attendant losses, so that exploitation, certainly up to a point, improves the productivity of the region. This fact almost certainly explains in part the failure of the early fears of exhaustion to be realized. The commercial fisheries are mainly concerned with the end product, i.e., the larger animals at or near the top.

The integration of the fisheries occurs also, as we shall see, in the mostly non-selective methods of capture such as the trawl, seine and pound net, which take an assortment of many kinds of fish that cannot be predetermined, and in the marketing of fish, wherein there are few fishes which have no equally acceptable substitute in the market; rather, the totality of most kinds of finfish collectively presses against the total market demand for any kind of fish. For all these reasons, it is unimportant if not impossible to isolate one kind of fish and treat it as an independent biological and economic unit.

The economically important matter is the quantity and value of the total yield of the fisheries, regionally and nationally. Such statistics of world fisheries as are available suggest that while particular species have fluctuated in abundance, the *yield of the sea fisheries as a whole or of any considerable region has not only been sustained, but has generally increased with increasing human populations,* and there is as yet no sign that they will not continue to do so. No single species so far as we know has ever become extinct, and no regional fishery in the world has ever been exhausted. The fisheries in North America as a whole and in all its regional parts (except some inland waters) have never been exploited to the point of diminishing returns, i.e., where more effort did not produce more fish. This condition probably obtains in all the world fisheries except perhaps locally in a few areas such as the North Sea and the Sea of Japan, and the Canadian-American Great Lakes, in the United States, and perhaps in all the more advanced countries increased production has been accomplished with a decrease in man-power resulting from more efficient methods.

Great Multiplicity of Species or Kinds of Fishes. The most comprehensive catalogue of the finfishes in and around the North American continent

(Jordan, Evermann and Clark, 1930) lists 4,137 species and subspecies of finfishes (fresh and salt water). We have seen no list of all the species in the world, nor any estimate of their number; we might surmise the total number to be 12,000 or perhaps many more. A correspondingly large number of mollusks and crustacea must be included to cover all of the fisheries.

Man has found use for, and catches practically everything of the range of one-half pound in size and up, that is sufficiently abundant to be worth while, and many of smaller size, such as shrimps, oysters, clams, sardines, smelts, and whitebait. Some, such as jellyfishes, sculpins, sting rays, conchs, starfishes, would be used if sufficiently abundant to be caught at low enough cost for the purpose for which they have a value, and new uses are being found from time to time. Sharks, which until a few years ago were not used, are now the basis of a major fishery as sources of vitamins, and to some extent for leather. There seem to be no useless fishes, though some are not used. The total number of commercial species in the world might be a thousand or even more. The great bulk of the commercial catch of fish throughout the world is in five families (each having numerous genera and species as members), viz., the herrings (about 45 per cent of all), codfishes, salmons, flatfishes, and mackerels. If we add two or three species of oysters and a dozen shrimps, with the sharks and rosefish coming into some prominence in recent years, we have the bulk of the world's production of fish and shellfish.

Of the 4100-odd species in and around North America, the U. S. Fish & Wildlife Service lists from year to year close to 200 commercial varieties or "species," some of them consisting of two or more true biological species; the total number including minor species used might be 500 or more. The fluctuations in quantity of any one species, even the most important, makes hardly a significant difference in the whole fishery. Many of these species are subdivided into trade classifications not shown in the statistics; buck and roe shad, silver and yellow eels, white and gray halibut, several size grades each of cod, haddock, halibut, whiting, mackerel, oysters, clams, shrimps, etc. In variety, the number of species of seafoods in this country approaches if it does not exceed the total number of species of all other foods both vegetable and animal used by man. *This fact of diversity of kinds and sizes of fish touches every aspect of the economics of production and marketing, and as a determinant is second in importance only to the non-private ownership of the source.*

Movements and Geographical Distribution of Fish. Each species has its characteristic geographical range, usually within temperature and depth limits; some are sedentary, others migratory; some spawn at sea, others come inshore or into sounds and bays or enter fresh water streams or otherwise become accessible at some particular season and not to be found at other seasons; some travel in schools, some move singly, some inhabit the bottom, and some live at the surface.

In the remoteness from the market of the sources of supply the fisheries are at a disadvantage with respect to agriculture. Most of the world's human populations are distributed around and in agricultural areas, where towns and cities can be supplied with agricultural produce from the surrounding countryside at relatively small cost. One need only glance at the map of North Carolina, itself a coastal State, to see the advantage of near-by agriculture in supplying the industrial cities and towns with food. This disadvantage of the fisheries is proportionately greater with respect to markets in the inland States and Provinces of North America, and the inland markets of all the continents. The great fisheries are all at sea, in many cases long distances off shore; at the nearest, they are on the fringes of the continents. Some of the richest bottoms are still too remote to be exploited, with present methods, costs, market values, and high perishability, so that the presently fished waters do not represent the total fishery resources of the world; the remote grounds remain unexplored as long as those nearer by can yield their products at lower cost.

Geographical expansions and contractions of the fisheries have occurred in various regions. In our earlier days most of our New England fisheries were near the coast; as these became inadequate (and great fears of extinction arose), long-range vessels were fitted out and extensively fished the Grand Bank of Newfoundland, bringing back large quantities of salt fish. When salt began to yield to ice as preservative, and the steam trawler replaced sail, new elements of cost were incurred, so that fishing returned to the nearer-by banks. The more remote banks will again be fished when and if demands and costs are again favorable. When in the North Sea fisheries of Europe the yield per unit of cost declined to a point which made more distant fishing competitively possible, large trawlers were built and sent to the fringes of the Arctic Ocean, so that part of the pressure on the North Sea was relieved. It may be expected that the North Sea will continue indefinitely to be fished to just the point of cost-price balance with the more remote grounds.

In a few places in the sea, rich fisheries are situated within reach of great developed centers, such as Boston, Seattle, San Pedro in the United States, Hull and Grimsby in England, Bergen, Norway, Shimonoseki, Japan, etc., where shipyards build, repair and supply vessels, and organized markets, freezers, canneries and reduction plants provide all the facilities for economical and efficient operation. But apart from such centers, almost all the waters offshore everywhere provide some fisheries which are scattered along great lengths of shore line, at villages and small towns remote from consuming markets. The aggregate production of such places is or could be important, but the lack of concentration, and often the seasonal nature of supply, present many of the most serious hindrances to development of the fisheries. These conditions prevail along much of the shore line of the North American continent.

Selectivity of Methods of Capture. To exploit the complicated source of wealth in the sea, the fishermen use gear which has varying degrees of selectivity. A purse seine is quite specific for schools of fish at the surface. The haul seine catches whatever is larger than the meshes of the net that encounters it; a pond net, weir or trap catches some part of anything that happens to be moving in a way to be intercepted by the leader; a trawl catches all the bottom fish which do not escape, in a narrow strip of bottom up to a height of six to eight feet; hooks catch whatever fish are attracted by the bait and with mouth big enough to take it; crab trot lines catch only crabs; "pots" or small cages catch lobsters, crabs, eels, sea bass, etc., depending on where they are set.

The fisherman is therefore not altogether free to produce and sell what the market seems to want, especially of finfish. With the catch-all types of gear he catches whatever happens to be present at the time and place, and wherever he uses his gear he produces in most cases several or many kinds of fish, which may not be the most desirable assortment, but which nevertheless he must sell, if he can. "Trash" fish, for which there is no market or which are not economically worth while, are discarded at sea. If they are, they may be food for other fishes as truly as they would be if consumed alive by enemies. For these reasons, among many reasons, the forces of supply and demand are only weakly operative for particular kinds of fish. Economically as well as biologically the totality of useful fish of a region tend to behave collectively.

Versatility of Methods and of Opportunities of Capture. Fishermen, however, do have some choice of what they catch. In the case of gill nets they can make the size of the meshes to catch a predetermined size of fish. They can drift them at the surface or sink them to the bottom. Variation of the mesh of trawls, seines, pounds, nets, etc., also may allow small fish to escape dead or alive. Minimum sizes of mesh are in many cases fixed by law.

Perhaps the most important controllable variable is the choice of time and place of fishing and, of course, appropriate gear and methods. By experience, fishermen learn that certain kinds of fish are more likely to be found at certain times and places, and to that extent can increase the production of them at will, but selectivity is never complete—"odd varieties" of fish other than those mainly sought are taken and must be disposed of. We shall see in the Section on Marketing that many kinds of finfish enter the same competitive markets, and are substituents one for another; that few fishes possess peculiar consumer appeal that cannot be substituted by other fishes from the same or different regions. Therefore, no one fish without special appeal of its own, even if it is biologically scarce, can in price get very far out of line with other fishes of similar quantity and attractiveness.

It does not follow however that at any one place and time these alternative choices of fish can be caught with the same cost and effort. Any one species may be at any one time scarce or abundant and therefore dear or cheap relative to other fishes. Fishermen exercise such freedom as they have of choice of methods, time, and place of capture, always seeking the abundant fish that can be caught cheaply and sold at a good price in preference to those which are for the time being scarce or out of season or cheap. Also, fishermen are in competition with each other, each always seeking to exploit opportunities that are neglected by others.

The haddock fishery in New England became very popular in the early and middle 1920's, rising to a peak of production in 1928 of about four times what it was in 1922. The fishery then began to diminish in productivity with corresponding increase in cost, whether from heavy fishing or natural fluctuation. A considerable part of the effort that had been expended on catching haddock was now turned to the pursuit of rosefish, which up to that time had been neglected, and the production of which increased enormously in the next few years. For similar reasons the production of flounders and soles and whiting of New England has been increasing in recent years. The total production of these three species or groups in 1887 in New England amounted to 2½ million pounds worth $62,000 (less than one per cent of the quantity and value); in 1945 they amounted to 271 million pounds valued at $11,500,000, or 32 per cent of the quantity of all fish and 20 per cent of the value. On the North Carolina coast the shrimp fishery was small for many years until in the middle 1940's with the increasing popularity of shrimp and prevailing high prices many of the fishermen in North Carolina went into the shrimp fishery. The result was a large increase in the yield of shrimp in North Carolina.

Changes in demand likewise react through prices in the primary markets to stimulate or depress the production of particular species. For example, the fading of demand for salt fish and the development of the fillet caused codfish to decline and haddock to rise in price with corresponding decline in production of the one and increase in the other. Production, prices, and total value of mackerel have also decreased, presumably for the same reason. A decline in price and production of oysters (up to 1940) coincided with a rise in price and production of shrimp, suggesting not a shortage of oysters (which would have caused a rise in price), nor abundance of shrimp (which would have caused a drop in price), but an increase in the demand for shrimp and a decline in the demand for oysters.

In all this is seen a characteristic behavior of the fisheries under heavy exploitation that is often overlooked, namely, that as any one species of fish is pursued and its abundance diminishes (as a result of fishing or any other cause), the cost of producing it rises relative to the cost of catching other species; if the price does not increase to compensate, the fishermen discover the diminution of returns from this fishery and some of them take up some other, so that part of the pressure is taken off the "over-fished" species, a process which amounts to an automatic economic regulation of the intensity and distribution of fishing. The principle applies also to the fisheries collectively of a region operating in competition with other regions. If the fisheries reach a point of diminishing returns in one region, economic compulsion operates to relieve the pressure in favor of another.

It appears to be impossible to exterminate a species or a fishery for profit, since the profit disappears before the fish is exterminated. Within the fisherman's freedom of choice to catch, and selectivity or non-selectivity of gear, each species or fishery tends to be fished to a point at which it just yields a wage to those engaged equal to what they could earn by fishing other species, or by working at some other trade ashore. Equilibrium would undoubtedly be established at this wage level for each species if natural fluctuations did not occur in the supply of various species and if market conditions remained constant. *This operation of economic law is such as to distribute the total fishing effort over the total fishery resources of a region and to deliver a total of yield into the consuming market just sufficient to meet total of demand.*

Some such law seems also to govern the total number of fishermen engaged. Fishing as a gainful occupation is in competition with all opportunities on shore. Some men leave shore employment and go fishing in times when they think opportunities are good and thus increase the competition among fishermen, produce more fish, and depress the prices, as a reaction to increased fishing. Theoretically, at least, *the total number of fishermen engaged is self-regulatory,* and the distribution of those engaged spreads itself out over all the opportunities of a region to satisfy the market with all the available kinds of fish at a price which will move them against the competition of fish from other regions and of other foods, such as meats and poultry. The composition of the total catch is regulated by this complex interrelationship of fluctuations in biological abundance and market demand and the attempt of the fishing effort to adjust itself to these variations. There are of course disequilibria due to the lag between the occurrence of adversity or opportunity and the discovery of, and the response to, either by fishermen. The tendency to saturate the opportunities also applies to the investment of capital in the construction of fishing vessels. As many vessels as can hope to operate at a profit are built, and for all the opportunities, and with as much versatility of purpose as possible, so that they, too, like the fishermen, spread themselves over all the opportunities of the region up to and often beyond the limit of sufficiency.

Fluctuations in Quantity and Composition of Catch. All fisheries are characterized by fluctuations caused by weather, wind and tide, vertical and horizontal movements of the different kinds of fish in search of food and in response to temperature, light, and saltiness of water and to the instinct to migrate for the purpose of spawning. These and fisherman's luck in finding the fish affect the day-to-day results of fishing. Many fishes perform annual migrations with considerable regularity and most, if not all, species undergo natural fluctuations in abundance in regular or irregular cycles of two to five years, or even up to a quarter-century or more, and a few have shifted their centers of abundance to different regions. The weakfish or sea trout, now absent from New England, has appeared there in commercial quantity and disappeared several times in the past two centuries; the bluefish disappeared suddenly in 1764 and was totally absent from the New England coast until 1830; the scup was abundant from the first arrival of the Colonists until some time after 1642 when it wholly disappeared until about 1794 when it reappeared; [13] the thimble-eye or chub mackerel has appeared and disappeared several times; the menhaden has shifted southward, and the croaker is now centered more northerly than it was a few years ago; in 1872 the whiting had not been seen in quantity at Cape Cod in many years (in 1945, 78 million pounds of it were produced); whether the present large production of rosefish is due to economic demand or whether it is in a wave of abundance after a long period of scarcity, we do not know. These movements and fluctuations affect different species differently or at different times, so that not all are present or absent or abundant or scarce at the same time and place, as will be seen on examination of the historical record of North Carolina species, Table 91, Appendix. It is therefore to be expected that the total yield of fish in quantity and composition will vary much locally and from day to day, less for larger areas from month to month, and still less for very large areas from year to year, the fluctuations being lost in the averages. There do not appear to have been in the historical record any great general biological scarcities of fish; scarcities are always confined to particular species.

These fluctuations of quantity and composition of catch are, however, one of the most difficult economic characteristics of the fisheries. They cause erratic prices and disappointment when good catches have been made, occasional dumpings of the catch in the more remote communities for want of a market, and interfere with the establishment of public familiarity with the

13. For further details on the long-range comings and goings of various species, see Report of the U. S. Commissioner of Fisheries, Part I, 1871-72, Sec. IV, Special Arguments for Regulating Sea Fisheries by Law, p. 73-124; also, same Report, Secs. V, VI and XIV; Baird (1889) and Appendix; and Bigelow and Welsh (1925) under the headings of the various species.

various kinds of fish and the establishment of habits of steady demand for them.

Unlike manufacturing establishments in most other fields, which can operate on a plan in which all factors of cost, sales, labor, finance, etc., are known or can be closely estimated and provided for in advance, the fisheries in all departments are governed by uncertainty and unpredictability in almost every important factor, so that executives and managers who are best qualified by experience to solve the complex problem of the industry are too occupied with day-to-day crises and emergencies to deal effectively with them.

Perishability. Fish and seafood generally are among the most perishable of all food products. Their flesh is naturally soft, easily damaged physically, and readily penetrated by bacteria; unlike red meats and poultry which are improved by the process of post-mortem "ripening," fish quickly develop odors which though not evidences of unwholesomeness are universally disliked.

The greatest of all the problems of local fisheries, especially in the lesser communities without the elaborate technical facilities of a great center such as Boston, is the *combination of erratic and unpredictable production in quantity and composition of highly perishable products.* This difficulty is often aggravated by lack in a given market of immediately current information about the production of other markets. If any dealer along the coast had exact knowledge of the current yield at other points widely distributed along the coast, it might be possible to appraise the market prospects, and to take large catches which occur at times if it were found that production of the same or market equivalent species at other points was relatively light. Dealers in communities remote from the big markets rarely have this detailed knowledge and cannot afford to take the risk of buying unusual quantities without it.

Standards of Quality. Clearly defined standards or grades have been established for most commodities, such as coal, grain, cotton, tobacco, oils, lumber, fruits, butter, and many others. Meats entering interstate commerce are inspected and stamped by government inspectors under Federal law. There are no quality standards of fresh fish, and the size classifications which have grown up in practice are generally elastic and unenforceable. Inspection of fish by government or trade association has never been found practicable because of the perishability of fish. A lot of fish might be tagged a certain grade one day and, by deterioration, belie its tag the next day. The individual fishes constituting a lot are too numerous for practical grading, though they may vary greatly in quality. The trade manages to get along without standards, but the absence of standards is just another of the many hindrances in the way of a more important position of the fisheries in the food supply.

Credit. We have seen that the fisheries tend to be overcrowded, competition to be at a maximum, and the rewards to be those of wage earners who often do not or cannot accumulate from their earnings working capital for their operations. This is especially true of fishermen in small communities where incomes are erratic and undependable; they need capital or credit for boats and gear, for supplies and family living expenses and for financing sales.

Unlike agriculture, wherein privately owned land can be pledged or mortgaged for credit, the fisheries cannot pledge the water as collateral. Boats are insurable, but at such high premiums that small fishing units are often without insurance and therefore not acceptable collateral for mortgage loans.

Frozen inventories are poor collateral for credit. They are subject to the hazards of spoilage and deterioration; their value is not accurately ascertainable or predictable where there are no futures trading markets and no official standards of grade.

In small communities one of the few sources of credit available to small fishermen is the shore dealer (or sometimes the remote commission merchant) who makes advances to be paid back in fish produce, in return for which as security the dealer usually requires exclusive right to sell the fishermen's produce until the debt is paid. Often the dealer also owns the boat or a large share of it. Such loans by the dealers are usually not motivated purely by the expectation of the return of interest with safety of principal as is bank credit which does not hamper the borrower's freedom to sell to his best advantage. The dealer may and often does waive interest on such debts, and, having a monopoly on the fisherman's produce, is in position to exercise a considerable degree of control over the prices which the fisherman, who is in poor bargaining position, must accept.

Corporate Form of Business. Most of the corporations in the fisheries are in the manufacturing and selling business rather than in catching fish, though some marketing corporations also operate fishing vessels or traps. Where vessels are separately incorporated, as the larger ones often are, the purpose of incorporation is usually to limit liability rather than to secure capital. In the business of catching fish, the problems of capital and credit are not as well solved by the corporate form of enterprise as they are in many other industries wherein substantial amounts of capital are obtained from a large number of investors for the conduct of large-size business. In other businesses where the corporate form is suitable, adequate capital is obtained, economies are realized by large scale operation, functions are departmentalized and performed by experts, the advantages of close management and discipline are obtained, and research, experimentation, and development can be supported as they cannot be by small companies. Large scale operation also often makes possible diversification, which is desirable in the fisheries in compensating for a poor season in one fishery with a good season in another.

In the business of catching fish, the actual fishing is remote from central control and not amenable to discipline. Little in the way of benefits from specialization is accomplished. Few worth while economies are effected by bigness. Diversification is in fact to some extent realized, but in spite of it, the earnings (and losses) of large fishing companies are erratic, the historical record is not good and they are unpopular with investors.

To these difficulties are added that of securing managers for decentralized operations who are, as employes, able and willing to make the necessarily quick and risky decisions which are better made by principals.

Cooperatives are discussed under Primary Marketing, p. 327.

Fishing Not Primarily for Subsistence of Fishermen. While fishermen make use of their own produce as food for themselves and families, fishing is not primarily an important subsistence industry, as is small agriculture, where a well-rounded diet can be produced in home gardens and with chickens, pig, and cow. With only 125,000 fishermen in this country producing an average of 32,500 pounds of fish per man, it is evident that fish is mainly a cash crop. In any event, fish could supply only the protein part of the diet. In some countries, such as Newfoundland and Japan, and in some of our small communities in this country remote from the big markets, fish is a more important element in the diet of the fishermen. In some of the larger fisheries such as trawling for cod, etc., menhaden and sardine fishing, their own products hardly enter the fishermen's diets at all. The fishermen are therefore under the necessity, in most cases, of marketing their produce for cash.

Unions have made very considerable progress in organizing fishermen in the trawling and other fishing operations where labor can be definitely distinguished from capital ownership, even though the fishermen's compensation is mainly in the lay or share. In trawling there is (or was) a small guaranteed wage. This and the terms of sharing the catch, length of watch and other conditions of work, time in port, number of crew members and such matters are subjects of negotiation between owners and union crews. In New England the fishermen's union also attempted to control prices by limiting the amount of catch to 134,000 pounds of fish per trip; unlimited catching would be perhaps 200,000 pounds average.[14] The shore handlers of sundry kinds including employes in commission markets and processing plants are unionized in the familiar industrial pattern. In the Pacific Northwest the Halibut Vessel Owners Association and the Fishermen's Union deal with each other and act jointly in marketing arrangements affecting both. This is also true of the California Sardine Vessel Owners and Fishermen's Union who negotiate the prices of sardines with the canneries and reduction plants. There are also fishermen's cooperative canneries.

14. This practice was found by a Massachusetts Superior Court on August 1, 1947, to be monopolistic and the Union was ordered to cease and desist fixing prices and restricting catch.

Primary Markets and Selling Arrangements for Fishermen

a. *Auction markets.* At large fishing centers, especially the landing ports of trawlers and similar fleets (such as Hull and Grimsby, England, Boston and Seattle), the fish are sold at public auction for immediate cash settlement. The selling agency is an independent organization or exchange which performs services for both buyer and seller, the buyers being members or otherwise privileged to attend the auction and to buy. The leaseholders on the Boston Fish Pier are privileged to attend the auction and to buy. The estimated quantity of each species by size and grades of a landed vessel is chalked up on a blackboard, and the captain or his delegate conducts the auction. The highest bids for all or part of each kind are accepted and settlement is made for cash on the day of sale. The system falls short in a few particulars of a strictly even-handed, impartial auction in that two or more buyers may limit competition by combining to bid, and that sales once made can be revoked for poor quality after the fish are unloaded. Since there are no recognized standards and enforceable quality grades and no official inspectors, such revocations and "sell-overs" may be for other reasons than poor quality—for instance, falling market prices. Nevertheless, the system works well and gives relatively free play to competition and the operation of the forces of supply and demand.

b. *Commission sales.* Selling on commission is generally practiced at large consuming rather than producing centers (London, New York, Chicago, etc.), and is more often secondary than primary, i.e., the produce has already been sold once at auction or to dealers at shore points, and re-sold on commission in the commission markets. However, at London, New York, Chicago, and other cities situated on the water, some primary production by fishermen is also sold on commission.

These commission markets are open to all producers and shippers. As example, a dealer or fisherman at Morehead City, North Carolina, has ten boxes of weakfish. He ices them, attaches a shipping label, consigning to John Doe & Co., Fulton Market, New York City. Doe pays the express charges, cartage, etc., if any, and sells directly to buyers from local retail markets, butcher shops, restaurants, and hotel and restaurant supply houses in person or by telephone communication; sales are made mostly in original packages, but some broken-package selling is done. John Doe & Co. finances the receivables and takes any risk involved therein. Practically all shipments are sold at some price on the day received, and buyers take their purchased goods away. Before the day is closed, the clerks make up the "account of sales" of each shipment received, showing gross receipts, the commission charged (12½ per cent in New York) and any expenses, and remit the net proceeds to the shipper by check. All persons are free to buy and sell in commission markets through the member dealers, without membership or other restrictions, the only "members" being the merchants who hold leases in the market buildings. Into such a market, with perhaps forty or fifty established merchants, a great variety of fresh fish and seafoods, and some frozen, from all sources within reach, are on sale.

Buyers may visit several shops before buying. The commission merchants are therefore in competition with each other in sales and in soliciting shipments from producing fishermen and shore dealers, often sending personal representatives or drummers to fishing communities for the purpose. They also supply a great deal of current market information to shippers, most of which is by telegraph or telephone, and at the expense, in both directions, of the merchant, the amount of which is substantial. In New York City the wholesale dealers jointly maintain a Fishery Council which decorates seafood trucks with attractive advertisements, does some newspaper advertising and cooperates with the home economics department of the municipal radio station in promoting the sale of fish and giving fishery information to the consumers in New York City. These merchants perform an indispensable service to producers and the consuming public and at considerable overhead expense not shown in their accounts of sales.

Nevertheless such markets have been regarded with some suspicion. The basis of settlement with shippers is the selling price, but no indisputable proof of what this price was is accessible to the distant shipper. Nor, in the absence of standards of quality impartially determined, does the shipper have any proof of inferiority if this is given as a reason for a low price returned. Further questions have arisen out of the efforts of commission merchants to avoid embarrassing comparisons of returns for the same kind of fish from one community shipped at the same time to one or more commission merchants who have no opportunity to explain to the shippers the many causes for varying prices for the same kinds of fish in the course of a business day. The averaging of returns in one way or another may avoid the embarrassing comparisons, but in the end, raise other and perhaps still more embarrassing questions, since any liberty taken with the returns opens the way for suspicion that returns to fishermen may be arbitrarily fixed and not those actually realized. The question of returns arises from the many legitimate causes for lower prices of some shipments, such as arrivals too late in the day for best prices, the arrival of large quantities of other kinds of fish, and inferior quality. Because of these and other difficulties the practice has been growing of buying "on the floor," i.e., outright purchase by the city dealers, sight unseen, of fish at the fishing ports before shipment.

The problems of commission marketing in the big cities are obviously not yet solved within the present framework of the law and equity to the satisfaction of all interested parties. The established practices now followed have evolved from long experience of the commission houses, whose actions are tempered and restrained by their competition with one another both in attracting the shipper's offerings and in their sales to the retail trade.

c. *Coastal Dealers*. Apart from the organized markets at great production centers, a residue of smaller fisheries in communities scattered on long coast lines must be provided with immediate primary markets for local fishermen. Such markets are usually individuals or small companies who receive the fish and ice, pack, ship, and sell in the various markets, and sometimes fillet, freeze, and store. Some are aggressive merchants who sell to distant wholesalers, retailers, hotels, etc., extend credit and finance the sales, fillet, freeze, and perform all appropriate services, including mere forwarding to commission houses. In fact, when we have in view the nature of their problems of dealing with a highly fluctuating supply of perishable produce, competing in a market everywhere characterized by gluts and scarcities, without quality standards and with generally weak credits and inadequate market information, the local dealer is often by necessity an opportunist, disposing wherever he can of the current production which comes to his hands. Some dealers operate retail fish shops or even restaurants. They often own boats or shares in them; they often advance credit to fishermen for gasoline, bait, ice, provisions and living expenses and usually require in return the right to receive and sell all the fisherman's catch, all or part of the proceeds to apply against the loan until it is paid.

Excessive charges by shore dealers made possible by this advance of credit and other devices may have a far-reaching effect on the whole production-distribution chain. By returning artificially low prices for fish, fishing as an occupation is made less remunerative, fishermen tend to be restricted to those of marginal ability, and the region where this is done is placed at a price disadvantage with respect to other communities where prices are competitively arrived at. The large margins to dealers attract more people into dealing, so that as fishermen are decreased in numbers, the number of dealers increases. On the marketing side, the large margin taken by the shore dealer leaves too little for subsequent wholesalers and retailers and final prices higher than necessary tend to restrict volume retail sales. Thus, both production and final sales are discouraged and the volume handled is smaller than it might otherwise be. Small volume in turn inevitably means high unit cost of distribution, which is perhaps the supreme economic problem of the fishing industry.

The terms on which the shore dealer settles with the fishermen vary. Sometimes he buys outright; sometimes he sells for the fisherman on commission; sometimes he simply takes the fish on indefinite terms and settles later at a price to be determined by his sales. When he ships to a city commission market he may receive cash settlement before he settles with the fisherman, in which case the first price is made in the city commission market; the fisherman assumes all and the dealer none of the risk in the transaction. The shore dealer may also receive seasonal cash advance from the commission merchant some of which he may in turn advance to fishermen. In this kind of business the shore dealer can do business with little working capital and no risk to speak of and renders little service to the fishermen. In some communities there are too many dealers any one or a few of whom with little, if any, increase in expense could handle the entire production. Multiplication of dealers adds to the over-all cost. Here, as everywhere, it is easy to point out the defects of the marketing mechanism, but difficult to show how they can be overcome.

If the shore dealer buys the fish outright from the fisherman, he makes the price and takes all the risks of subsequent market prices, weather and spoilage, and where he must extend credit on his sales he must furnish the capital and take the credit risks, too. He will of course minimize these risks as much as possible, and so will his competitor, by offering the minimum price to the fishermen. Somebody must furnish the working capital and take the considerable risks of both working and invested capital, as well as exert the selling effort and do all the other work. If the fisherman is not prepared to do these things himself, he must expect less than if he did.

d. *Fishermen's Cooperatives.* Many of the objections to the corporate form of business apply to fishermen's cooperatives which are often mentioned as a solution of the capital, management, and selling problems of fisheries production.

Few fishermen's cooperatives have been tried in this country. During the NRA days of the 1930's cooperatives were established with Federal Government sponsorship and finance at Rockland, Me., Edenton, Morehead City and Southport, N. C., and Clearwater, Fla. All failed. In the Pacific Northwest, the Halibut Vessel Owners Association and the Halibut Fishermen's Union jointly manufacture and sell vitamin oil from fish livers through a cooperative management, but the fish are sold through the Seattle auction. At Prince Rupert, B. C., a similar arrangement markets the fish (halibut, salmon, etc.) as well as the livers and liver oil. In both these cases the fisheries concerned are controlled by international commissions under treaty agreements and the conditions appear to be more favorable to cooperative action than those of other fisheries generally.

Cooperatives rely on the capital of their members rather than that of stockholders, and fishermen have no more savings capital for such purposes collectively than they have individually. Since credit to some extent is necessary to inland distributors, wholesalers and retailers, the cooperative must exercise the judgment and control of credit, and take the risks involved, or deal only through commission merchants for cash, and the latter are perhaps the least satisfactory of all outlets for fish.

But an even more serious difficulty with cooperatives, which seems to have been the basic cause of failure of most of those which have been tried, is the practical difficulty of finding and hiring men with the experience, energy, imagination and general business ability, of providing them with the incentive to build a sound merchandising organization and to keep the peace among strongly rival and individualistic members. Men who have these talents are usually in business for themselves. Fishermen might well be reluctant to pay the handsome salaries and participation in profits which are necessary to get sufficiently able management.

e. *Marketing by Fishermen for Canneries, Freezers and other Processors.* In a considerable part of the fisheries, the traps, vessels, etc., are owned in whole or part by the shore plants. Fishermen are engaged to fish the traps and man the vessels under an arrangement for a season at a fixed price per pound, barrel or other unit. These transactions are sometimes called sales, but are actually wages for labor, the amount of compensation being determined by the catch, at a pre-fixed rate. A considerable part of the time and labor involved may be constant, the variable being in setting and hauling nets, unrigging and rigging pound traps, etc.

MARKETING, DISTRIBUTION, AND CONSUMPTION

Place of the Fisheries in the Food Industry. The fisheries are dominated at the extreme ends of the production-distribution chain by two refractory determinants; at the source by unlimited competition in the non-privately owned water; at the extreme opposite, the point of consumption, by the almost constant per capita requirement for food, which is the main determinant of the food industry. The greater part of the commerce in fishery products is in human food and subject to this determinant.

Inelastic Demand for Food. The per capita consumption of food of all kinds, including the water content, bones, husks, fats, and other wastes, is variously estimated at from 1500 to 1800 pounds per year. The estimates differ largely in what weights are used and, of course, contain undeterminable errors. Sherman et al. (1944) estimated on the basis of a house-to-house canvass that housekeeping families and single persons in the civilian non-institutional population of the United States consumed at home an average of almost 30 pounds of food per person per week, as brought into family kitchens from retail stores, garden or farm, but before further preparation for table use. They estimated the unavoidable refuse at about 8 per cent plus undetermined avoidable waste.

Harper (1945) estimated that the per capita consumption of food throughout the world is also not far from constant:

Quantities of Food Eaten. The belief prevails that wide differences exist, even in normal times, in the *quantity* of food eaten per person in different parts of the world. We visualize the Chinese, Japanese, and Indians as existing on only a fraction of the food we eat. But this is not true.[15] Food consumption on no continent differs more than a few per cent one way or the other from the world average of about 560 pounds, dry weight, per person.

Why do our ideas on this question differ so much from the facts? It is partly because famines in areas like China and India have been over-emphasized. The periodic famines which occur in these areas are local and temporary. Some people die, but following the famine, when good crops return, the survivors—who are *most* of the people, on a proportionate basis—eat enough extra to rebuild their bodies to about their former weights. The *life-time* consumption of the survivors is affected little by the famine.

The difference between overeating and starvation is an amazingly small amount of food. To illustrate, if an ordinary adult were to reduce the amount of his food intake by only about three per cent, he would lose about 10 pounds of weight in a year's time; if he were to increase it by three per cent, he would gain about 10 pounds in a year. This change in weight would, of course, be so small as to be unnoticeable day by day, and hardly noticeable week by week. But in 10 years' time it would amount to a loss or gain of 100 pounds. This amount of change is conceivable only for a person either seriously overweight or underweight, as the case may be, before this loss or gain occurred; it is unthinkable on a continuing basis, on a national scale.

The record of the consumption of food in the United States, considered in a historical annual series from 1909 to 1948, is presented in detail in a report by the U. S. Department of Agriculture, prepared under the supervision of Cavin and Burk (1949). For each kind of food consumed in each year the amount, expressed in customary retail weights, which was available for consumption (i.e., "disappeared") was computed as the sum of ascertained or partly estimated production, stocks on hand at the beginning of the year, and imports, less the sum of exports and stocks on hand at the close of the year. Numerous corrections and adjustments are made (for the details of which see the publication cited), so as to make the record as accurate and as comparable throughout as possible. Summary serial tables exhibit the quantities by weight of the various classes of foods and of the totals of all foods consumed per capita per annum, and also computations of the annual average content per capita per day of food energy in calories, the various nutritive elements in appropriate units, and both of the latter in terms of indexes for comparative purposes.

15. "Quantity," as used here, refers to the amount of food on a *dry basis*. To include the full weight of foods with their varying water contents, from cereals with a low water content to lettuce having 95 per cent water, is to use a basis for comparison that is meaningless for this purpose. Perhaps equally satisfactory, and giving essentially the same conclusions as these based on dry weights, would have been comparisons in terms of calories or total digestible nutrients.

TABLE 5

Apparent per Capita Food Consumption in the United States by Major Food Groups, Estimated Retail Weights, and Total Food Energy in Calories, 1909-1940 *

Year	Dairy products excluding butter †	Eggs ‡	Meat, poultry, and fish §	Fats and oils including fat cuts and butter ‖	Dry beans, peas, nuts and soya products ‡‡	Potatoes and sweet-potatoes **	Citrus fruit and to-matoes **	Leafy green and yellow vege-tables **	Other vege-tables and fruit **	Grain products	Sugars and syrups ††	Coffee, tea and cocoa ‡‡	Totals: Retail weight equiv-alent	Totals: Food energy average per day §§
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cal.
1909	388	35	161	59	11	204	44	76	209	291	84	10	1,572	3,480
1910	367	37	154	58	10	206	44	73	204	289	86	10	1,538	3,450
1911	355	40	159	60	10	168	44	69	216	281	88	9	1,499	3,410
1912	398	37	153	57	10	191	46	75	228	279	86	11	1,571	3,420
1913	388	36	150	58	10	194	45	72	201	279	92	10	1,535	3,430
1914	372	36	148	61	10	171	52	72	222	282	90	10	1,526	3,450
1915	369	38	143	61	10	192	51	75	222	270	87	11	1,529	3,390
1916	366	36	147	61	8	154	48	73	203	276	87	12	1,471	3,370
1917	376	34	143	57	11	168	50	76	202	276	88	14	1,495	3,360
1918	404	34	148	60	12	185	48	83	202	249	89	13	1,527	3,330
1919	380	36	148	61	10	169	52	76	202	263	104	13	1,514	3,430
1920	389	36	145	58	12	162	53	88	224	248	101	13	1,529	3,340
1921	388	36	141	58	10	168	55	73	185	236	100	13	1,463	3,240
1922	385	38	146	62	10	170	51	81	225	242	118	13	1,541	3,440
1923	373	39	153	66	11	181	60	77	209	237	105	14	1,525	3,420
1924	381	39	153	65	13	164	63	84	218	233	115	13	1,541	3,450
1925	381	38	148	65	13	160	59	81	210	228	118	12	1,513	3,420
1926	381	41	147	65	13	141	59	83	238	231	118	14	1,531	3,440
1927	380	41	145	65	15	156	60	89	207	231	118	13	1,520	3,440
1928	382	41	141	67	14	164	56	84	228	236	120	13	1,546	3,490
1929	387	40	140	67	14	165	68	92	218	231	112	14	1,548	3,450
1930	385	40	139	67	16	144	60	88	216	227	124	13	1,519	3,460
1931	382	40	137	66	14	150	70	92	231	220	114	14	1,530	3,370
1932	385	38	137	66	14	156	67	92	204	209	109	14	1,491	3,280
1933	385	36	142	66	14	151	67	86	197	203	110	14	1,471	3,250
1934	375	35	149	66	15	152	70	93	198	200	110	14	1,477	3,250
1935	380	34	129	60	14	158	82	96	222	201	110	15	1,501	3,160
1936	385	35	141	64	16	142	79	91	213	196	112	16	1,490	3,260
1937	386	37	136	64	15	138	80	98	233	196	109	15	1,507	3,220
1938	386	37	135	65	17	144	85	107	225	196	108	16	1,521	3,240
1939	391	38	142	68	16	132	98	104	233	194	111	17	1,544	3,300
1940	391	38	149	70	15	138	94	104	233	191	107	17	1,547	3.320
Avge	382	37	145	63	13	164	61	84	215	238	104	13	1,520	3,368
% of total	25.2	2.4	9.5	4.2	0.9	10.8	4.0	5.5	14.2	15.7	6.8	0.9	100.1	100

* Source: U. S. Dept. Ag., Bur. Ag. Econ. (Cavin & Burk, 1949). † Sum of approximate retail weights of individual products. ‡ Allows for breakage from farm to retail. § Excludes bacon and other fat pork cuts. Includes edible offal, game and small quantity of noncommercial fish. ‖ Actual weight except for "other edible fats and oils." ‡‡ Nuts shelled. ** Including fresh and processed items and produce of town and city gardens. †† Excluding use in condensed milk, processed fruits and vegetables. ‡‡ Includes coffee on roasted basis, and chocolate liquor equivalent of cocoa and chocolate products. §§ Calculated on recommendations of Special Comm. F.A.O., 1947.

We have arranged as our Table 5 the data in Cavin and Burk's summary (their Table 38) of apparent annual per capita consumption by weight for the 32-year period, 1909-1940, arranged in twelve categories of food, and the totals of all foods; also included is the series of corresponding calculated energy contents in calories taken from their Table 39; we have averaged the columns and computed the percentage of the average of each class of food on the average total consumption for the period.[16]

In our Fig. 1, these data are exhibited in graphic form.[17] The curves for the several classes of foods are slightly smoothed by a 3-point moving average so as to avoid the confusion of crossing over by the wiggles in so many curves compressed into small space, but the totals by weight and calorific content are plotted unsmoothed.

For the many important and interesting implications of this study, the reader must be referred to the original report. For our purposes here it suffices to call attention to the main points bearing on the economics of the fisheries as a part of the food industry.

The total amount of food in customary retail weights which disappeared was almost constant at 1,520 pounds per capita per year over the 32-year period, 1909-1940, of turbulent economics which included a depression after the First World War, an inflationary boom, another and violent depression and recovery. In this 32-year series, the average annual deviation, plus or minus, from the average of the entire period was 2.0 per cent; the maxima of deviation were + 3.4 per cent (1909) and —3.8 per cent (1921).

The total energy content was also, for our purposes, almost constant around the average of 3,368 calories per capita per day; the average annual deviation from the average of the entire period was 2.6 per cent, with a maximum in any one year of +6.7 per cent (1928) and −3.4 per cent (1935).

Not only the total weights and energy content per capita, but also the nutritive elements (protein, fat, calcium, iron and the common vitamins)

16. We have omitted from our presentation the data for the war and postwar period in which a marked increase in per capita consumption occurred. The total rose rapidly from 1,547 pounds in 1940 to the unprecedented 1,705 pounds in 1947 and dropped back to 1,581 pounds in 1948. The largest part of the increase was in dairy products, and a noticeable amount in meats, etc., citrus fruits and leafy vegetables. There appear to be reasons for regarding this period as highly abnormal and the figures misleading for our present purposes, involving such matters as the wartime demand for milk for the suddenly increased number of babies born, black market operations, hoarding by consumers, many of whom bought to the limit of ration coupons regardless of need during the rationing period and the rush to buy when rationing was discontinued on October 15, 1946, shipment of gift parcels to needy persons abroad and the exclusion of the military consumption from the data.

17. A logarithmic scale is used here (as in all of our other graphs) in which, unlike the arithmetical scale, like relative changes or changes in per cent, cause like deflections or slopes of the curves, regardless of the kinds or sizes of units used. For example, a 10 per cent change in the 400 pounds of milk will cause the same slope or deflection of the milk line as a 10 per cent change would cause in the 10 pounds of coffee line. The logarithmic scale also makes it possible to plot the wide range of quantities from less than ten pounds of beans to the 1500 pounds total food and the 3400 calories.

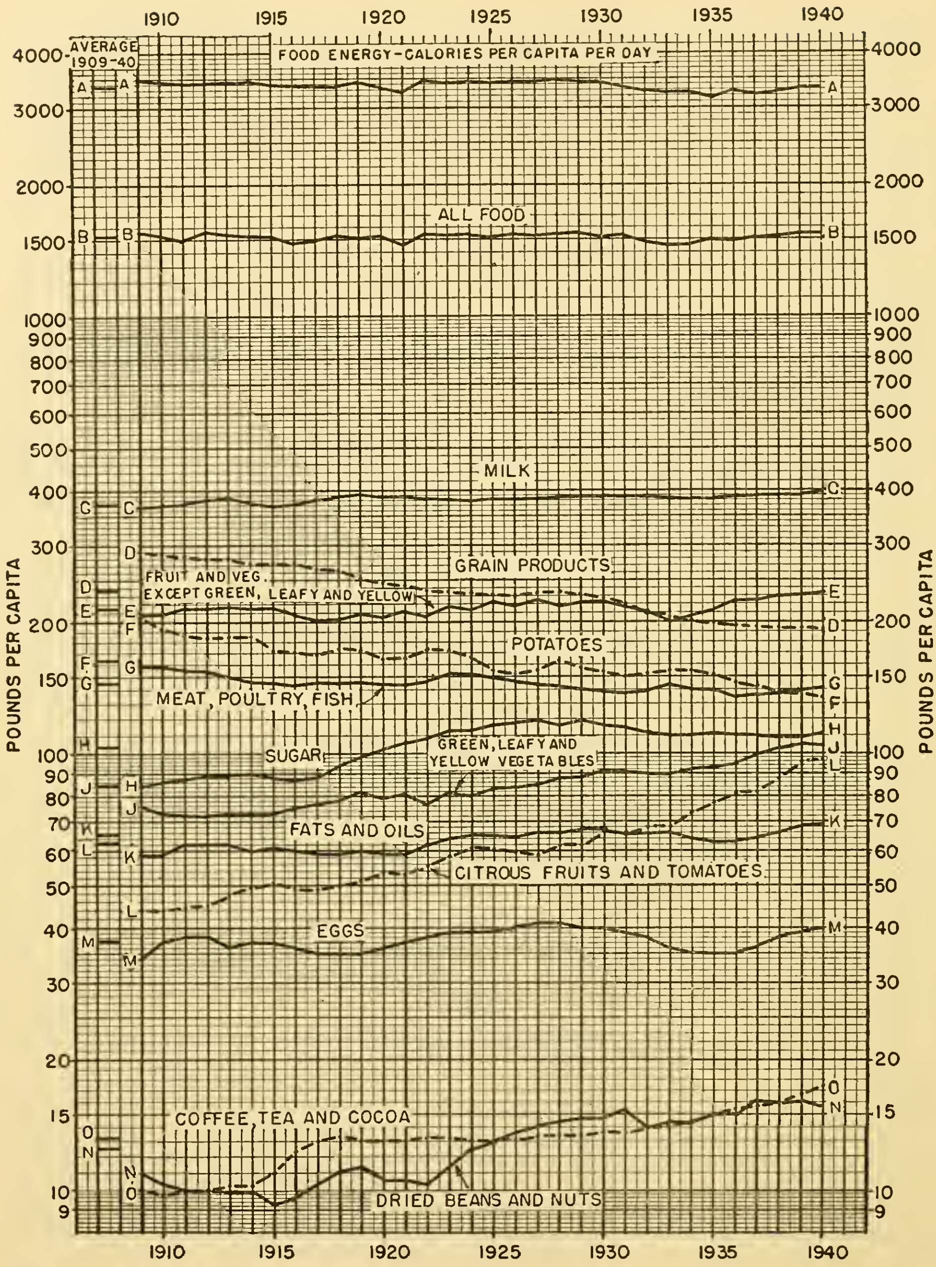

FIG. 1. Apparent per capita food consumption, United States, 1909-1940: Food energy (top curve) in average calories per capita per day; all others in pounds customary retail weights per year; curves for food energy and all foods not smoothed; all others smoothed slightly by 3-point moving average. Data from Cavin & Burke (1949).

were remarkably constant, the average annual deviations ranging from 1.7 per cent (riboflavin or vitamin B_2) to 4.5 per cent (ascorbic acid or vitamin C); a few of the maxima of deviations were somewhat larger, four out of 20 deviations being more than ± 10 per cent from the average; here, however, the larger deviations mostly result from significant increases in the late 1930's by the widespread interest in vitamins and minerals in the diet, and by the artificial addition of them to bread, milk, oleomargarine, etc. Prior to that time these deviations were smaller, and of the same order of magnitude as those of weight and energy content.

The figures above are subject not only to the errors of determination, estimate, and the factors of correction, but include also avoidable and unavoidable waste, spoilage, and the amounts fed to cats and dogs.[18] The totals therefore do not represent, in either weight or calorific or nutritive content, the amounts of food actually consumed, which must have been substantially less.

The total amount of food available or which disappeared in each of the years and as an average for the entire period considered was well above the Recommended Daily Allowances[19] for the United States population as a whole in total energy content and in the quantity of each of the essential protein, minerals and vitamins, indicating that the national dietary, considered as a statistical average, is adequate in both quantity and nutritive content.[20]

While the classes of foods and even the individual food products exhibit a remarkable constancy, there were changes among them which were of such nature as to compensate one another, so that the totals of weight, calorific content and the composition in nutritive elements showed, over all, little change from year to year.

The major and persistent changes that did occur were mainly decreases in grain products and potatoes, of low water and high energy contents, and corresponding increases in the watery but "protective" citrus fruits and green, leafy and yellow vegetables; a sufficient increase occurred in fats and sugars to make up the difference in energy content between the watery fruits and vegetables and the high-energy potatoes and dry grains.

This, the only major and persistent change or trend, did not come about suddenly, capriciously, or accidentally, but was undoubtedly the result of a long-continued pressure of thousands of articles in newspapers and magazines, lectures, books, advertisements, radio broadcasts, and educational

18. Fish alone was canned for dog and cat food to the extent of 63,783,000 net edible pounds in 1948.

19. National Research Council, Food and Nutrition Board, Reprint & Circular Series No. 129, 1948.

20. The above does not mean that the total food is uniformly distributed and everybody well fed. According to Edward Stieglitz (Book review, Science, Vol. 106, July 25, 1947, p. 92), 28 per cent of the U. S. population were 10 per cent or more *over* their optimum weight and only 12.8 per cent were 10 per cent or more *under* their mean normal weight.

courses over a period of a quarter-century, bringing to the consuming public awareness of the advantages of a better diet of protective foods.

All the above characteristics of the food market are but reflections of the underlying determinants of food economics, which are to be found in the physiological requirements of the animal body and in the factors of economic geography.

Physiological Basis of Food Economics. The first nutritive requirement of the human body is for *basal metabolism,* which is the amount of food energy required when the stomach is empty and the body is in complete repose; it energizes the circulation of the blood, respiration, muscle tonus, and other vital activities, but most of it is dissipated as heat in keeping the body warmer than its surroundings; quantitatively it is mathematically related to the weight and surface area of the body, and varies slightly from person to person; being in adult males about 40 calories per sq. meter of body surface per hour, and adult females 37 calories, or around 1800 and 1500 calories, respectively, per day. It is not subject to any voluntary variation (except medication) or economic influence.

In addition to the requirement of food for basal metabolism is that which supplies energy for work and all other physical activity of the body. For this use the body acts as an engine which transforms chemical energy of the food to muscular contraction or work, with a certain amount of loss as muscular heat in overcoming friction and viscosity of the tissues. This part of the food intake is directly related to the amount of physical activity; it is proportionately greater in the young than in the old, and greater in people of active than in those of sedentary habits.

The third major portion of food goes to growth of infants and children into adults, including extra requirements of pregnant or lactating mothers; it is the excess of total food assimilated above the requirements of basal metabolism and physical work. In this class may be included the excess fat accumulated by some people, especially adults in middle life. All of the food which accumulates in growth and fat is accounted for in the end and returned to nature in the bodies of deceased persons.

The total of the above three requirements of food energy range from about 1200 to 1600 calories per day for infants and young children and 2100 calories for sedentary and aged women, to 2800 for moderately active men and women (most of us), 3800 for boys in their teens, and 4500 for strong men in the prime of life engaged at hard labor. Taken as a statistical whole, the food requirement of the United States population works out at around 2800 to 3000 calories per capita per day, which agrees well enough with the actual amounts shown in the table after allowance is made for converting retail weights into food actually consumed, basic digestive inefficiency, etc.

This brief sketch takes no account of the variations from person to person in sickness and health, and under various climates and conditions of life, refinements, balancing and possible improvements in the details of diet with which the science of nutrition is concerned. For our purposes it is sufficient to note that there is little room for any voluntary expansion or contraction of the total with more or less money, income, or pressure of advertisement; it is fixed by the basic requirements of the human body as a machine, and there is little cause to wonder at the constancy in the national figures of food consumption as shown in the table.

Not only is this true of the gross quantity of food, but also of its individual components. The human body on the average requires a minimum of about 70 gm of protein per day, of which ten essential amino acids must be present in certain required amounts, also minima of fats and carbohydrates, iron, calcium, etc., as well as of several vitamins. On examination in detail of the historical record above referred to, it will be found that with little or no consciousness on the part of individual consumers, their choices of foods over the years add up and balance out so as to provide a very close approximation to the total amount, the energy content and the individual components which the body requires under the prevailing circumstances of life. Of the thousands of plants and animals on the earth which man might cultivate and domesticate for food, he has narrowed the list down to a few hundred (or a few dozen for the bulk of it), and of these few, his selections from day to day meet, with remarkable exactness, the basic requirements of his body. Change and improvement in diet, projected by scientific research in nutrition, are concerned with remarkably small differences between what is and what might be consumed, and these changes, as we shall see, are effected only by long continued pressure against great resistance and inertia.

The above study by Cavin and Burk is based on the situation in the United States; in all countries the total per capita requirements for energy and nutritive elements vary but little, but the total gross weight, being dependent on the kinds of food which make up the bulk, probably varies somewhat from country to country (Harper, 1945). In some parts of our country and to a considerable extent in some of the poorer and densely populated countries, the diet is in greater part the cheaper cereals, beans, rice, potatoes, and vegetables; in richer ones, the more expensive meats, poultry, dairy products, eggs, and fruits. In any country the shift may be toward higher or lower money value quality with prosperity and depression and with the income and education of the individual.[21] The total amount of food, of course, increases with increase of population.

21. For data and discussion of food consumption by families of different income levels, in city, town, country, regions, etc., see Food and Life, U. S. Dept. of Ag., Yearbook of Agriculture, 1939, especially Stiebling and Coons, Present Day Diets in the United States, p. 295-320, Yearbook Separate No. 1682; Sherman et al., 1944, How Families Use their Incomes, U. S. Dept. of Ag. Misc. Pub. No. 653.

It follows from the above, perhaps oversimplified, considerations that increases in the per capita consumption of one product or class of products must have the general effect of causing a decrease in the consumption of some other products of a similar or equivalent class.

In dealing with the economics of fish products in a national or regional dietary our main concern is the share in the limited total that can be supplied by fish products, which, being animal flesh and fat, compete, so far as we know, as the full nutritive equal, with meat, poultry, game, eggs, and perhaps cheese. The position that fish occupies in the dietary is fixed by a great number of determinants which dictate how much, where, when, and by whom, fish is purchased in competition with meats, etc. Many factors, such as price, national, racial, or religious customs, palatability, availability, appeal to the eye of the shopper, familiarity, convenience of preparation, and many others, determine not only how much of all kinds of fish collectively (as of any other kind of food) will be sold, but relatively, how much of each kind. Any improvement in any of these determinants with respect to, say, fish, expresses itself in greater demand and more sales. More sales up to a point result in lower cost per unit of handling, making possible still lower prices and still further increases in sales until no further increase in volume handled will result in lower costs. Increases in sales could be expected to work back to the fishermen, who would then receive more total money for their larger catch. The dealers would handle more fish and make more money and under the pressure of competition would be obliged to pass part of the savings to the fishermen and part to the trade. The larger reward attracts more fishermen from occupations ashore, and more investments in boats. The increased number of fishermen and boats divide the increased revenue, so that individually they are perhaps not greatly bettered, but the total revenue to the fishing community is increased.

Regional and National Dietary Pattern. The gross composition of national or regional dietaries is dictated by customs and habits which are historically made by factors of economic geography. Examples are Italian paste foods, tomato sauce, cuttlefish, squid, tuna and olive oil; German sauerkraut, sausages, and pork; Mexican maize, meat and pepper dishes of Indian origin; Dutch cheese; English roast beef and cabbage, Newfoundland potatoes and "Newfoundland turkey" or codfish; Chinese bamboo shoots and soya beans. The origin and historical reasons for many of these are known, some are lost in the ancient past. Some of our present forms of food are hangovers from primitive methods of preservation—smoked and salt-cured meats and fish, cheese, wine, pickles, etc., the liking for which still persists long after the need for them has been outmoded by better methods of preservation, such as canning, 125 years old, and refrigeration, 75 years old. Many of the food habits have become fixed by religious custom, law, and tradition, which, once established, are handed down from generation to generation and are exceedingly stubborn facts in food economics. In the United States, the colonists of various national origins brought their native habits, which were soon altered by new conditions of economic geography varying with different sections of the country. To the earliest colonies along the coast, fish, being easily caught, were important as part of the diet and as export goods for revenue. As the colonists moved into the interior, long distances, poor roads, and warm climate put them out of reach of fresh ocean fish, while abundance of rich land and good climate yielded the greatest plenty of high-quality food of agricultural origin. Accordingly, a continental pattern of food habits was established on the products of the farm from which fish was practically excluded everywhere except on the coastal fringe and around the Great Lakes. The new wave of immigrants from 1870 to 1914 brought national groups with new influences and reimposed some of the old-country habits—the Irish to Boston and New York, the Germans to Wisconsin and Missouri, Scandinavians to Minnesota, and Chinese to California, to mention only a few.

It is impossible to treat here, except in the briefest outline, the factors which have made and are still making our national dietary pattern. It is a spotty regional and local patchwork resulting from imposition of a new over an old pattern, later modified by improvements in agriculture, the coming of railroads, refrigerator cars and warehouses, still later by refrigerated auto trucks, and now by esthetic and scientific sophistication of consumers, mechanization of industry and daily life, rapidly increasing percentage of old people in the population, and many other influences which fix the gross composition of our diet, and, in particular, how much fish is included.[22]

Gross Composition of the National Dietary. The amount of fish in the diet of different countries varies greatly, as shown by production of 111 pounds per capita in Japan, 48 in Great Britain, to 20 in France, 8 in Mexico and 3 in Brazil. (FAO, 1945; other authors estimate these quantities at considerably lower, but proportionate, figures; some allowance must be made for imports and exports which vary from country to country.) The per capita consumption of meat and fish in the United States for the years 1930-47 are compared in Table 6.

The teachings of the history and economic geography of food are not only that the total quantity of food per capita is approximately a constant, but that the composition can and does change but slowly, and in response only to potent and persistent influence; that the amount of fish entering into the national or a regional dietary cannot be increased by wishing or hoping

22. For extensive information, treated here in briefest outline, see Yearbook of Agriculture, 1939; also Furnas and Furnas (1937).

TABLE 6

United States per Capita Consumption of Fish and Meat

Year	Fish Production gross weights United States and Alaska *	Fish Consumption † net edible portions				Meats, ‡ dressed weights exclusive of lard
		Fresh and Frozen	Canned	Cured	Total	
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
1929	23.4	—	—	—	—	—
1930	21.7	5.9	3.3	1.3	10.5	129
1931	18.3	5.0	3.2	1.0	9.2	130
1932	16.4	4.4	3.4	1.1	8.9	130
1933	18.0	4.2	3.9	0.9	9.0	138
1934	21.3	4.4	4.2	0.9	9.5	137
1935	21.7	5.2	4.7	1.1	11.0	116
1936	23.7	5.2	5.8	1.0	12.0	127
1937	23.4	5.6	4.2	0.9	10.7	125
1938	22.2	5.3	4.8	1.0	11.1	126
1939	22.6	5.4	4.6	0.9	10.9	133
1940	21.4	5.7	4.2	0.9	10.8	140

* Based on adjusted statistics in the Section of this Survey on Quantitative Economics. Weights are as landed or as usually reported by Fish & Wildlife Service. Cod, haddock, etc., gutted; mollusks, net edible weights. Production of Mississippi River system considered to be 45 million pounds in all years. Not adjusted for exports and imports.

† Data from Sherr, Power, Kahn et. al. (1948). Adjusted for exports and imports.

‡ Bureau of Agricultural Economics.

or sporadic advertising, nor (as seems to be so often assumed), by merely catching more of this, or that, or all fish. Any increase in the share of fish in the dietary (at the expense and against the competition of other items therein) can be effected only insofar as the determinants of demand are changed favorably for fish.

Our concern here is therefore with an examination of the determinants of demand, what they are, how they operate, and to what extent they can be influenced and how.

Factors which Affect Demand for and Distribution of Fish. In the United States, including Alaska and the Mississippi River system, for the period 1936-40 inclusive, the annual average total production of fish (4.362 billion pounds) was approximately a third (31.4 per cent) fresh and frozen, a third (30.6 per cent) canned, a little more than a third (35.5 per cent) made into by-products (fish meal, etc.), or used for-bait, and 2.5 per cent cured, smoked, salted, etc. Those which are canned cease to be fish in the trade sense and become canned goods; they pass through a system of brokers and wholesalers entirely apart from the channels for the distribution of fresh and frozen fish. Some of our comments (on religious custom, etc.) apply to fish in any form, but otherwise we confine ourselves here mainly to the commerce in fresh and frozen fish.

a. *Esthetic Characteristics.* The delicacies are mostly shellfish, oysters, shrimp, clams, scallops, crabs, lobsters, and certain forms of finfish, caviar, anchovies, sardines, and smoked products, such as herring, whitefish, salmon, sturgeon, etc. These are mostly expensive appetizers, hors d'oeuvres, or special dishes. The delicacies as here defined account for a substantial part of the money value of the fisheries, but a smaller part of the tonnage. In the United States in 1940 the shellfish alone before any kind of preparation amounted to about 25 per cent of the total value, and 11 per cent (much of it wholly edible, without waste) of the total pounds of the catch of fish of the country. The shellfishes stand in a class by themselves as gourmet items whose value is mainly esthetic since in quantity they contribute only a trifle in the total of national nutrition (2.5 per cent as much as all meat and only about 40 per cent as much as the domestic cheese). They are high in water content and low in fat and calories and when rated in terms of nutritional value only are excessively expensive.

Fishery products of the luxury class, including most of the shellfish, and some finfish such as whitefish and pompano, are *sui generis* in the market, are not substitutable by similar products, so that on scarcity their prices usually rise disproportionately, yielding to the fishermen more money for less production. On the other hand, the market for such items is definitely limited and excessive production will cause a sharp drop in prices. *Staple* or *finfish,* on the other hand, mostly have little or no *sui-generis-ness* (to coin a needed word); i.e., most of the bulk of common finfishes are ready substitutes one for another; it is a matter of indifference to the restaurateur and his guests whether he serves fillet of sole, flounder or haddock. There are a few differences or price classes, the fat and the lean ones, etc., but generally consumers can distinguish but poorly between approximate equivalents. For this reason the bulk of finfishes tend to act as an economic unit, all tend to move up and down together, and no one can depart far from its particular level in the general price scale.

Finfish generally are characterized by a fish flavor or odor, to which many people object, especially that of stale fish which develops quickly and easily, while meats and poultry are improved in flavor by the post-mortem process of ripening. Fishy odors are undoubtedly a hindrance to demand; they are also a troublesome factor in tainting kitchen utensils, refrigerators, the hands, and the air of kitchens; they are a considerable commercial impediment in that fish cannot be stored in refrigerated warehouses where eggs, butter and meats are stored, so that when trade is insufficient to support a public cold storage for fish, dealers have to provide their own, and in smaller places there is none and frozen or chilled fish cannot be held. Cold storage lockers and deep freeze cabinets are a promising new development in this field.

Apart from the fishy flavor, fish generally, especially the less fatty ones, are somewhat insipid. Pure proteins are practically tasteless; red meats and game generally owe their high flavors to the blood and "extractives" which are held in the tissues at slaughter. When slaughtered most fishes hold little, and some of them almost no, blood and extractives; generally they require special seasonings to overcome the deficiency of flavor. The bones in fish cooked whole are exceedingly objectionable. Few people know where the bones are, or how to eat a cooked whole fish without getting bones mixed with the flesh (an operation requiring some skill even of the expert). The consumer often gives up, leaving much edible portion, mixed with bones, on the plate. This objection is now being overcome by filleting the fish at some time prior to cooking.

Fish generally is not as belly filling as meats and usually does not give to the hearty eater as enduring a sense of having eaten a substantial meal. When one has a stomach-upset or food poisoning, it is almost always ascribed to fish (usually without proof) if any has been recently eaten. Superstitions about harmful combinations of fish, lobsters, shrimp, and crab with milk, ice cream, beer, etc., are widespread, and many people seem to think, without diagnosis, that they are "allergic" to fish. Typhoid epidemics and sewage pollutions of oysters and clams undoubtedly are a mental hazard out of proportion to their reality. On the other hand, with our increasing mechanization and diminishing demand for heavy foods, and with increasing proportion of elderly people in the population, fish is a more and more suitable source of animal protein and fat in the diet.

b. *Unfamiliarity of the Public with Fish.* The multiplicity of kinds of fish (about 150 fin and 40 shell), is undoubtedly a serious impediment to the sale of fish. We have no statistics on the point, but it seems to us certain that few American housewives in a typical inland city could identify the common fishes which they might see on exhibition on ice in a restaurant window. The same housewives could almost certainly identify all the ordinary cuts of meat, as well as poultry. This unfamiliarity is aggravated by the profusion of unstandardized common names, and ignorance of seasons of abundance, and leads to diffidence in purchasing and to deception by unscrupulous dealers. Being unfamiliar with methods of dressing and filleting, buyers of whole unpackaged fish leave this somewhat unpleasant work to the fishmonger who is often himself unskillful, so that a disappointingly small (and therefore expensive) edible portion is obtained from the gross weight purchased.

c. *Discontinuity of Supply and Consumers' Habits.* Habit is well known to be an important determinant of the choice of foods. Some of our food habits are temporary, but many or most of them are of long standing, acquired in childhood and passed from generation to generation. Not only are the consumers' habits themselves tenacious, but industries, often themselves complex, are built around them to supply the demand and become deeply embedded in the general economy. Any attempt to change or disestablish a fixed food habit is sure to be met, not only by the passive resistance to change on the part of the consumers, but by active fighting back of the challenged and well established producers.

Continuity of supply is highly important to the establishment or maintenance of a habit for any particular kind of food. In this respect a large part of the fisheries is at a disadvantage in the discontinuous, fluctuating, and seasonal nature of its supply. While some of our fishes, such as cod and haddock, are in year-round supply, and others, such as salmon, are made regularly available by preservation, a large part of the fisheries is without either of these aids. This is especially true of the miscellaneous fisheries for migratory species scattered along the coasts which are separately and locally too small to support manufacture and are without the militant power which would be required to force them into the market against established habit and competitive opposition. The industry relies for a large part of its market on the demand for fish of unspecified kinds, which is obviously not a firm foundation on which to hope to base a new habit. The motivation for heavy advertising drive is not present for the obvious reason that the benefits inure only in part to the advertiser of unbranded commodities; cooperative or trade association advertising is difficult to maintain, and governmentally subsidized help is certain to arouse political opposition.

d. *Religious Customs and Traditions.* The Jewish dietary laws permit only fishes with *both scales and fins* (Ginsberg, 1944). The fast days in Lent, Fridays throughout the year, and certain other days long established by the Roman Catholic and other churches have been adopted by the trade and public generally as fish days, with far-reaching effect. Whether the dedication of a particular day to fish is an advantage to the fisheries or not is at least doubtful. In effect it provides for 52 (sometimes 53) Fridays, plus Wednesdays in Lent and several Ember days. Insofar as each week's business is concentrated on Friday, each Friday represents 2 per cent of the year's trade. When a feast day, such as Christmas, falls on Thursday or Friday, that week's business is greatly reduced, even though the Roman Catholics observe the previous day as fast day. New Year's Day always falls on the same day as Christmas, and Thanksgiving Day practically eliminates one week every year, by reason of the left-over turkey; it would benefit the fisheries to celebrate Thanksgiving on Tuesday. A detailed study of holidays in a perpetual calendar would probably show a direct adverse effect of the fixed Friday on the sales of fish.

Even if one day must be chosen for fish, Friday is a poor day, because unsold goods may have to be carried over Sunday. By Monday, even if they are still good, they are always looked upon with suspicion. Dealers are therefore careful not to order more than they feel sure they can sell, for the profit, if any, is made on the last few pounds sold.

Friday fish day also has the effect of concentrating the work of distribution, so that all trucks, help, store space and facilities, and other overhead items of expense must be adequate to handle peak loads in a short time with little to do the remainder of the week. This effect would not be serious if the distributive mechanism were the same as that used for the meats which are displaced by fish on Fridays. The trucks, etc., would merely shift from meats to fish. Fish are for the most part moved by their own distributive system, partly because the odors, etc., may be imparted to other foods. Prior to 1921 the "Big Five" meat packers distributed fish, but were restrained from handling fish by a Consent Decree in the Federal District Court of the District of Columbia in that year under proceedings in an anti-trust case. The Decree was reaffirmed in 1929 on petition for rehearing by the packers. It is easily shown that meat packers could deliver fish locally along with meats (sales of one being down when the other is up) at a much lower cost per pound than an independent and separate fish distributing system could, with smaller volume and all overhead items taken into account.

Expense of Distribution. It was shown in the section on Production that, on the whole, fish are produced at first cost considerably lower than that of meat animals. It is a question for future investigation whether, or to what extent, this differential carries through to the consumer. Such information as we have suggests that most of the initial advantage is lost. The costs between the seacoast and the inland consuming markets are undoubtedly higher for fish than the corresponding costs of, and with fewer compensations than, meat products, in a number of details, among which are:

a. *Value of By-products.* At the source, meats gain an immediate advantage over fish in the greater number and value of the by-products derived from the animal. (See below, section on Manufacturing.)

b. *Labor in Manufacture.* Meats also gain an immediate advantage in the larger size of the individual animals, requiring less labor for butchering or any other manufacturing preparation than the very large number of individual fishes that must be handled for the same quantity and purpose.

c. *Cost of Distribution of Small Volume.* Since the per capita consumption of fish is small, all the overhead items of cost must be absorbed by a smaller total volume for a given community. In towns of 50,000 to 100,000 population beef, pork, lamb, etc., may arrive in carload lots by railway and, being relatively less perishable, may be held in large lots in cool rooms and locally distributed in large trucks, whereas fish, to the extent of not more than 15 per cent as much, must be delivered in small lots and disposed of immediately because of the greater perishability and because this small quantity, as we have just seen, is concentrated at a peak on one day a week. In small towns and villages the volume may be too small to be delivered economically at all.

d. *Shrinkage* in weight is commonly overlooked, but it may and often does amount to 10 per cent or more between landed and retail weights of whole fish, and must be allowed for between the successive dealers. Finfish are soft and lose weight very readily when handled, or when pressed down under ice in boxes and barrels. Loss by shrinkage is minimized in fish shipped as fillets; in fact, when brined, as they usually are in this country, fillets pick up four per cent or more of weight in the brine bath after they are cut. The washing or blowing of shucked oysters adds to their weight.

e. *Spoilage.* The loss of fish by spoilage in process of distribution is undoubtedly greater than that of meats. Losses must be and are reflected in the final prices in the long run, regardless of who is chargeable for them in a particular case. The *fear* of loss is perhaps a more potent deterrent than realized loss, especially in summer when all dealers minimize purchases to their estimates of sure sales rather than run the risk of loss on goods that might have to be carried over a week-end. In some products, a little pressure on a merchant by fear of loss sometimes promotes volume of sales, but in the case of fish, fear of loss seems to have the contrary effect of causing him to avoid the risk. Meats, of course, are carried over with little risk.

f. *Credit Losses.* Theoretically at least, a good case could be made for the proposition that credits should not outlive the goods on which they are extended, i.e., no credit should be granted on perishable fish which are either sold and consumed or spoiled and dumped, and cannot be repossessed, within a few days after shipment. Nevertheless, such credits are commonly extended, often 30 days, or tenth proximo, or indefinitely, resting only on the general credit rating of the dealer. In times of depression fish dealers and restaurants usually have little equipment, inventories, receivables, or other assets of value. Hotels are notoriously slow pay and the average life of the independent retail establishment is short. Credit losses, like those caused by spoilage, must be in the end provided for in the cost of distribution and reflected in final prices.

g. *Excess Weights Shipped.* In the case of whole fish, and oysters, clams, etc., in the shell, the shipping weights are excessive in proportion to the edible parts. Meats are always shipped dressed. Whole fish, on the average, are probably not over 40 per cent edible, and often less, as filleted by

TABLE 7

Values at Farm and Retail, Marketing Margin, Fifty-eight Foods, Hourly Earnings and Freight Rates ||

Year	Farm value *	Retail value *	Margin	Farm value as percentage of retail value	Index of hourly earnings of wage workers † 1926 = 100		Index of freight rates on farm food products 1926 = 100
					Current purchasing power	Constant purchasing power §	
	Dollars	Dollars	Dollars	Per cent	Per cent		Per cent
1913	134	252	118	53	44	63	67
1914	137	258	121	53	45	66	67
1915	134	258	124	52	45	65	67
1916	155	285	130	54	48	56	67
1917	223	370	147	60	56	48	68
1918	245	424	179	58	71	54	85
1919	267	470	203	57	80	58	85
1920	272	514	242	53	102	66	110
1921	179	404	225	44	95	97	108
1922	170	374	204	45	91	94	101
1923	173	384	211	45	95	94	101
1924	170	381	211	45	97	99	100
1925	198	410	212	48	99	96	100
1926	202	418	216	48	100	100	100
1927	190	406	216	47	101	105	100
1928	194	407	213	48	101	104	98
1929	195	415	220	47	102	107	98
1930	171	391	220	44	100	116	98
1931	121	322	201	38	95	130	97
1932	88	270	182	33	81	125	98
1933 ‡	92	264	172	35	78	118	97
1934 ‡	108	295	187	37	88	117	95
1935 ‡	138	331	193	42	90	112	92
1936	152	342	190	44	92	114	91
1937	160	353	193	45	101	117	92
1938	130	321	191	40	102	130	96
1939	126	311	185	41	102	132	96
1940	132	314	182	42	104	132	96

Estimates of annual purchases of foods by a typical workingman's family were obtained from the 1918-19 Cost of Living Survey made by the U. S. Bureau of Labor Statistics. The 58 foods include meat, dairy and poultry products, bakery and cereal products, a number of fresh and canned fruits and vegetables, and several miscellaneous items.

* Retail price data are from the U. S. Bureau of Labor Statistics, farm price data are principally those estimated by the Bureau of Agricultural Economics.

† The index of hourly earnings excludes agricultural workers and was published through 1934 by the U. S. Bureau of Labor Statistics. The indexes for years after 1935 have been estimated from hourly earnings in selected industries.

‡ No allowance is made for processing taxes on wheat, rye, rice, hogs, corn, peanuts, and sugar, which, on the quantities of these products included in annual family purchases, amounted to about $2.00 in 1933, $10.00 in 1934, and $11.00 in 1935.

§ In terms of the All-Commodity Wholesale Price Index, 1926 = 100 (B.L.S.)

|| U. S. Dept. of Agriculture, Bur. of Ag. Econ., National Nutrition Conference for Defense, May 26-28, 1941, Sec. 7.

unskilled butchers or retail fishmongers; where the 60 per cent offal plus ice and box are shipped in less-than-carload lots, the shipping costs are obviously extravagant. The practice of filleting at the source helps to overcome this handicap.

h. *Excessive Mark-ups in Prices by Shore Dealers,* especially in the smaller fishing communities. In some communities the number of dealers appears to be out of proportion to the number of fishermen and the amount of fish to be marketed, so that to survive on the small amount of goods handled severally by them, the dealers must mark up prices excessively; on a considerable part of what they sell, a second commission is charged by the large city wholesalers.

i. *General Primitiveness and Crudity All Along the Line,* of an industry which has never been the beneficiary of the scientific research, technical and engineering improvements in efficiency, expert management and salesmanship which are necessary to meet its competition squarely, and which have only feeble assistance from government, universities, and foundations. We do not even have the basic facts and statistical data from which to determine definitely where and what the weaknesses and inefficiencies are, and to measure them.

Fishermen's Share of the Final Value Compared with Farmers'. The net effect of all the factors mentioned above, most of them adverse to fish, is a *high cost of distribution which probably cancels most if not all of the low-cost advantage enjoyed by the fisheries at the port of landing.* Table 7, prepared by the Bureau of Agricultural Economics, shows, for 58 agricultural foods, the farm and retail values, the margin between the two in dollars, the farmers' share as per cent of retail values and for comparison the index hourly earnings of wage earners, and the freight rates. We have inserted a column of figures which are the annual equivalents of workers' hourly wages in money of constant purchasing power, 1926 = 100. The relation of farmer's share and the other costs of processing and distribution for certain particular foods and for all (agricultural) foods is presented graphically in Fig. 2.[23] It is observed that, say, in 1940 the working man's family retail food bill was $314, of which the farmer received $132, or 42 per cent, with a margin between the two of $182 for all other charges, expenses and profits. According to the graph, the farmer (in 1934 and 1935) received 40.3 per cent of the retail value of pork (approximately the same as the average percentage for all foods in those two years).

We have no statistical data on the average retail prices of fish, but it is

23. The table and graph are reproduced from U. S. Dept. of Agric., Bur. of Ag. Econ., (Handbook for) National Nutrition Conference for Defense, May 26-28, 1941, Sec. 7, Distribution & Processing of Foods, 11 p. See also, A. C. Hoffman and K. V. Waugh, Reducing the Costs of Food Distribution, in Food and Life, U. S. Dept. of Agric., Agricultural Year Book, 1940, p. 627-637.

obvious that the cost of distribution of fish is proportionately far more than it is for agricultural products, and that the fisherman receives a smaller share of the consumer's dollar spent for fish than the farmer does for each dollar spent for farm foods, and, as shown in the table, the farmer's share has tended downward. If the farmer's percentage for pork (40.3 per cent

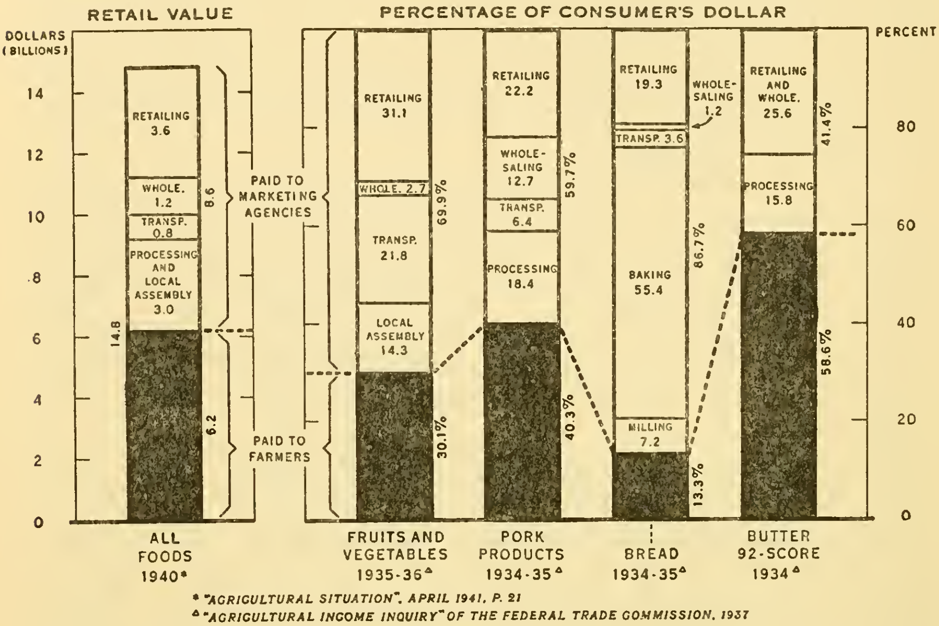

Fig. 2. BREAKDOWN OF FARM-TO-RETAIL PRICE SPREADS BY MARKETING FUNCTIONS

The proportion of the consumers' dollar represented by the charges for processing, transporting, wholesaling, and retailing food products varies widely, depending on the type of the product. For most food products the retail margin is the largest single element of the marketing spread, though this does not necessarily mean that retailing is done less efficiently than the other functions of food processing and distribution.

of the retail price) were applied to fish, then the retail selling price for all fish and for certain species would be shown as in Table 8.

Without statistical data on fish, we know that fish did not sell at retail for any such prices in 1940. Freight, express, ice, containers, etc., would consume most if not all the margin. These charges, as well as other overhead, being based on weight and not on value would in any event be greater percentagewise on cheaper goods.

In the attempt to check the above showing quantitatively, we have examined some of the current newspaper advertising of food stores in New York City and in North Carolina. They clearly show that extensive market research is needed before quantitative comparison can be made, since the net edible portions of fish and meats respectively cannot be ascertained

TABLE 8

Calculation of What the Retail Selling Price of Fish (1940) Would Be if Fisherman Received Same Percentage of Retail Value as Farmer Did for Pork (in 1934-35)

Fish	Fisherman's average price 1940 Cents	If fisherman's share is 40.3%, retail price in 1940 would be Cents
Cod	3.05	7.50
Haddock	3.30	8.20
Halibut	8.60	21.30
Gray trout (squeteague)	3.40	8.40
Sea bass	2.40	6.00
Mackerel (northern)	1.60	4.10
All food fish & shellfish	4.60	11.30

for comparison from newspaper advertisements. The indications, however, are that the edible part of even the cheaper fish costs as much as sausage, chopped beef, shoulder of lamb, etc., and when full allowance is made for edible portions, are equal in cost to the medium-priced cuts, and the more popular and choice fishes cost as much as choice cuts of meat. Some data bearing on this question is to be found in Sherman et al. (1944), showing the relative costs of fish and competitive foods to domestic households in 1942.

Distribution or Accessibility of Fish to the Consuming Public. One of the most important determinants of the quantity of fish consumed in national or regional dietaries is accessibility or opportunity of consumers to buy it. National average per capita calculations in a country as large as ours have only a limited significance. Actually, the products of the whole world's fisheries are consumed largely in small areas at high per capita rates, and very little elsewhere. In the United States, the distribution has been and still is extremely "spotty," though slightly less so now than it was thirty years ago. New York City is estimated to consume more than 20 per cent of the entire national production of food fish marketed fresh or frozen. No recent data on local per capita consumption of fish have come to our attention. During the 1920's the Bureau of Fisheries made marketing surveys in a number of cities, indicating, in edible portions, 32 pounds per capita in New York, 18 in Jacksonville, 11 in Atlanta and Pittsburgh, 9 in St. Louis and 6 in Louisville.[24] If fish were equally accessible and attractively

24. See (New York) Fiedler and Matthews, Rept. Comm. Fish. for 1925, (Doc. 996); (St. Louis) Fiedler, Rept. Comm. Fish., 1927 (Doc. 1026); (Atlanta) Fiedler, Rept. Comm. Fish., 1928 (Doc. 1039); (Jacksonville) Fiedler, Rept. Comm. Fish., 1928 (Doc. 1036); (Louisville) Hopkinson, Bur. Fish. Econ. Circ. No. 50; (Pittsburgh) Econ. Circ. No. 52.

presented everywhere, it cannot be doubted that the national per capita demand would increase. One pound per capita per year increase in edible portion would be equivalent to nearly half a billion pounds of whole fish or a third of the present production of fresh and frozen fish.

Local Preferences for Particular Species. Further study of distribution reveals the preference in certain localities for certain particular kinds of fish. For example, mullet and red snapper, though popular in the South, are rarely seen in New York; New England whiting for many years enjoyed sale in only one market in the United States, namely, St. Louis, later Kansas City, and still later, some of the other mid-western cities—notably in Louisville and Nashville; cod is preferred in New York and Detroit, haddock in Boston, catfish is primarily preferred in the South; "ocean perch" or rosefish seems to be preferred in Des Moines, Kansas City, Minneapolis, Milwaukee and St. Louis; flounder is popular in Philadelphia except when shad is available; the Jewish population of New York is strongly inclined to fresh water species—carp, perch, etc.—and the fresh water fish trade of New York is almost entirely in the hands of the Jewish fish merchants.

The geographic influences which we mentioned earlier do not explain these and many other local preferences. The latter are undoubtedly caused by historical events which have initially created persistent local demand, but failed to be recorded and are lost to history. The catch of whiting and rosefish from New England, until a few years ago insignificant or nonexistent in commerce, grew in the past few years to a production of 175 to 200 million pounds, or one-fourth of the total finfish of New England (and three-fourths as much as cod and haddock combined). This remarkable development was certainly in part a response to a long established and persistent demand for small pan fish by the rapidly growing midwestern population which had overwhelmed the fisheries of the lakes and rivers. It may also be in part due to a change in the relative abundance in the water and in cost of production of the species concerned. Without the demand the fish would not have been produced, however abundant; and without the supply the demand could not have been met at costs and prices that would not kill demand. A comparison of fishermen's prices for these four species (rosefish, whiting, cod and haddock) shows that even after allowing for the differences in recovery of edible portions (cod, haddock and whiting 40-42 per cent, rosefish 27 per cent) the fishermen could advantageously produce these substitute species and sell them at prices to the consumer lower than those for cod and haddock. This is but one example of the interaction of biological and economic factors as a self-regulatory mechanism, and points out the futility of attempt by public authority to determine, from biological reasoning only, how much of what particular fishes the fisherman should catch and, by corollary reasoning, what fishes should be sold.

Domestic Household and Institutional Consumption. It is generally considered in the trade that restaurants, hotel dining rooms, and institutions are relatively more important consumers of fish than private homes, though we have no direct statistical data from which to make the comparison. Sherman et al. (1944) in a national survey of domestic food consumption (mostly after Easter) in 1942 indicate that the consumption of fish in homes was 13.3 pounds per capita of the whole country, which can be compared with upwards of 20 pounds production (we do not have the data for 1942 for all fish). Since the per capita for homes only is less than that for all outlets, restaurants and homes, it is inferrible that the per capita of restaurants is greater than that in homes. The data on which these calculations are based, however, are none too reliable.

In judging the market potentialities of a region such as North Carolina with a small urban and large rural population, consideration has to be given not only to the difficulties and overhead costs of delivering fish to small communities, but also to the relative importance of restaurants and private homes.

Resultant Effect of Determinants on Amount of Fish in the Dietary. We have mentioned a few of the factors favorable and unfavorable which taken all together determine how much fish on the average people buy, viz., the esthetic (or unesthetic) qualities of odors, bones, insipidity, belly filling satisfaction or lack of it, superstitions and beliefs, direct and indirect effects of religious customs and traditions, economic difficulties which increase costs between shore and consumers and minimize volume of sales, spotty availability, unfamiliarity of the public with the many kinds of fish, discontinuity of supply—and such favorable qualities as those possessed by the gourmet items, lightness and digestibility, suitability for people of sedentary habits, and escape from monotony of meats—all these factors, favorable and unfavorable, taken together fix the amount of fish that is admitted to the inelastic dietary. These factors are objective determinants, some of which can be, but none have been, measured quantitatively by economic research; they are no less potent, indeed they seem to us more potent, in determining the magnitude and prosperity of the fisheries industry than biological and legislative factors of production. Aside from the effects of booms and depressions, inflations, deflations and wars, all of which are temporary, *there appears in the record so far no reason to expect any spontaneous events that will help the fisheries of this country as a whole to any higher degree of prosperity than they now have.* The chief problem of the fisheries industry is to improve its distribution and to develop the markets in regions where consumption is now far below the national average.

Importance of Technical Improvements and Merchandising Enterprise. It is known that Kansas City and St. Louis are among the best markets in the interior of the country for certain kinds of ocean fishes. They were for years oases in a fisheries market desert. The origin of these markets was the enterprise of particularly able merchants and their organizations operating effectively for many years. These examples show clearly that *demand for fish is subject to change, can be created and encouraged by aggressive effort,* and can have an important bearing on the possibilities of marketing fish in North Carolina.

The most effective development for increasing the share of fish in the national dietary has been and is the combination filleting-packaging-quick-freezing-refrigerated cars and trucks and deep-freeze-retail-and-home-cabinets. These items and developments here concatenated are one development.

Up to the end of World War I, all fish that were not canned or cured were shipped whole in boxes or barrels of ice. One hundred pounds of whole fish with a like amount of ice and 25 pounds of barrel or box weighed 225 pounds and contained 40 pounds of edible fish. This perishable product, with a bad record for spoilage and refusal, took the highest railroad and express tariff, and on arrival at city of destination was practically excluded by its disagreeable nature from favorable location by landlords and zoning regulations, and from food shops where other goods were sold; it was forced to some poorly accessible corner of the city market. Finally, when and if purchased, the housewife often had the problem of disposal of 60 per cent of the whole as useless and disagreeable waste. The new marketing technique began in 1921 in the separation and shipment of edible portions of fish, followed in 1924 by quick freezing and shortly thereafter (1925) by unit packaging of not only frozen fish (which could not stand alone in the market), but also (1927) of fruits, vegetables, poultry, meats, berries, etc. Soon followed the installation of refrigerated dispensing cabinets (1930), making possible the marketing of unit-packaged frozen perishables, and therefore the widespread expansion of retail distribution and finally (1940) domestic "deep freeze" storage cabinets; and lately (1946) pre-cooked complete meals in frozen form. The prospect for the next improvement is air transport for the more expensive products.[25] These developments have greatly facilitated and are facilitating the mass distribution of fish (as well as other perishables) by the great chain store organizations and thousands of other retail food stores, and have presented fish to consumers to whom it had been theretofore inaccessible. Fishery statistics of the region (New England) where these improvements originated and reached their highest development clearly reflect the benefits in a growth considerably exceeding

25. See Larsen, Reitz and Burgum (1948).

the general Index of Industrial Production. (See below, p. 381, also Figs. 7 and 9, and Tables 41 and 48.)

Advertising and the Competitive Position of Fishery Products. Commodity goods are generally not advertised (though there are exceptions), even when they have competitors in other commodity goods (coal vs. fuel oil and natural gas). The benefits of expensive advertising would inure only in part to a single advertiser of unbranded and unidentified products, the rest to the benefit of his competitors. Such advertising as is done in the food field is very largely of branded specialities, i.e., low cost, high price products, with sufficient gross margin to pay for the expensive advertising. The citrus fruit growers of California and Florida cooperatively advertise their few kinds of fruit. In the fisheries the competition is internal, i.e., fish vs. fish of other kinds and places, or of fishermen and dealers with each other for whatever market exists spontaneously, with little effort to increase the total of fish vs. its real competitors, meat, poultry, and eggs. The fisheries are not a single industry but an assortment of allied mutually competitive industries. Cooperative trade association advertising is frequently undertaken in some industries, as it has been at one time and another in the fisheries (one is under way now), but in the past they have always broken down through failure of support by the many diverse small and competitive interests for the sustained program on a national scale that would be necessary for real success. Sporadic advertising programs are regarded by experts as a waste of money.

The fisheries considered broadly have in fact a most excellent story to tell which would be the envy of many another industry. It has "romance" in the mysteries of the ocean and fascinating life in the sea, in the vastness of its depths and areas, in the marvellous round of world chemistry, in human interest in fishing and fishermen, in the variety of their products, their low cost and excellent food values. The advertiser of fish would be embarrassed, not by inability to think of something to say about his products that has not been worn threadbare by repetition, but by the overwhelming profusion of too many things that could be said.

Competition for a place in the national dietary is severe; every item in it is struggling for a larger place, and there is no golden rule other than the well known formula of better goods, more attractively presented at more places, aggressively merchandised, efficiently delivered at lower cost and cheaper prices where and when it is wanted.

MANUFACTURING

Effects of Fluctuations in Supply on Employment of Capital and Labor. Fluctuations and discontinuity of supply of raw material profoundly affect the economics of manufacture of fishery products and by-products. Where the supply is seasonal, both plant investment and labor are idle between seasons. When the plant is not working, not only is capital unproductive but the labor force must be disbanded, and reorganized for each new season. Even where the raw material is in year-round supply, it fluctuates in quantity and often also in price from day to day. Under the latter conditions, it would be advantageous to buy raw materials only on days of plentiful supply and low price, and not to buy on days of short supply. Such operations tend to equalize prices and absorb the full production but at the expense of a larger number of idle days in the year, and do not provide continuity and security of employment of labor, so that if the market cushion is provided for the fishermen, it is to the disadvantage of shore labor. The fisherman's problem, arising from irregularity of supply, is to a considerable extent merely transferred to the shore processor.

Limits to Mechanization. Because of the periods of idleness, especially where manufacture is seasonal, it is necessary to keep the capital investment as low as possible; machinery must be simple and cheap. The damp and salty atmosphere at the seashore is highly corrosive and in prolonged periods of idleness the machinery deteriorates rapidly unless it is made of stainless materials, which are expensive and involve much capital investment, but where precision and close tolerances are necessary, stainless metals must be used.

In the mechanization of manufacture, the fish industry is embarrassed, as it is throughout, by the many kinds and sizes of fish. It is now possible to design a machine that will do almost anything the human hand can do, and feasible if it does the same thing all the time and it is economical to do so, but then only if the volume of manufacture is large enough to justify the design and construction of the machines. The problem is difficult and expensive in the fisheries, even for one species of fish which varies greatly in size; when to this difficulty is added the requirement of versatility of machines to work on different kinds of fishes of diverse shapes and structures, the problems are often beyond economical solution.

Main- and By-products Manufacture. The main products of the fisheries are used mostly for human food. In canning most of the equipment serves for fish that is standard for other foods; it is neither delicate nor very expensive and operates at high speed. The great bulk of canned fish is in a very few species, salmon, tuna, and sardines, which are known and accepted in world trade. In this country, a secondary line includes shrimp (inferior to, and in competition with, fresh shrimp most of the time), mackerel, oysters, dog and cat food, codfish flakes and-cakes (the latter about two-thirds potatoes), and clams for chowder. To this may be added a long list of appetizers, hors d'oeuvres and tidbits, most of which are "dust catchers" on grocers' shelves. The business in these items is slow and difficult. Canned fish are classified in the trade as groceries, and do not move through the same channels of trade as fresh and frozen fish. If we assume that on the average canned fish is 60 per cent of the whole fish from which derived, the total pack is about 29 per cent of the whole catch of fish in the United States and Alaska in 1940, and 42 per cent of that part of the catch which is used for human food.

Salting is obsolescent as a preservative, and smoking is of limited importance.

Freezing is now, next to canning, the preeminent preservative, and is becoming more important with fillets and other prepared edible portions. The total of all fish frozen in 1940 was about 5 per cent of the total catch of all fish in the United States, and about 7.5 per cent of that part of the catch which was used for human food. These figures are somewhat misleading, since 26 per cent of the total frozen is in fillets, shown separately, and an unknown quantity not shown separately. If the 26 per cent edible portions separately shown are converted to round fish on the 40 per cent basis, the percentages would be 7 per cent and 10.5 per cent respectively. Tables 59 and 60, Appendix, set forth the money values of canned and quantities of frozen fish in the United States in 1940.

Refrigeration serves several economic needs, (1) to level off short term fluctuations by relieving temporarily glutted markets; some of this is done by chilling rather than freezing; (2) to carry over the excess heavy production from summer to winter season, which is the season of heavy demand. Table 61, Appendix, shows, for 1945, the monthly production and disposal of the catch of fish in the United States; 66 per cent of all fish was produced in the months June to October, inclusive, and 24 per cent November to March, inclusive; (3) to play an essential role in the new system of distributing "quick" frozen packaged foods at retail. In economic aspect, one important factor is often (and sometimes disastrously) overlooked in the location of a general purpose freezer and cold storage, i.e., that these plants usually best serve their purposes at or near the big city markets. Whether to freeze or to sell fresh at the market is usually determined by price on the spot. The shipper, remote by one to three days from the market is in no position to determine what the price will be when the fish arrive, and therefore cannot decide whether to freeze or sell.

Filleting. The business of filleting at the source beginning in 1921 has grown to such extent that, in 1940, the production was 111,200,097 pounds, valued at $13,149,372, or 11.8 cents per pound. In addition 14,274,543 pounds of steaks and other edible portions were produced, at a value of

$791,653, or 5.54 cents per pound. The total of all edible portions manufactured at the source was 125,474,640 pounds, valued at $13,941,015, or 11.1 cents per pound, made from 31 trade species of fishes.

The catch of these 31 species was 948,826,000 pounds, valued at $29,-670,000, or 3.13 cents per pound. We do not know the equivalent in whole fish of the edible portions. The average edible portions that were recovered in the laboratory by Atwater (1888) of 63 specimens representing 36 species was 48.22 per cent without skins. This figure is doubtless too high for an average of commercial filleting by hand as now practiced. Rosefish, now one of our major items (not used for food in Atwater's time), yields only about 26 per cent, including skin, but after candling to remove those fillets which contain parasites; cod and haddock yield about 40 per cent (of gutted fish) skins off.

At three assumed average percentages of recovery, there are calculated in Table 9 the equivalent pounds of whole fish required to make the 125,-500,000 pounds of edible portions, the percentages these quantities of whole fish are of the total production of the 31 species from which edible portions were made, and of the total production of fish marketed as fresh or frozen, and, finally, the cost of raw materials per pound of fillets.

TABLE 9

Production of 125,500,000 Pounds of Fillets and Other Edible Portions 1940; at Specified Assumed Percentages of Recovery, the Calculated Equivalents in Whole Fish, the Percentages These Are of Catch, and the Equivalent Raw Material Costs

Assumed recovery percent	Equivalent in whole fish million pounds	Percentage of total catch		Equivalent of cost raw material per pound of fillets cents
		Of 31 species from which derived *	Of all fish marketed fresh or frozen †	
36	346	36.5	23.7	9.7
38	330	34.6	22.6	8.2
40	313	32.8	21.4	7.8

* Total catch of the 31 species from which edible portions were made, 948,826,000 pounds, valued at $29,670,000, or 3.13 cents per pound.

† Total round fish weight of fish marketed in fresh or frozen form in 1940, 1,461 million pounds, unofficial estimate, U. S. Fish & Wildlife Service.

Although these figures are over-all unweighted averages and at assumed, probably generous, estimates of recovery, they give some idea of the narrow profit margins on which the fillet business is based. With a market value of 11.1 cents per pound, we may compare costs of materials at from 7.83

cents to 9.7 cents to which must be added costs of labor and supervision, overhead, packaging, depreciation, sales, bad debts and manufacturer's profit, if any. The most favorable assumption of recovery allows only 3.27 cents and the least favorable 1.4 cents to cover all these items. It is clear from these figures how close is the margin on which filleting is done. *The business of filleting, as practiced in 1940, yields practically no manufacturing profit,* but it improves the competitive position of fish making a more convenient and presentable product which is salable through outlets which cannot handle whole fish. It also affords employment of labor at the points of production and retains the offal for possible manufacture of by-products.

Filleting can be, and nearly all of it has been, done by hand. It requires a considerable skill, and some filleters are more skillful than others, so that the averages of speed and recovery are well below the best. With diminishing size of fish, the cost of filleting mounts rapidly; with increasing size, the labor cost diminishes up to the point where the individual fillets are too big and must be subdivided. Filleting machines are just now coming into use which yield a higher percentage of weight than the average hand filleting. These machines are complicated, made to close tolerances of precision, and necessarily made of stainless steels, so that they are expensive.

In places where raw material is available the year round, and volume is large (as in cod, haddock, pollock and rosefish fisheries of New England), the more nearly continuous operations are favorable to the employment of both labor and capital; large and continuous volume also makes feasible the use of expensive filleting and accessory conveying and other machinery and leaves a sufficient volume of offal for economical manufacture of fish meal. All of these things compound the disadvantages of smaller fishing communities with smaller volume of assorted kinds of fish in intermittent supply. These disadvantages can be compensated only in part by less continuous employment of labor and at lower wages. Thus it appears that, at least with respect to finfish of the coarser varieties, *the smaller communities have been put to a still greater disadvantage by the trend toward edible portions than they already suffered with whole fish.* At the same time, because of the growing popularity and marketing advantages of fillets, *smaller communities are being put to a certain compulsion to fillet or else see their present disadvantages further aggravated.*

By-products. In value of by-products, fish are undoubtedly at a disadvantage in competition with land animal industry. The latter, in addition to edible meat, yields gelatin, hides, hair and wool, membranes, and a wide variety of biological and medicinal products of high unit value, such as insulin, adrenalin; liver, thyroid, and pituitary extracts; hormones, pepsin, pancreatin, trypsin, bile salts, cholestorol from spinal cords, products made from blood, and a great many others, as well as lard, suet, brains, liver, heart, kidneys, sweetbreads, etc., used for food.

Finfish are vertebrate animals, though not mammals. Their bodies are cold. They have glands, liver, and viscera which produce hormones, enzymes, etc., but we know relatively little about these substances in detail. Fishes have thyroid glands, their stomachs and intestines produce digestive enzymes which are active at very low temperatures, and we know that at least some fishes produce insulin. It is a common error, however, to speak of fish broadly in such way as this, as if all fishes were physiologically alike. They are probably as diverse physiologically as they are anatomically.

Glandular and other biological products of fishes, some possibly of great value, have so far been commercially unavailable (except the liver oils) because individual specimens are too small and numerous for economical recovery of the glands. It is quite practicable to pluck out of hogs on a conveyor line the pancreas, kidneys, liver, etc. The corresponding organs in fishes are too small and too difficult to find. Even the vitamin-bearing liver oil widely prevalent in fishes is economically produced only from certain large fishes whose livers are very rich, such as cod, halibut, tunas, swordfish and sharks. The organs of fishes (except, to a small extent, the roes) are not even used as food.

The by-products so far recovered from fish are relatively few, and mostly crude and low priced. Among the high priced items are exceptionally rich vitamin liver oils from certain species, and pearl essence, a minor product made from the silvery epidermis on herring scales. The glue industry based on cod skins is successful and well established, as is the shark-skin leather industry on a small scale, but the tanning of other fish skins has made little progress. Isinglass formerly made from the air bladders of cod and hake has been supplanted by other clarifiers of beer and wine, and the industry based on it has disappeared. It may be that amino acids or protein hydrolysates made from fish can be something of permanent value, but they must compete with proteins from animals and especially with skim milk and yeast, from the latter of which most of the present production is derived. Just now, one of the amino acids, methionine, of great nutritive value, found especially in fish muscle, is attracting attention.[26] Protamines, used in medicine to retard the effect of insulin, have been made from the milt of salmon. The livers of the tile-fish contain what appears to be an exceptionally powerful fat-splitting enzyme which might be of commercial value, but it has not been studied scientifically. Seaweeds yield agar, alginic acid, carrageenin and other gels and mucilages of importance. In short, the sea offers a tantalizing assortment of possibilities of fine chemicals and biologicals, but under the handicap of small size of individual fish, irregularity

26. The synthetic product is (Sept. 1947) on the market at $11.00 per pound.

of supply, the few and poorly equipped laboratories, the non-scientifically-minded fisheries industry has done little to exploit them.

By-product Oil and Meal. The leading products of the fisheries other than human food are oil and the dried substance of fish free, or nearly free, of oil. The dry substance of edible grade for animals is fish meal, of lower grade it is scrap used for fertilizer.

Meal and oil are made as by-products from the residues of fish left from filleting, canning and other preparations. Meal, oil, and scrap are the main products from the menhaden, dogfish, and shark fisheries, and from a large part of the production of certain edible fishes, such as pilchard, herring, and some others caught and processed in their entirety for this purpose.

a. *Fish Oil.* It is a singular fact that the oil or fat in fishes is stored in either the body of the fish, or in the liver, but rarely in quantity in both body and liver. In the salmon, herring, menhaden, shad, mackerel, mullet, eel, etc., the bulk of the oil is in the body; in the sharks and codfishes it is contained in very large quantities in the liver (50 per cent or more) and the livers of halibut, tunas, swordfish, and several others, contain 10 per cent to 20 per cent oil. The liver oils are generally rich, and the body oils relatively poor, in vitamins A or D or both. Accordingly, the liver oils used for medicinal purposes command a very much higher price than body oils which are used mostly for industrial purposes. Vitamin A is present in all fish livers that have been examined, but in greatly varying amounts and concentration; vitamin D is much less prevalent, being absent from all sharks and sturgeons (whose bones are not calcified); it is found in high concentration only in the swordfish and tunas. Both vitamins seem to be most highly concentrated in big fishes and old individuals, and in species that are high on the chain of life, several stages from the basic vegetation. These are not only more economical to handle because of their large size but yield more vitamins. Much vitamin liver oils go to waste in small fishes because of the expense of collecting the livers.

By far the greater part of vitamin liver oils come from Pacific Ocean species, both oriental and occidental. The tuna, swordfish and halibut, found in both the Atlantic and Pacific yield oils of about the same quantity and potency, but these fishes seem to be less abundant in the Atlantic. The greatest of all sources of vitamin A are the Pacific sharks (dogfish, soupfin and hammerhead). Their relatives, the Atlantic spiny dogfish and the South Atlantic and Caribbean sharks, yield relatively low potency oils.

All of the vitamins were originally found in and derived from natural foods; all of the common ones are now manufactured synthetically, except, until recently, A; however, this vitamin may go the way of all the others from natural sources to chemical synthesis. Announcement was recently made[27] of the synthesis of vitamin A and the beginning of a pilot plant for commercial manufacture. It is therefore not safe to assume that the fish industry has a permanent monopoly on vitamin A. Indeed, with the accelerating advance of the arts of chemical synthesis the days of many natural products in commerce may well be numbered.

The average U. S. production of fish body oil for the four years, 1940-43, inclusive, was 22,769,699 gallons of fish body oils (inclusive of menhaden, but exclusive of whale and seal), valued at $12,009,689, vitamin liver oils 969,157 gallons valued at $11,209,154. The total of all oils was worth $23,218,843. Those manufactured oils were in value equal to about 17 per cent of the total value of whole finfish caught in 1943.

The statistical position of fish meal, fertilizer and oil manufacture in the United States in 1940 is shown in Table 62, Appendix.

Fish Meal and Fertilizer. The menhaden is used solely for the manufacture of fish meal, fertilizer and oil; a large part of the catch of Pacific Coast pilchard or sardines, and some part of the Alaska and North Atlantic herring are used whole for the same purpose, and in large centers of filleting and canning, the residues are used for manufacture of fish meal (and oil from the residues of fatty fishes).

The main use of fish meal is as a protein supplement (5 to 10 per cent) to cereals as chicken feed. Much careful scientific work has been done on the rations of chickens. Table 10 presents (hitherto unpublished) data supplied by, and published here by permission of, Dr. R. M. Bethke of Ohio Agricultural Experiment Station, comparing the nutritive values of various protein supplements, when fed at the same level of protein content of the whole feed. The results are expressed in grain feed consumed per gram of growth of chicks to eight weeks old, and the percentage of mortality.

In the United States there is strong demand for fish meal; in the world as a whole the demand may well continue for all that can be produced economically because of the relatively small amount (5-10 per cent) required to supplement cereal ration for production of poultry, meat and eggs where, as in human foods, protein is the scarcest fraction. Yet, as in vitamin A, we cannot take for granted a monopoly in any market. Recent (1948) discovery and isolation of the cobalt-containing "animal protein factor"

27. Cawley, J. D., C. D. Robeson, L. Weisler, E. M. Shantz, M. D. Embree, and J. D. Baxter. Crystalline Synthetic Vitamin A. Paper presented at the Section on Enzymes, Hormones and Vitamins, New York meeting of the American Chemical Society, Sept. 15, 1947. See also Chem. & Eng. News, Vol. 27, 1949, p. 2106; Helvetica Chemica Acta, Vol. 32, 1949, p. 443-452. Distillation Products, Inc., began production of vitamin A in 1948, and in Drug & Allied Industries, Vol. 36, No. 2, February, 1950, full scale commercial production was announced by Hoffman-LaRoche, Inc.; and small scale commercial production with full scale in the near future by Charles Pfizer & Co., and by Merck & Company.

TABLE 10

Rates of Growth of Chickens on Rations Containing Various Protein Supplements

Supplement in Ration	Trials	Chicks	Average weight at 8 weeks	Average feed per gram gain	Average Mortality
	No.	No.	Gm.	Gm.	Pct.
Soybean oil meal (expeller)	8	370	616	3.26	0.54
Soybean oil meal + 5% dried skim milk	6	290	652	3.16	0.34
Meat scraps (50% protein)	6	280	556	3.47	1.80
Meat scraps + 5% dried skim milk	5	240	615	3.30	0.00
Menhaden fish meal	8	360	658	2.99	0.28
Menhaden fish meal + 5% dried skim milk	6	280	665	3.01	0.00

(vitamin B_{12}) is already (1949) being advertised to reduce the protein requirement in chicken feed by as much as one-half.

Bethke who furnished the material in Table 10 estimated that the United States poultry and other animal industry could use about 375,000 tons of fish meal per year (as of 1942). This amount would be the equivalent of the entire production of every kind of fish in the United States and Alaska in 1940.

In 1940, the United States produced 126,736 tons of fish meal valued at \$5,471,557 (\$43.20 per ton, average), and imported 39,233 tons valued at \$1,909,531 (\$48.60 per ton). It produced 66,508 tons of scrap valued at \$2,362,264 (\$35.50 per ton) and imported 6,900 tons valued at \$310,586. The grand total of all production of meal and scrap was 193,244 tons, worth \$7,833,821.

Nearly half of this total production of meal was in very fat fish (pilchard, menhaden, and herring) which because of the value of the oil can support fishing operations for meal and oil only; the remainder was largely derived from residues in tuna and mackerel canneries on the Pacific Coast, the waste from which yielded a substantial amount of oil; from shrimp canneries and from cod, haddock, redfish, etc., filleting operations—material on hand the cost of which could be charged to the canned or filleted products.

Marine animal tissues and even seaweeds are unsurpassed as fertilizers, for they furnish not only nitrogen, phosphorus, potash, calcium, sulphur, etc., but also the exceedingly important trace elements, iodine, boron, manganese, fluorine, copper, cobalt, and several others, some of which are essential for plants, others for animals, and still others essential for both plants and animals.

The ocean contains and could supply a practically unlimited amount of meal and fertilizer of highest quality not only from the inedible residues of fish now caught, but from "trash" fish—such as starfish, sea urchins, skates, sculpins, horseshoe crabs, sharks, lizard fish, mussels, porcupine fish, trigger fish, fool fish, leatherjackets, sea anemones, jellyfish, sponges—in fact, all the odds and ends that are not otherwise useful. Some of the richest agricultural land in the world is the northern coast of France which was fertilized for centuries with seaweed. The utilization of this oceanic material would go a long way to promote the production of food for man. It might even be biologically helpful to the fisheries in removing some of the enemies, and competition for food, of the fishes we most esteem.

The sea could thus not only supply man with edible food, but could forever furnish replenishment of fertility to the soil for agricultural production and the nitrogenous nourishment of animals. It is all a matter of cost.

The sale of fish and other products for human food is governed only in part by price in relation to scientific calculation of nutritive values; demand and price are heavily influenced also by such qualities as taste, odor and appearance of the product, and habits, whims and prejudices of the consumers. Meal is purchased by the chicken grower and farmer solely on very close and unemotional calculation of cost and performance against the market prices of their products. The esthetic feelings of chickens and farm animals are not taken into consideration.

Apart from the oil content, the average water content of fish is about 80 per cent and the flesh-and-bone content about 20 per cent. On the average, wet fish, less oil, dries to about 1/5 of its weight, so that each one dollar of cost per ton wet weight becomes $5 on the dry weight. Moreover, oil itself is generally of value only insofar as it can be economically extracted and sold as oil; it cannot be extracted economically unless the percentage is relatively high. Most fishes average about 5 per cent oil content which is rather low for economic removal by present methods. Five per cent oil in wet fish is 25 per cent in dry meal, which is objectionable in feed and useless in fertilizer. The fat content of the residue meal from oily fishes is reduced to about 6 per cent or 7 per cent by efficient methods of manufacture.

With the average value of fish meal in 1940 less than $50 per ton,[28] the fish would be worth only ½ cent per pound even without cost of preservative, handling, manufacture, overhead, or profit. It has been found in the New England trawler fishery that it does not pay to bring in trash fish even after they are caught because labor cannot be compensated for handling, to say nothing of preservation, without making the material too expensive for the manufacture of fish meal. It is therefore a disconcerting fact that

28. These costs and values of 1940 are of course now changed greatly, but their position relative to the value of the dollar probably remains or will remain unchanged.

in cost and with technical methods now available, the vast resources of the sea, except those which pay their way with oil or human edible portions, are economically beyond reach for fertilizer and animal nutrition.

In small communities the fisheries are probably again at a disadvantage in competition with big centers like Boston. Fish meal manufacture is a low-price large-volume operation; no satisfactory process has been developed for making it economically on a small scale.[29] Though the present outlook does not seem very favorable, it is perhaps not hopeless that much needed small and inexpensive plants for converting residues from filleting, trash fish, etc., into fish meal may be established in small fishing communities, where the labor would be of the nature of self-employment by fishermen and their families.

Concentration of Manufacture in Few Species and Places. The data summarized briefly in this section on manufacture clearly show that of the two hundred or more commercial species of fishes produced along the approximately 10,000 miles of general coastline of continental United States and the southern coast of Alaska, by far the greater part of manufacture is based on a very small number of species or varieties. Of the canned fish, 92 per cent of the value of product in 1940 was made up of salmons, tunas, sardines, shrimp, mackerel, and clams; of the frozen fish and fillets two-thirds of the total was in eight trade varieties; of fish meal, 88 per cent was made up of five trade varieties, and of fertilizer 96 per cent was menhaden, and in oils, both body and liver, a small list of fishes yield the greater part. In each of these manufactures a long list of minor and "other" varieties taken together contribute a small part of the total. Also it is well known that the great bulk of the manufacture (detailed data not available) is done in a few cities or fishing centers—Boston, Gloucester, Seattle, San Francisco, Monterey, San Pedro, and a few others. The products are manufactured from the species which are in large enough volume and steady enough supply to justify investment of capital and employment of labor and support wide enough distribution to build public familiarity and demand; and the work is done in places where this supply is landed, facilities, skilled labor and transportaton are all available, and where the raw material accumulates for the manufacture of by-products.

"Mother" Ships, Manufacturing, and Processing at Sea. The fisheries of the United States and, indeed, of all other countries are prosecuted in fresh water and around the fringes of the land as near to consuming markets as costs of production permit, but even the near-by ocean fisheries are situated at a disadvantage in competition with agriculture, a disadvantage which

29. A home-made apparatus with process of operation requiring much hand labor has been described by the Anglo-American Caribbean Commission (1945); it is doubtful that this technique would be practicable in North Carolina.

is aggravated by the perishability of the product. Latent fisheries at still more remote places in the world which might add substantially to the world's food supply are little or not at all exploited. Various proposals have been made, and some of them tried, to fillet, package, freeze, can, and otherwise manufacture or process at sea, to provide "mother" or transport vessels to service fishing vessels at sea and transport their produce to market, and in various other ways to ameliorate the difficulties deriving from remoteness and perishability. Unfortunately most of the experience in this direction has turned out to be disappointing, for a variety of reasons which cannot be here reviewed in detail.

In the case of "mother" ships to supply trawlers or other vessels at sea and to collect and transport their produce to market, there are to be considered the technical difficulties of transferring fuel, ice, and fish from one vessel to another in all kinds of weather at sea even if it can be demonstrated that, on the average, the value of the additional fish caught in the increased fishing time of the trawlers is not outweighed by the cost of the transport vessel and crew. In some remote fisheries, such as those for tuna where the product is of relatively high value and the shore industry based on it is substantially profitable, the refrigerated vessels can be considered as economically justifiable transportation not otherwise available. There seem to be few fisheries having such characteristics.

In the case of proposals to fillet, package, and freeze, or simply to freeze, at sea it should be understood that a trawler (and nearly any other kind of fishing vessel) is a highly specialized implement designed on the basis of long experience for the sole purpose of catching fish. If it must also perform these other operations it must be a larger and more expensive vessel to accommodate the additional motive power, fuel, refrigerating compressors and freezing equipment, packaging machinery, materials and supplies, storage spaces, larger crew and dining and living quarters. Such a vessel is large and poorly maneuverable, and as a fishing vessel it is inferior to the standard trawler; as a portable factory and crew it is idle when fish are not caught, and has none of the advantages of mass production. Unless the operations are expanded to manufacture fish meal which now seems out of the question, the offal must be dumped as waste.

The large factory ship of the "hen and chickens" type, i.e., a large factory, storage, and dormitory ship attended and supplied by a fleet of smaller fishing vessels, does not have a good history of experience. The Japanese operated floating canneries for crab and salmon, but European experience in halibut fishing and freezing in Davis Straits west of Greenland was financially a failure.

In all such operations—trawlers, mother ships, and floating factories—among the difficulties are those of finding a satisfactory basis of settling with crew, and of exercising managerial remote control. Fishing is traditionally rewarded by sharing the proceeds of the catch among crews, captains, and owners, and manufacturing labor is traditionally compensated by wages. To devise an equitable system of risks and rewards where a hunting expedition is to be mixed up with an industrial manufacturing operation would be no simple undertaking. The human problems arising from the crowding of large numbers of men for long periods of time in small quarters with little or no recreation, and with the inevitable conflicts and sicknesses, as well as mechanical and many other kinds of mishaps, constitute a formidable hindrance to an enterprise which requires large capital investment and offers only a narrow margin of profit even if successful. Yet herein lie the problems that must be solved if the resources of the sea as a whole are to be fully put to use. The reason why the remote fisheries of the world are not exploited is not to be found in ignorance or unawareness on the part of the fish industry, but in the fact that it does not pay to exploit them. As long as all the fish that the markets require can be supplied at the cost of fishing near by, no one is going to distant waters at higher cost to try to supply still more.

Quantitative Consideration of the Fisheries

COMPARATIVE MAGNITUDES OF THE FISHERIES

Presented here are some quantitative data, assembled and calculated from various sources, which are useful in viewing the magnitudes of the fisheries in their proper perspectives and relations to other magnitudes, and necessary to the understanding of the economic position of the fisheries as a whole.

Land and Sea, World Magnitudes. The production of fish in the world, partly estimated, is 37 billion pounds per year (FAO, 1945); if 15 per cent of this is inedible, the remaining 85 per cent or 31.5 billion pounds is human food. The population of the world is about 2.2 billion; the per capita wet weight of whole fish per year is therefore about 14.3 pounds, which may be compared with about 1500 pounds gross weight per capita consumption of all food (1520 in the United States); i.e., as a rough approximation, fish is a little less than one per cent of the total food supply of the world by physical weight. If fish as landed is on the average 40 per cent edible flesh, then the amount available for food would be about 5.6 pounds per capita per year. Fish flesh is about 75 per cent water, 25 per cent solids. On the dry basis, the gross per capita would be 3.6 pounds and net edible 1.4 pounds per year out of the annual 560 pounds dry weight per capita estimated by Harper (1945). Fish thus supplies about 0.65 per cent of the gross weight, dry basis, of the food of man. Fish contains, on the wet basis, about 18 per cent protein having

1700 calories per pound of protein and 5 per cent of fat having 4000 calories per pound of fat, or about 500 calories derived from protein and fat per pound wet weight of fish. If the edible portion is 18 per cent protein, fish would supply 466 gm. protein per capita per year or about 6.7 days' recommended allowance of 70 gms. per day.[30] Assuming that all fish produce is human food, the world production of about 5.7 pounds net edible fish therefore appears to contribute about 2800 calories as a maximum or one day's adult energy requirement, or 0.27 per cent of the required energy for each inhabitant of the world each year, at the rate of less than one-half pound per acre of ocean. This is a small amount of subsistence to be derived from the 71 per cent of the whole surface of the earth which is covered by sea and receives 71 per cent of the sun's energy arriving on the earth and contains the great bulk of the earth's fertilizers. The 139,295,000 square miles of ocean area is 40.4 acres per capita of the world's population, the gross product of which is only 266 pounds per square mile, or 0.42 pounds per acre.[31, 32]

The 57,655,000 square miles of land area of the earth, 16.8 acres per capita, supports 2.2 billion people with a little less than 100 pounds of food per acre, or over 99 per cent of the supply, and in addition the non-food products of agriculture and forestry. On the average 2½ acres of cultivated farm land supplies the subsistence for one person. (United States, 2.43 acres.)[33]

Various estimates have been made of the annual production or pasturage of basic vegetable matter in sea water, one of which is 4,000 tons minimum per square mile in the English Channel (literature cited and reviewed by Harvey, 1928). Riley (1941, 1944) summarizes the literature and presents original findings showing that the average basic production in Long Island Sound involves the fixation of 375 grams of carbon per square meter of surface per year which we compute (at $C \times 13.5 =$ wet plankton) is equivalent to 14,400 tons of vegetables per square mile per year. For Riley's estimated average production of the open ocean (340 grams total carbon fixation per square meter per year) the vegetable production would be 13,100 tons per square mile per year. Riley (1941) reckons the animal plankton in Long Island Sound at probably 0.1 to 1.0 per cent of the vegetables on which it subsists, or, say, up to 140 tons per square mile, with an absolute maximum of 17 per cent or 2,200 tons. The larger animals, including fish would, of course, be a still smaller amount. With these figures may be compared our

30. Nat. Res. Council, Food and Nutrition Board, Reprint & Circular Series, No. 129, 1948.

31. See Taylor (1932) for a summary of the various magnitudes of the ocean.

32. The above reckoning does not include whales, the world catch of which may be estimated at about 10 per cent as much as the catch of fish. At the present rate of capture, regulated by international agreement at 16,000 "blue whale units" (unit = 1 whale 100 ft. long) per year, the yield is about 2 billion pounds of oil and 3 billion pounds of scrap and bones; about 2 billion pounds of edible meat could be supplied by whales. Very little of it is now used for human food.

33. See Cooper, Barton and Brodell (1947), p. 24, for details of farm acreage and its produce.

five tons of fish ultimately derived from this vegetation in United States coastal and inland waters, and only 266 *pounds* per square mile of the whole ocean.[34] Riley concludes that the production of vegetation per square mile at sea is considerably higher than that of forest or cultivated land (160 grams of C on cultivated land, 200 to 250 in good forests, corresponding to 4,900 and 6,120 tons, respectively, of wet vegetation per square mile).

Comparative Magnitudes of the United States Fisheries. In recent years the gross yield of the commercial fisheries of the United States and Alaska has ranged from 4 to 4½ billion pounds or 2 to 2¼ million tons annually, valued (1940) at about $100,000,000. This amount is about 11 per cent of the estimated world production of 37 billion pounds.[35] While seemingly large (and increasing with increasing human population), this gross yield appears to be small not only by comparison with the fertility, productivity and area of the waters concerned, but also with the yield of the fisheries in other parts of the world, with the yield of competing products of agricultural origin on land, and with numerous other criteria of measurement.

The area of the continental shelf of the United States proper (narrow under-water offshore ledge or fringe of the continent out to the 100-fathom line) is about 300,000 square statute miles; that of the southeast and southern shore of Alaska (Dixon's Entrance to Attu Island) about 150,000, and the inland fresh waters including the Great Lakes, about 100,000 square miles.[36] In addition, there are sounds, bays, and estuarial inshore waters, and certain offshore banks of a few thousand square miles.[37] Also, some of the yield from pelagic (surface swimming) species (such as tuna, mackerel, herring, etc.) is taken at sea beyond the shelf. For a roughly indicative calculation, however, we may take the area of the shelf as our source of fish in the United States. On this basis, and at an annual total of 2 million tons of fish, our waters yield about 10,000 pounds or 5 tons of produce per square mile, or 15.6 pounds per acre, of continental shelf. This quantity, while small, is much larger than the average of world production if reckoned per square mile (266 pounds) or per acre (0.42 pounds) of the whole ocean. This 5 tons of fish per square mile appears exceedingly small when compared with the estimated 10,400 tons of vegetation per square mile of open sea, and 14,000 tons in Long Island Sound.

Recalling again Riley's estimate that this production of basic vegetable food at sea is about twice what it is on cultivated farm land (10,400 tons of wet vegetation at sea, 4,900 tons on cultivated land), it is interesting to

34. Seiwell (1935) estimates the carbon fixation even of the relatively poor waters of the tropical western Atlantic (between 14 degrees N. and 3 degrees N. along the 40th meridian) at 278 gm. per square meter per year.

35. Food and Agriculture Organization, 1945.

36. Information supplied by U. S. Coast & Geodetic Survey.

37. The New England offshore banks, including the Grand Bank of Newfoundland, have about 75,000 sq. mi. area.

compare the amount of agricultural land in the United States with the amount of productive fisheries bottom area of fresh and salt water.

It is difficult to find a basis for comparison of the amount of agricultural land in the United States with the area of bottom that is fished or accessible to fishing. The area of the continental shelf of the United States, southeastern Alaska, plus the Great Lakes, etc., as above, is about 352 million acres, with an indefinite addition in areas at sea beyond the limits of the continental shelf of which the northeastern banks constitute about 50 million acres. The agricultural land of the United States is summarized for 1945 as follows: [38]

In farms (Millions of acres)	1,142
Pasture	529
Not plowable	420
Plowable	109
Crop failure and cropland lying idle or fallow	50
Cropland harvested	353
Farmsteads, lanes and waste	44
Forests and cut-over land	166
Pastured	95
Not pastured	71

It will be noticed that the continental shelf, etc., is almost exactly the same area as the agricultural cropland actually harvested, not including pasture land. Nearly all of the cattle and sheep production is based on pasture land, but pigs and poultry are largely fed from harvested crops, while fisheries at sea may be regarded as all based on the equivalent of pasturage.

Agriculture supported a farm population of 30,546,911; the fisheries (including Alaska) supported, at least in part, 124,795 fishermen (1940), or, with their families, perhaps 400,000 people; agriculture produced vegetable crops to the value of $3,470,000,000 [39] and livestock of $4,873,000,000,[39] both together $8,343,000,000; the gross value of all fish was $100,000,000. United States agriculture produced 18,995,000,000 pounds [39] of *dressed* meat, which at 54 per cent, represents 35 billion pounds of whole animals on the hoof, or nearly equal to the 37 billion pounds of the estimated entire world production of whole fish; United States fisheries produced 4,000,000,000 pounds *gross* weight of fish, or about 1,600,000,000 pounds of net edible fish flesh; but about a third of all was used for oil, fish meal and fertilizer. Moreover, United States agriculture continues to enhance its efficiency of production. Mechanization alone since the end of World War I has released for production of other crops 55,000,000 acres formerly used for growing animal feed. Each farm worker today produces food for himself and thirteen others; in 1850, himself and three others.[40]

38. Statistical Abstract 1948, Table 653.

39. From the U. S. Bureau of Agricultural Economics: Statistical Abstract 1947, Tables 700 and 731.

40. Cooper, Barton and Brodell, 1947.

The infinitesimal smallness of the draft on the waters by our fisheries is further shown by the amount of fertilizing elements which have been extracted from the water and are contained in fish. At an estimated average content of 3 per cent nitrogen and 2.2 per cent P_2O_5 (phosphorus pentoxide), fish are considered to be good agricultural fertilizer and have been so used. If the entire production of fish of the United States and Alaska were converted to fertilizer, it would provide only 7.4 per cent of the nitrogen (815,000 tons N) contained in the supply of commercial fertilizers allocated to the United States in 1948 by the International Emergency Food Council[41] and 2.3 per cent of the estimated (1,850,000 tons) phosphate (P_2O_5) supply.[41] Indeed, the P_2O_5 supply in 1948 itself nearly *equals the total wet weight of our annual fish production* (2,250,000 tons 75 per cent water), and the fertilizer elemental fixed nitrogen supply is 36 per cent as much as the total wet weight of all fish produced. At this rate, if the entire catch of fish of the United States and Alaska were used for fertilizer, it would take thirteen years' fishing to supply one year's requirement of agricultural nitrogen, and forty-two years for the phosphorus.

If the water over the continental shelf is an average of 50 fathoms or 300 feet deep, the 300,000 square miles of area of continental shelf of the United States proper would represent 17,100 cubic miles of sea water, and the 150,000 square miles off south and southeast Alaska, 8,540 cubic miles of sea water, a total of 25,640 cubic miles (not including inland fresh water). If we assume an average nitrogen content of 80 mg. N., and phosphorus of 20 mg. P_2O_5 per cubic meter, 187 cubic miles underlying 0.73 per cent of the area of surface would contain all the nitrogen and 548 cubic miles underlying 2.1 per cent of the area would contain all the phosphorus of our entire 4½ billion pounds of fish per year; at a uniform depth of .01 mile (52.8 ft.) the corresponding areas of water would be 83 per cent of that of Lake Michigan for the nitrogen and 1.7 times that of Lake Superior for the phosphorus. That is to say, the draft on the fertilizer content of the ocean water would be negligible, even if the supply were not continuously replenished by circulation of the water.

We cannot here discuss in detail the causes of this unfavorable comparison of the yield of the water with that of the land. The difference may be found in part in our failure to make the fullest use of aquatic resources; in another part the great difference may be accounted for by the losses in the numerous steps in transformation of microscopic aquatic vegetation into useful animals. Almost certainly the difference lies, on the one hand, mainly in the controlled restriction of agricultural production to wanted plants and their direct conversion into desirable animals, and on the other, the undirected course of wildlife at sea. In the uncontrolled state on land (as among the

41. Lodge, F. S., Fertilizers in 1947-48. Chemical & Engineering News, Vol. 26, p. 18-19, 1948.

primitive tribes) it is obvious that by far the greater part of all vegetation escapes conversion into any form of animal life; a small part is eaten by insects and their larvae, by grazing animals, rodents, and birds, but most of it is degraded by molds and bacteria into humus, and eventually oxidized into inorganic substance, or else formed into peat, lignite, or coal. At sea, it also appears probable that most of the vegetation fails to enter the animal chain, but decomposes in the water and returns to the fertilizer cycle, or sinks to the bottom and there decomposes or is converted to petroleum, while of that small part which is transformed into animal life, the greater part assumes forms not useful to man.

Comparative Production of Principal Fishing Regions of the World. Comparison of the fish production of the North American continent and its component parts with that of the North Sea, all of northwestern Europe, and the Far East, indicates that waters of the Western Hemisphere are relatively lightly fished in comparison with those of other parts of the world, and that the more heavily fished waters of the older fisheries are themselves continuing to yield larger quantities than ever, insofar as statistics are available for comparison with prior years.

Table 11 has been constructed for such comparisons. For example, the North Sea alone, having 210,000 square miles of bottom, less than one-third the area of the Gulf of Mexico, produced (on the average of 1936-37-38) of herring 6.4 tons; non-herring 2.3 tons; all fish 8.7 tons per square mile, a total of 2,846 million pounds, or 63 per cent as much fish as the entire United States and Alaska, including all fresh water fisheries; and 45 per cent as much fish as the entire North American continent, in both oceans and fresh water, Mexico, Newfoundland, St. Pierre, Miquelon, Canada, and Alaska.

In the North Sea, the volume of production of the last four pre-war years (1935-38) was the largest for any consecutive four years of record, although this sea has been fished for centuries, intensively for the past fifty years and with little benefit of regulatory legislation. While the production of bottom living fishes as a whole declined, some of the bottom species declining apparently to the point of diminishing returns, the increase in the herring fisheries more than compensated, so that the yield of the sea as a whole was at a record level.

The entire North American continent, fresh and salt water, both oceans and the Gulfs of Mexico and California, produces only 70 per cent as much fish as the single-ocean fisheries of northwestern Europe from Gibraltar to the Arctic, but exclusive of Spain and Soviet Russia.[42] It produces only 82

42. For which two countries the figures for the Atlantic Ocean production are not separately available. For Spain, Atlantic and Mediterranean in 1940 the production was 967 million pounds (FAO, 1945).

TABLE 11

Percentage Comparison of Production of Principal Fishing Regions of the World. All Figures Based on Three-year Averages, 1936-37-38, Except Newfoundland (1937), Mexico (1940), Soviet Asia (1938), and China (1939). Quantities in Thousands of Pounds

(Example: The production of the North Sea was 41 per cent as great as that of Japan proper).

World * 36,779,900									
45	Pacific East Asia, Indian Ocean excluded: China, Japan, Soviet Pacific † 16,724,900								
25	55	Northwestern Europe ‡ 9,149,600							
19	42	76	Japan proper § 6,972,900						
17	38	66	91	North America: United States, ‖ Alaska, ♯ Canada ‡‡ Newfoundland, §§ Mexico ‖‖ 6,348,500					
12	27	49	64	70	Japan coastal fisheries only ** 4,483,400				
12	27	49	64	70	100	United States ‖ and Alaska ♯ 4,474,600			
10	22	40	52	57	81	81	United States ‖ 48 States only 3,626,900		
8	17	29	41	45	63	63	78	North Sea †† 2,832,524	
5	11	20	27	30	42	42	52	66	Canada ‡‡ Newfoundland, etc. §§ Mexico ‖‖ 1,874,500

* Food & Agriculture Organization, (1945).
† Pacific only, excluding Indian Ocean:
Japan proper 6,972,871,000, Supreme Commander Allied Powers, (1947), Average 1936-37-38.
Japan colonial, 4,734,135,000 " " " " " " "
Soviet Asia, 2,127,849,000, (1938) Food & Agriculture Organization (1945).
China, 2,890,000,000, (1939) " " " "
‡ All countries of Atlantic Northwestern Europe from Gibraltar to the Arctic, except Spain and Soviet Russia; Greenland and Mediterranean France excepted. Averages mostly for 1936-37-38, a small amount 1935-36-37. Source: Cons. Perm., Bull. Statistique, 1938 (1944).
§ Japan proper; fisheries based on main islands, including all coastal, inland and overseas fisheries, but excluding colonial fisheries, aquiculture, seaweeds, whales and other aquatic animals not fish and shellfish. SCAP, (1947).
‖ This Report, Appendix, Table 39, average of 1936-37-38, for seven coastal and Great Lakes regions, plus Mississippi River, including shells, 1931.
♯ Alaska, this Report, Appendix, Table 52, average of 1936-37-38, exclusive of whale products, etc.
** Fish and shellfish only; other aquatic animals and seaweed excluded. SCAP, (1947).
†† Average 1936-37-38. Cons. Perm., Bull. Stat., 1938 (1944).
‡‡ Average for 1936-37-38, 1,267,819,000 pounds: Fisheries Statistics of Canada, 1945 (1947).
§§ Newfoundland, 1937, 450,000,000, St. Pierre and Miquelon, 1942, 1,638,000. Total 451,638,000 pounds. Food & Agriculture Organization (1945).
‖‖ 1940, 155,100,000. Food & Agriculture Organization, (1945).

per cent as much as the fisheries based on Japan proper, exclusive of her colonial fisheries, and 36 per cent as much as the Pacific coast of eastern Asia, according to the figures available (FAO). The fisheries of Japan proper are prosecuted in a coastal strip extending from 30 degrees to 50 degrees N. lat., equivalent to the distance from northern Florida to northern Newfoundland.

It is a striking fact that the herring family (Clupeidae) supplies almost the same 45 per cent of the total production of fish and shellfish of each of the three major fishing areas of the world for which we have statistics, representing about 57 per cent of the total partly estimated world production (36,800 million pounds).

TABLE 12

Per Cent of the Total Production of Fish and Shellfish Supplied by the Herring Family (Clupeidae)

	Number of years average	Total Production fish and shellfish pounds (000,000)	Herring family pounds (000,000)	Per cent herring family
Northern Europe * (16 countries), 1935-38	4	8,400	3,870	46.1
Canada, 1941-44 †	4	1,349	624	46.7
United States and Alaska, 1936-40 ‡	5	4,384	1,997	45.6
Japan, coastal and off-shore, 1936-39 §	4	6,690	2,992	44.7
All, above regions		20,823	9,483	45.6

* Atlantic herring, pilchard, sprats.

† Atlantic and Pacific herrings, Pacific pilchard, alewives, shad.

‡ Atlantic and Pacific herrings, Pacific pilchard, menhaden, alewives, shad, hickory shad.

§ Pacific herring, and other herrings, a sardine (*Sardinia melanosticta*), some anchovies (*Engraulis* and *Etrumeus*).

Summary. The take of fish from the water appears to be exceedingly small when considered along with a variety of other magnitudes, such as (1) the basic amount of vegetable food produced per acre of sea, and the basic production per acre of agricultural land; (2) the water area, compared with the land area of the world; (3) the amount of fertilizer contained in fish when compared with the small amount of water which would contain this amount of chemical nutrients, and also when compared with the amount of chemical fertilizer actually used each year by American agriculture; (4) for the United States and the North American continent, the extent and production of our fishery under-water areas compared with the extent and production of intensely fished areas in other parts of the world; (5) the amount and value of fish as compared with the amount and value of agricultural produce, plant and animal; (6) the small contribution made to the dietary (about one per cent of either the gross bulk or the food energy in the United States); (7) for the United States, the number of fishermen and their families who are provided livelihood by the fisheries compared to the actual farm population.

When these comparisons are made, the production of fish, and the draft made upon the waters by the fisheries everywhere, and especially in the United States, appear to be trifling, and the question urges itself upon us, are the fisheries really capable of yielding only so little as this, and that little half herrings? If, at the present level of exploitation, our main concern must be that even this little may be too much for safety, then the fisheries cannot be looked upon as a major source of subsistence for man as a whole, and is of considerable importance in only a few limited spots.

These comparisons carry the implication that the extent and danger of exploitation at present practiced possibly may not be the main problem of the fisheries, since depletion has not seriously and continuously occurred in the fisheries of any region, and the implication also that the real and pressing problem is to find ways and means of making greater and more effective use of what the waters offer. The economic data to be found further in this chapter seem to point to the same conclusion.

THE UNITED STATES FISHERIES

The total quantity, value, and prices of all fishery products and of food fish of the United States fisheries, and the average numbers of fishermen engaged therein, all considered broadly and historically, exhibit definite characteristics and trends. In order to bring these into view, the historical record of the fisheries of the whole country was examined and, after necessary adjustments, the main data were arranged in tabular and graphic forms, in which can be seen the working of the main determinants of the fisheries. These general data will be presented first, and will be followed by a consideration of the fisheries in some of their parts, sections, species, and other details, wherein will be seen, at least in outline, the mechanism by which these determinants operate.

Procedure. The data used in this quantitative study, except where otherwise specifically noted, are those of the U. S. Fish & Wildlife Service and its predecessor Federal Government agencies. For purposes of field statistical canvasses, the country has usually been divided by the Federal agency into nine regions, as shown in the calendar and index of such canvasses in Table

37, Appendix, which we have endeavored to make complete.[43] It was found impracticable to use in this study the statistical record prior to 1887; since useful data from Alaska are not available with satisfactory continuity and content prior to 1929, only limited use could be made of the figures from that territory; the Mississippi River and its tributaries have also been omitted because they have been canvassed only six times and apparently not always over the same geographical area, though summary tables of both Alaska and Mississippi have been included for convenient reference. The main serial tables which we have constructed and relied on in this report are therefore made up of data from seven regions—the five Atlantic and Gulf of Mexico regions, the Great Lakes (American side only) and the Pacific States. The degree of coverage and the distribution of the canvasses in various time periods are shown in Table 13.

TABLE 13

Recapitulation and Per Cent Coverage of Regional Statistical Data of United States Fisheries 1887-1940. (Seven * Regions of the United States Proper Considered in this Report)

Period	Number of canvasses required for complete annual coverage of all seven * regions	Number carried out	Per cent of total annual coverage of all seven * regions
1887-91	35	22	63.0
1892-96	35	3	8.6
1897-08	84	24	28.5
1887-08	154	49	31.9
1909-20	84	6	7.2
1921-27	49	16	32.7
1928-40	91	81	89.0
1921-40	140	97	69.0
1887-1940	378	152	40.2

* New England, Mid-Atlantic, Chesapeake, South Atlantic, Gulf of Mexico, Great Lakes, Pacific.

In the entire 54-year period, 1887-1940, the seven regions here considered were all canvassed (or the data otherwise obtained) simultaneously only in

43. Numerous partial and special surveys of regions, States, rivers and particular fisheries, summaries, etc., and records of vessel landings, are also available. Some of the regional data in the calendar, especially in late years, were obtained by some of the States and published and sponsored by the Federal Government.

1908 and the years 1929-32 and 1937-40.[44] The period between 1908 and 1915 is totally void, and nearly so to 1918 or 1920. For practical purposes the whole statistical history covered is therefore in two separated periods, 1887-1908 and 1915-1940, and some of the graphs cover, for the late period, only the most dependable years, the period 1921-1940. The annual series for the early and late periods were made continuous by interpolation in the void years within these periods.

In preparation for interpolation the data for the various States and parts of States were first assigned consistently, so far as possible, to their proper regions (as they are not in the original records). This operation required considerable manipulation. The total numbers of fishermen (not consistently classified in the record) for the regions and years were abstracted so as to exclude "shoresmen" and men on transporting vessels (apparently not fishing), but to include so far as could be determined all those regular and casual, on vessels or boats, or inshore, who were actually engaged in fishing however much or little. It is not possible to assign fishermen to the various particular fisheries such as ground fish, shrimp, oysters, pilchard, food fish generally, or menhaden, sponges, seaweeds, whales, etc.; such conclusions concerning fishermen as are admissible at all relate only to total gross quantity and value of all fishery products produced by them.

Quantities and values of fishery products are arranged in three series of tables, relating to (a) all fishery products of whatever kind, and all fishermen, (b) food fish only, and (c) oysters.

a. *All Fishery Products.* The quantities and money values of all fishery products of every kind for all the years canvassed from 1887 to 1940 were tabulated for each region; quantities and values of seed oysters (since 1902, before which time they were not consistently shown) were deducted from the totals as not a proper credit to production, but the seed oyster fishermen are properly left in as part of the cost of producing oysters. For the original record of quantities of market oyster meats (reported up to 1931 uniformly as 7 pounds per bushel) were substituted the revised figures[45] prepared by the Fish & Wildlife Service and based on ascertained regional recoveries of oyster meats per bushel in the shell. In these regional tabulations of all fishery products the money values were converted to equivalent money of constant purchasing power in terms of the All-Commodity Wholesale Price

44. The 1908 canvass of the entire country was done by the U. S. Bureau of Census in cooperation with the Bureau of Fisheries. It has been said by various students of the subject that because this canvass was carried out by somewhat different methods, the results are not comparable with those of other years. However, no marked aberrations of that year's canvass were noticed in any of our tables or graphs.

45. Summary published in: Status of Wildlife in the United States, Senate Report No. 1203, 76th Congress, 3rd Session, 1940, p. 180-181.

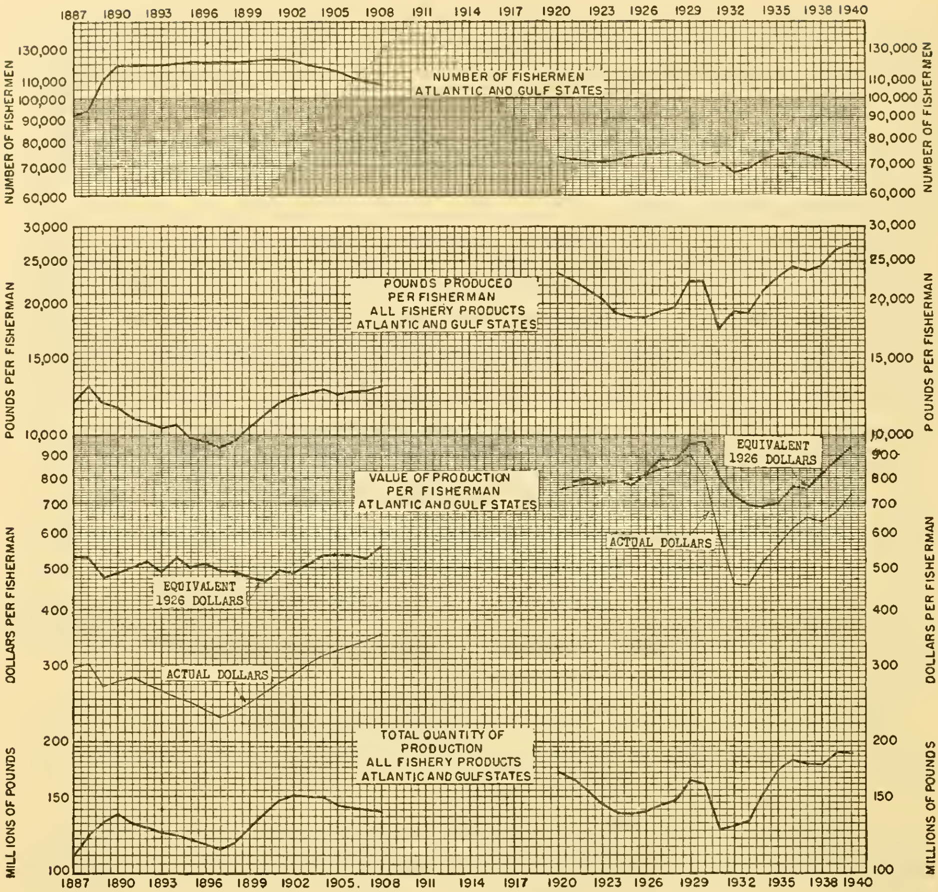

FIG. 3. Fishermen of the Atlantic and Gulf coasts, and the quantity and value of their total product, 1887-1940. Inadequate statistical record 1909-1919.

Index, 1926 = 100.[46] Annual average prices and average production and values per fisherman were then calculated, the money items in terms of both actual and deflated money.

These regional tabulations, Tables 41 to 47 in the Appendix, were then expanded into annual series from 1887 to 1908 and 1915 to 1940 by straight-line interpolation of quantities and actual values for the void years. The actual value for each interpolated year was then converted to constant money value by the index for that year, and both kinds of prices, as well as production and income per fisherman were calculated for the whole series as was done in the regional tables. The series for the regions as thus expanded by interpolation (considered as work sheets and not here published) were then

46. U. S. Bureau of Labor Statistics; see Statistical Abstract, 1947, Tables 318 and 323. The index is based on wholesale prices of about 900 commodities.

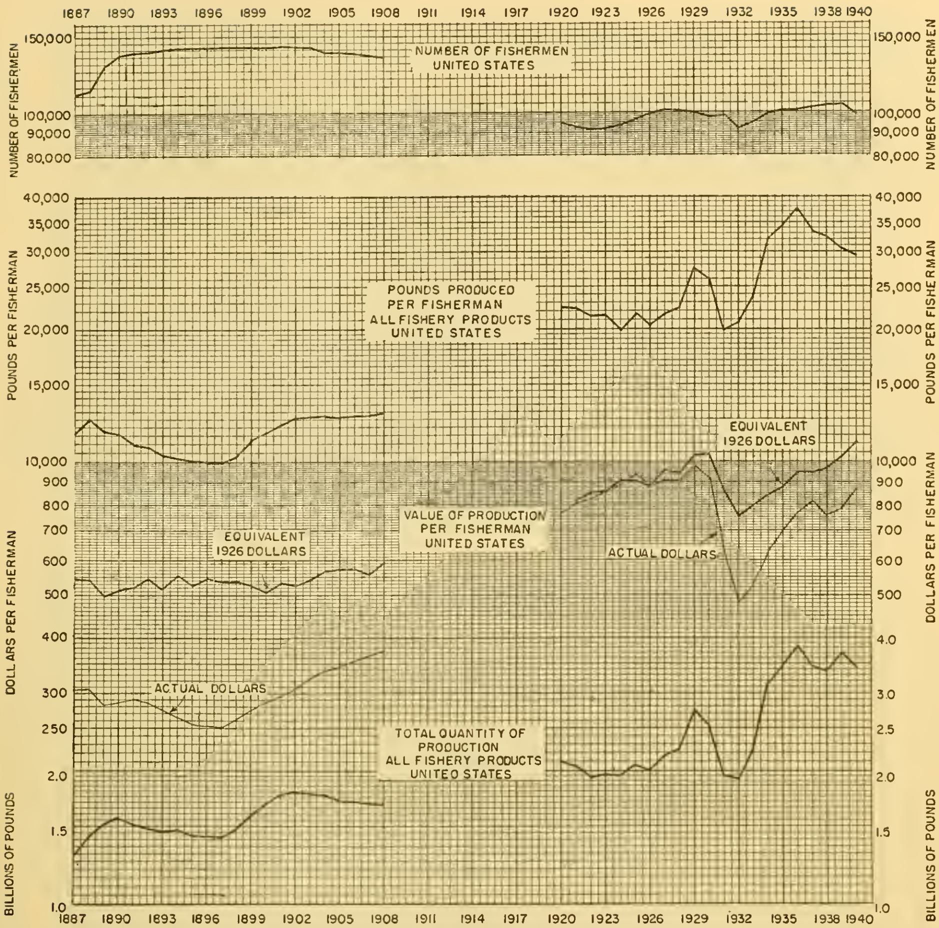

FIG. 4. Fishermen of the United States, seven regions (Mississippi River and Alaska excluded), and the quantity and value of their total product, 1887-1940. Inadequate statistical record 1909-1919.

combined into a sub-total for the five Atlantic–Gulf regions, and are presented as Table 38, Appendix, and into a grand total for the whole country (seven regions) as Table 39, Appendix. These data are represented in graphic form as Figs. 3 and 4 in the text.

b. *Food Fish* (*and Shellfish*). As a somewhat less heterogeneous (but still far from homogeneous) presentation, a second series of tables and graphs was prepared for food fish (and shellfish) only. From the data for all fishery products, after the oyster adjustments as above indicated had been made, there were removed all quantities and values of all, or nearly all, items which were not considered to be used for human food and could be identified as such. Among these are: all menhaden, whale products, sponges, shells,

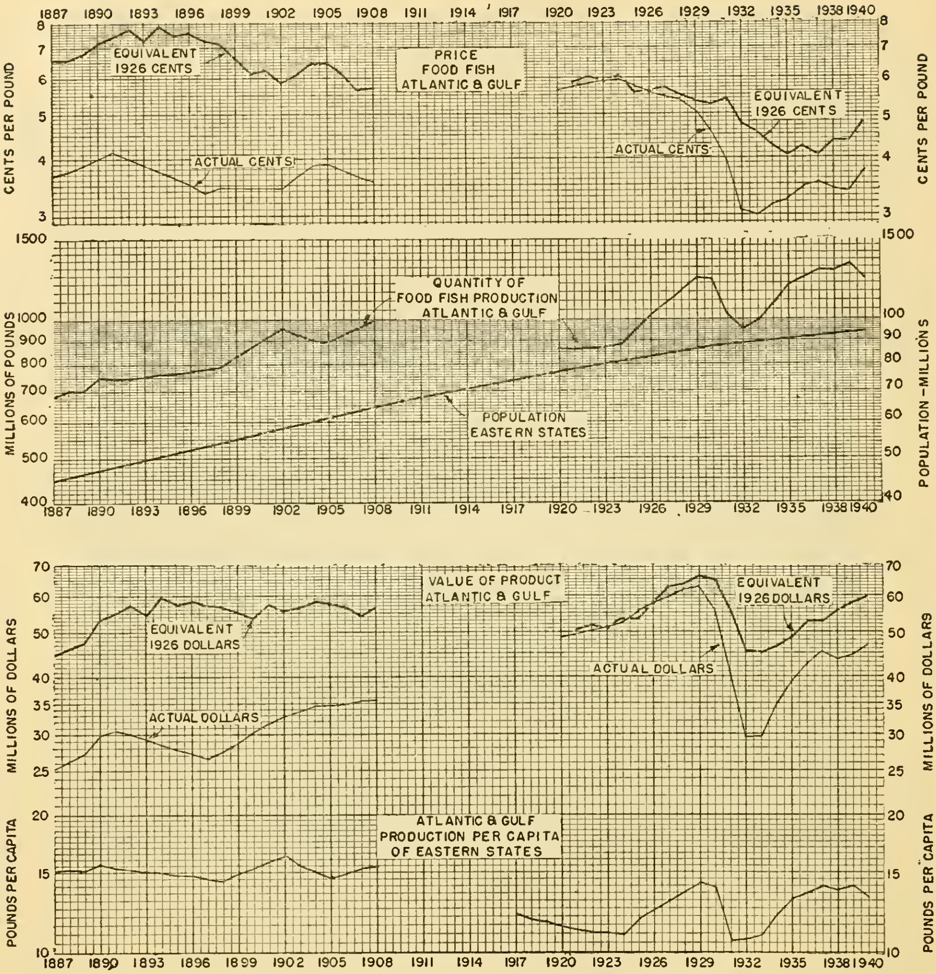

FIG. 5. Food fish production of the Atlantic and Gulf coasts, quantity, values, and prices, 1887-1940. Inadequate statistical record 1909-1919. Population Eastern States (28 cis-Mississippi River States, including Louisiana and District of Columbia).

seaweeds, furs and skins, oils, etc. Of the Pacific coast pilchard, that part which is represented by the sardine pack (estimated at 120 pounds of fresh fish per standard case of sardines) was included as human food; the remainder was treated as non-food.

After these adjustments had been made, tables were set up in the same manner as already described for all fishery products, viz., regional tables of the actual canvasses of food fish only: Tables 48 to 51, Appendix; a table composed of regional tables expanded by interpolation combined to a subtotal annual series for the Atlantic–Gulf regions; and a grand total for the whole country (seven regions), Table 40, Appendix, and Figs. 5 and 6 in the text.

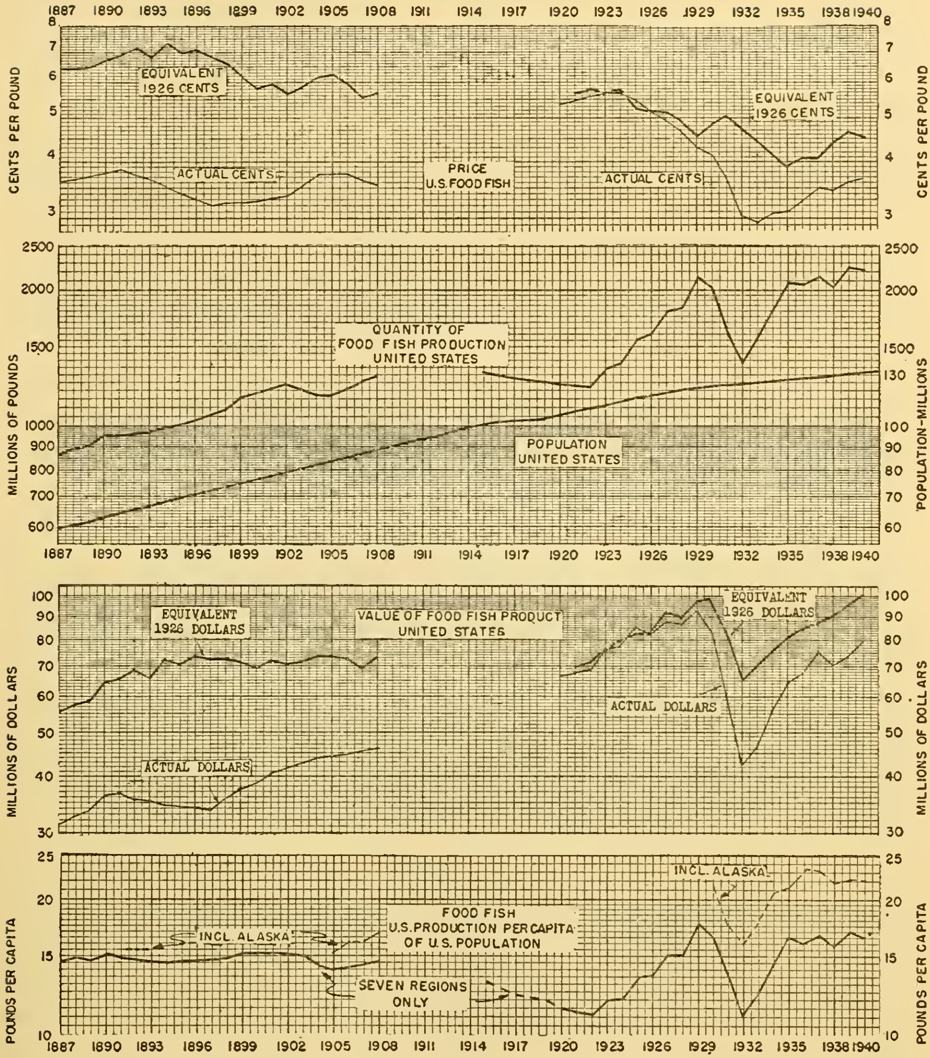

Fig. 6. Food fish production of the United States, seven regions (Mississippi River and Alaska excluded), quantity, values, and prices, 1887-1940. Inadequate statistical record 1909-1919.

c. *Oysters.* A similar procedure was followed in summarizing the statistical record of the oyster industry for the Atlantic–Gulf regions only, Pacific excluded. Since the numbers of oyster fishermen are not separately ascertainable, the tabulation shows only quantities, values, and prices of Eastern oysters in actual and deflated (1926) money. (Table 57, Appendix, and Fig. 15 in the text.)

d. *Corrections Not Made. Seaweeds* occur in quantities varying from 115 to 150 million pounds only in New England and in large quantity only for the years 1887-1889 and at very low prices; by the time of the next canvass in 1897 they had declined to less than one million pounds. In interpolation after 1889 their influence continues with diminishing force to 1897, depressing average prices of all fish and increasing the apparent quantity of product per fisherman. It would be desirable to remove this item from the data if the number of fishermen who produced it were known. No adjustment for this item was made in the tabulation of all fishery products, but seaweeds are of course excluded from the tabulation of food fish.

Bait, like seed oysters, is not a marketable product of the fisheries, but an item of cost of production which should be removed for a proper economic showing. In early years (prior to the coming of the steam trawler in 1905) it was an item of large volume and low price, but diminished steadily to relative unimportance in the later period. Bait is not separately shown in the original records and therefore cannot be removed or estimated with any accuracy. No correction was made in any of the tables herein for bait.

Salt fish for years prior to 1908, where separately shown, was added in all the original reports as salted weight, in with fresh weights, to arrive at totals. In 1908, for the first time, salt fish was converted to, and added into the totals as fresh weights. In some years and regions it is not separately shown, and in no case have we found in the early statistical reports factors for converting salted to fresh weights, though factors for some of the species were in later years published by the Government agency; nor is it always clear in the original reports whether the salted fish is a product of shore manufacture or a primary product of the fishermen. In the early years (1887 and well into the 1890's) salt fish was of great importance; in 1887 it constituted more than 20 per cent, as salt weight, of all New England fish and if converted to fresh weight and the total adjusted accordingly, it would constitute well over a third. In the Chesapeake, South Atlantic (chiefly alewives and mullet), and Pacific (cod and salmon) regions it may have been about 20 per cent of the total. It began to decline even before the steam trawler appeared, and was practically extinct by 1920. During its day it was sold (much of it in the export market) at prices which if converted to the fresh weight basis were much cheaper than fresh fish, and involved costs which are not now ascertainable, but on the salt weight basis it was slightly higher per pound than fresh. It could not have been sold fresh, if at all, without greatly depressing fresh fish prices. If we convert salt weights by estimation to fresh, we distort prices; if we do not convert we convey a false biological picture of the yield of the water. For the Pacific, in one of the summary series prepared by the Bureau of Fisheries,[47] and used herein, all salt fish had been converted to fresh weight; otherwise, salt weights are not herein converted to fresh weights in either series of the main tables.

47. Rept. Comm. 1931, p. 472.

Biologically the total out-take from the water is understated if the adjustment for neither the bait nor salt fish is made, or if both adjustments are made. Economically, if neither adjustment is made, the two distortions tend to compensate as to quantity but not value. We made a set of tables in which the adjustment was made for New England salt fish only (not bait), but they are not here used because on balance they appear to introduce at least as much distortion into the general tables as they correct. In some of the subsidiary tables, where the data are available for specific fishes (as cod and mackerel) the quantities are converted from salt to fresh weight basis, as they must be for proper comparison. All of these uncertainties being taken

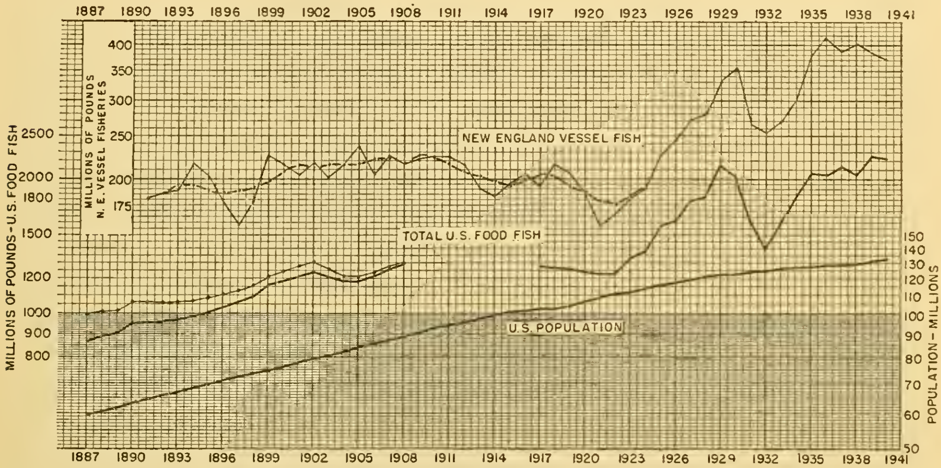

FIG. 7. Test comparison for validity of procedure.

Top curve: Actual record of weighed-in production (all food fish) trip by trip New England vessel fisheries, Boston and Gloucester (from 1891) and Portland, Me. (from 1916) as yearly totals, to 1940; salt fish converted to fresh by the factor of 2; dot-dash line, 5-point moving average, 1892-1924.

Middle curve: Production of all food fish, seven regions of the United States adjusted, interpolated, and totaled as described in text; dotted line, estimated correction if all salt fish are converted to fresh; (does not include Alaska or Mississippi River system).

Bottom curve: Population of the 48 United States, Bureau of Census yearly estimates.

into account, and balanced one against another, it appears probable that the conclusions drawn herein would not be changed qualitatively and would be changed only slightly quantitatively by such adjustments as could be made.

Validity of Data and Procedure. As test of the validity of the main tables and graphs as drawn up above, there is available for comparison the record from 1891 to 1940 of the landings of the New England vessel fisheries. This is the only continuous annual (except only 1892) and undoubtedly the most accurate record we have of a major fishery in the country, the weighed-in quantities and actual sales transactions being recorded.

The production of the New England vessel fisheries is shown in the upper line, Fig. 7. In this curve the salt fish have been converted (by the factor 2) to fresh weights as usually landed. The middle line, void from 1908 to 1915, represents the total production of food fish and shellfish in the United States (seven regions). The bottom line is the population of the United States. These curves are all drawn to logarithmic scale in which like changes in per cent are expressed by like slopes of curves regardless of amounts and sizes of units.

Since the record of the vessel fisheries is both actual and annual, it shows more deviation from year to year (continuous line) up to 1921 than does the total production curve which for the early period is considerably smoothed by its method of derivation (68 per cent interpolated). The vessel fishery curve shows the depressions of 1897 and 1921, while the total food fishery curve does not. To make the two curves more truly comparable, the vessel fishery curve from 1891 to 1923 is therefore smoothed by a five-point moving average (dot-dash line). This smoothed curve of vessel fisheries and the partly interpolated curve of production of all United States food fisheries are then, for the period up to 1923, in good agreement. They are in still better agreement when the salt fish in the total United States curve is converted by approximation to fresh fish (dotted line). Both curves (even the unsmoothed vessel fisheries) for the earlier period are smoother than either curve is for the late period; the earlier period was a more tranquil economic period than the later.

Both New England vessel and national food fisheries failed to keep pace with population until about 1922, in which year both reached a low point with reference to population. Subsequent to 1922, little salt fish is involved in either curve, neither is smoothed, both are based on good statistical records and are in good agreement. The two curves, one representing a large but local fishery of a dozen or so species and a few hundred fishermen, the other (of which the first is about an 18 per cent component) representing national production of more than 200 species of food fish by more than 100,000 men, are in such close agreement as not only to validate the national curve and the method of its derivation, but also to suggest that whatever is the determinant of one is also the determinant of the other.

In the numerous subsidiary tables presented herein in interpretation of the above described main tables, wherever the procedure is not obvious, explanations are made in the text or footnotes.

Characteristics of the Fisheries as Indicated by the Data. Consideration is here necessarily restricted mainly to food fish; the total of all fishery products is considered only in comparing the performance of the geographical regions and of fishermen. The statistical history of food fisheries of the United States is exhibited graphically in Fig. 5, on which the following observations may be made:

Production and Population. The curve of total production of all food fish of the seven regions of the United States, if completely smoothed from end to end, would almost exactly parallel the curve of population of the United States; accordingly, the curve of production per capita of population (bottom line) if completely smoothed would be a horizontal line. These facts indicate that notwithstanding widespread fears to the contrary, *the fisheries of this country as a whole have been able to afford and continue to afford a production increasing in pace with the growth of the population.*

When the two parts of the production curve are separately considered, i.e., from 1887 to 1922, and from 1922 to 1940, it is seen that production relative to population declined in the earlier period and rapidly increased during the latter period, with a turning point at about 1921 or 1922. This behavior of the total production curve conforms to well known events in the history of the industry. Throughout the earlier period fish were marketed either salt or otherwise cured, or if fresh, were shipped whole on ice and marketed under many impediments. Salt fish lost its appeal, and all fish were increasingly at a disadvantage in competition with many other foods more attractively prepared, packaged, and marketed. The year 1921 marks the beginning of filleting, attractive packaging, refrigeration, and the entry of chain stores and the opening of the mid-west to the merchandising of fishery products. A sharp turn for the better came in that year.

The total money value in actual current dollars for the total production of food fish increased, as did also total value in dollars of constant (1926) purchasing power; however, the two curves of actual and constant money values are much closer together in the later than in the earlier period, indicating that *the increase in the total value of fish in dollars was in part cancelled by the diminishing purchasing power of the dollar.* In the United States, production has not only followed and continues to follow the growth of population, but has done so, at least up to 1940, at diminishing real prices. The top pairs of curves in Fig. 5 for the United States and Fig. 6 for the Atlantic-Gulf regions both show that actual annual average prices of all food fish were about the same from 1920 to 1940 as they were from 1887 to 1908. In the latter chart, the population curve is that of the 28 States east of the Mississippi River including Louisiana, and the District of Columbia.

Average actual prices were slightly higher during the late period only for a brief postwar period in the early and middle '20's before postwar vessel-building and expansion caught up with the new demand brought on by filleting, freezing and chain store merchandising and increased population. When they caught up, prices began and continued to decline. These observations relate to actual prices; when money values and prices are translated into purchasing power for all commodities or for all foods it is seen in Table 14 that at no time subsequent to World War I could a unit quantity of the average of all United States food fish be exchanged for as much of either all commodities or all foods as it could before 1908, except for a brief period in 1922 to 1924 when they barely reached the earlier level; for the whole period 1921-1940, the ratio of the all fish price index to either the all-commodity or all-food index of the Bureau of Labor Statistics was off by 25 to 30 per cent from what it had been on the average for the period 1887-1908. *The average price of food fish in terms of purchasing power for all commodities or for all foods had decreased both in the whole United States and in the Atlantic-Gulf regions separately.*

It is true that the requirements of the expanding population have been met in part by the opening and expansion of new Pacific and Alaskan fisheries; however, the production of the New England vessel fisheries has kept up with the growth of population at a slightly lower exchange price, and the Atlantic-Gulf regions as a whole, while not quite keeping up, have produced a substantially increased quantity of food fishery products and sold it at a lower price per pound relative to all commodities and all foods.

Deviations in Production from Year to Year. One might expect to find the total product of the fisheries highly variable from year to year, since the many fisheries are affected by such uncertainties as the weather, "red tides" and other submarine catastrophes, unpredictable migrations, and fluctuations of abundance of the fishes, and since they produce so many kinds of fishes from such a vast coast line without interchange of information or any form of control. On the contrary, the total production of all food fish of the entire country is represented by a relatively smooth curve (somewhat over-smoothed during the period of sparse field canvasses) from 1887 to 1908; but even in the more frequently canvassed period after 1921 it moves without sharp zig-zags from year to year, in accordance with definite trends over periods of years, to 1940. It appears that whatever may be the fluctuations in particular fisheries, localities, and regions, they compensate and accommodate themselves to one another or cancel one another out, in such way that the sum of the products of all the fisheries is a total which, while not constant, moves from year to year in accordance with some definite trend, regardless of what any particular fishery may do. This is an example of large-scale order resting on small-scale disorder, which is familiar in insurance and many other statistical phenomena.

The Trend of Volume of Fish Production. The trend of total production of the food fisheries, as a unit, follows an economic rather than biological pattern of behavior. The pattern of the economic cycle of prosperity and depression is expressed in many statistical series, such as those of national income, volume of production of numerous industries, or of all industry; wholesale, retail, and foreign trade, sales by mail order houses, employment, bank debits, stock and bond prices, sales of postage stamps, sales of life

TABLE 14

Relative Exchange Value of Food Fish for All Commodities and All Foods; Ratios of Food Fish Price Index (1926 = 100) to All-Commodity Wholesale Price Index (1926 = 100), B.L.S., and to All-Food Wholesale Price Index (1926 = 100) B.L.S.

Year	Ratio Food Fish Price Index to All-commodity price index		Ratio Food Fish Price Index to All-food price index		Year	Ratio Food Fish Price Index to All-commodity price index		Ratio Food Fish Price Index to All-food price index	
	U. S.	Atl-Gulf	U. S.	Atl-Gulf		U. S.	Atl-Gulf	U. S.	Atl-Gulf
1887	1.26	1.18			1921	1.09	1.05	1.18	1.14
1888	1.26	1.18			1922	1.12	1.07	1.24	1.19
1889	1.26	1.22			1923	1.09	1.05	1.18	1.14
1890	1.31	1.28	1.33	1.30	1924	1.12	1.07	1.21	1.16
1891	1.34	1.32	1.37	1.35	1925	1.03	1.00	1.06	1.03
1892	1.39	1.38	1.43	1.41	1926	1.00	1.00	1.00	1.00
1893	1.33	1.30	1.30	1.27	1927	1.00	1.02	.99	1.01
1894	1.43	1.40	1.42	1.39	1928	.95	.98	.91	.94
1895	1.36	1.33	1.40	1.37	1929	.88	.95	.84	.91
1896	1.38	1.35	1.45	1.42	1930	.94	.94	.90	.90
1897	1.33	1.30	1.37	1.33	1931	.98	.96	.86	.94
1898	1.30	1.28	1.32	1.30	1932	.92	.85	.97	.86
1899	1.21	1.18	1.32	1.30	1933	.86	.81	.94	.89
1900	1.14	1.10	1.25	1.22	1934	.80	.76	.85	.81
1901	1.16	1.12	1.28	1.23	1935	.75	.73	.76	.70
1902	1.11	1.04	1.22	1.15	1936	.79	.76	.78	.75
1903	1.14	1.09	1.32	1.25	1937	.79	.73	.79	.73
1904	1.21	1.15	1.34	1.28	1938	.86	.78	.92	.83
1905	1.21	1.15	1.32	1.26	1939	.91	.79	.99	.88
1906	1.16	1.09	1.38	1.26	1940	.89	.86	.98	.95
1907	1.08	1.01	1.24	1.12					
1908	1.11	1.02	1.19	1.09					
Average	1.24	1.20	1.33	1.33		.94	.91	.97	.94
					Per cent change*	—24.50	—24.30	—27.20	—29.80

* From averages of early to late period; averages unweighted.

insurance, and many others. In general, when compared in year-by-year series over a period of years, these economic indicators exhibit a common pattern, differing among themselves only in detail, each according to its peculiar circumstances. These series for our purposes are best considered in two categories—goods series and money series; the one is concerned with the ups and downs of production and movement of physical goods, the other with money values, such as income, bank deposits and debits, and prices.

Goods-curve Comparisons, United States. Fig. 8 shows in the lower part a number of such serial patterns, taken more or less at random from various sources,[48] in the United States for the period between the two world wars, 1921-1940. The composite of a great many of these series representing all of industry, and commonly used as indicator (goods), is shown at the top as the Index of Industrial Production maintained current by the Federal Reserve Board. In Fig. 9 may be compared this same index (middle curve) with the physical volume of fish production of the seven regions of the United States (top curve) and with that of the New England vessel landings (bottom curve). All three curves exhibit clearly the trade cycle, at minimum in the postwar depression of 1921, maximum at the inflationary boom of 1929, depression minimum in 1932 and another maximum in 1937. *The curve of national food fish production agrees closely with that of the Index of Industrial Production* ($r = +0.74$).[48-a] The only noticeable difference is the absence of the sharp minimum in 1921 (postwar depression). This part of our curve is flattened out by interpolation from the war-time period of few canvasses, and would undoubtedly exhibit the dip (dotted) if field statistics had been available, as they were in the cases of the continuous annual series of the vessel fisheries and of Canadian production (Fig. 10), both of which show the 1921 dip. The curve of New England vessel landings also conforms generally to the index of industrial production but, being a local component, it conforms with less fidelity than does the curve of the fish production of the whole country—in which aberrations from the average cancel one another out. Every region and even most of the specific fisheries show the influence of the trade cycle. Fig. 4 (bottom curve) represents total United States production of all fishery products, food and non-food. Here we see the same pattern of the trade cycle, but heavily influenced by the rapid rise of the California pilchard fishery which had its origin in and shortly after World War I, and rose to great heights in the 1930's. A large part of the product of this fishery serves non-food uses.

Goods-curves, Canada and Europe. Fig. 10 shows at the bottom a pair of curves for a similar comparison in Canada. The upper of these two curves represents the total physical volume of all fish in Canada; the lower, the Canadian Index of Industrial Production. The conformity here appears convincing ($r = +0.86$), even better than the corresponding United States curves, and does not show the same secular growth. However, Canadian fish production is considerably more influenced by exports than is that of

48. See for many of these, Standard and Poor's (1942); The Conference Board, Economic Almanac; Statistical Abstract of the United States. 48-a. See footnote 51, p. 390.

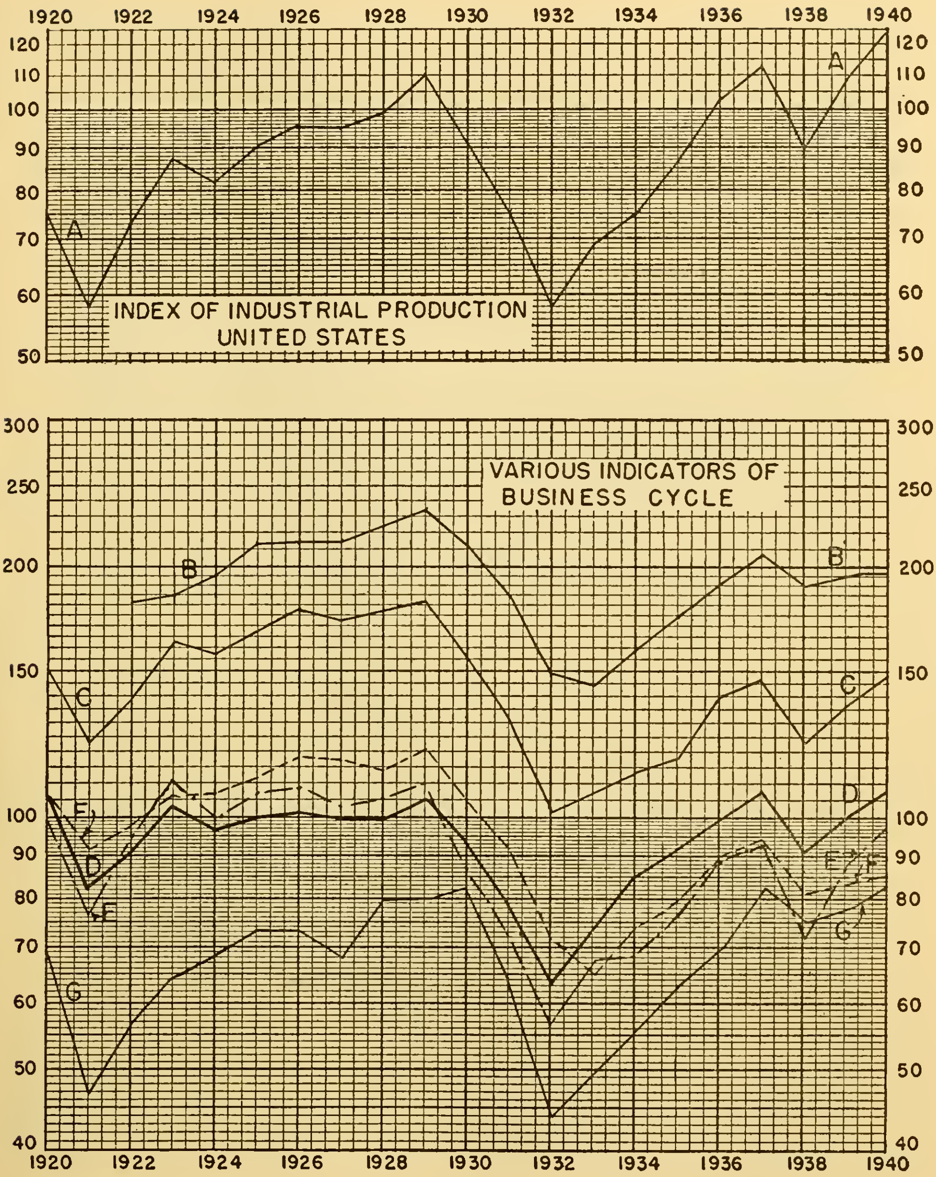

FIG. 8. Sundry Non-money Series of Indicators of the United States Business Cycle in Various Units: A. Index of Industrial Production, 1935-39 = 100, Federal Reserve Board; B. Number of telegrams sent in tens of millions, American Tel. & Tel. Co.; C. Railroad freight in billions of loaded car-miles, I.C.C.; D. Composite employment index, 1923-25 = 100, Bureau of Labor Statistics; E. Index of Industrial Activity, secular trend = 100, Cleveland Trust Co.; F. Advertising Index, 1923-32 = 100, McCann-Erickson, Inc.; G. Fertilizer Consumption, in hundreds of thousands of tons, National Fertilizer Association.

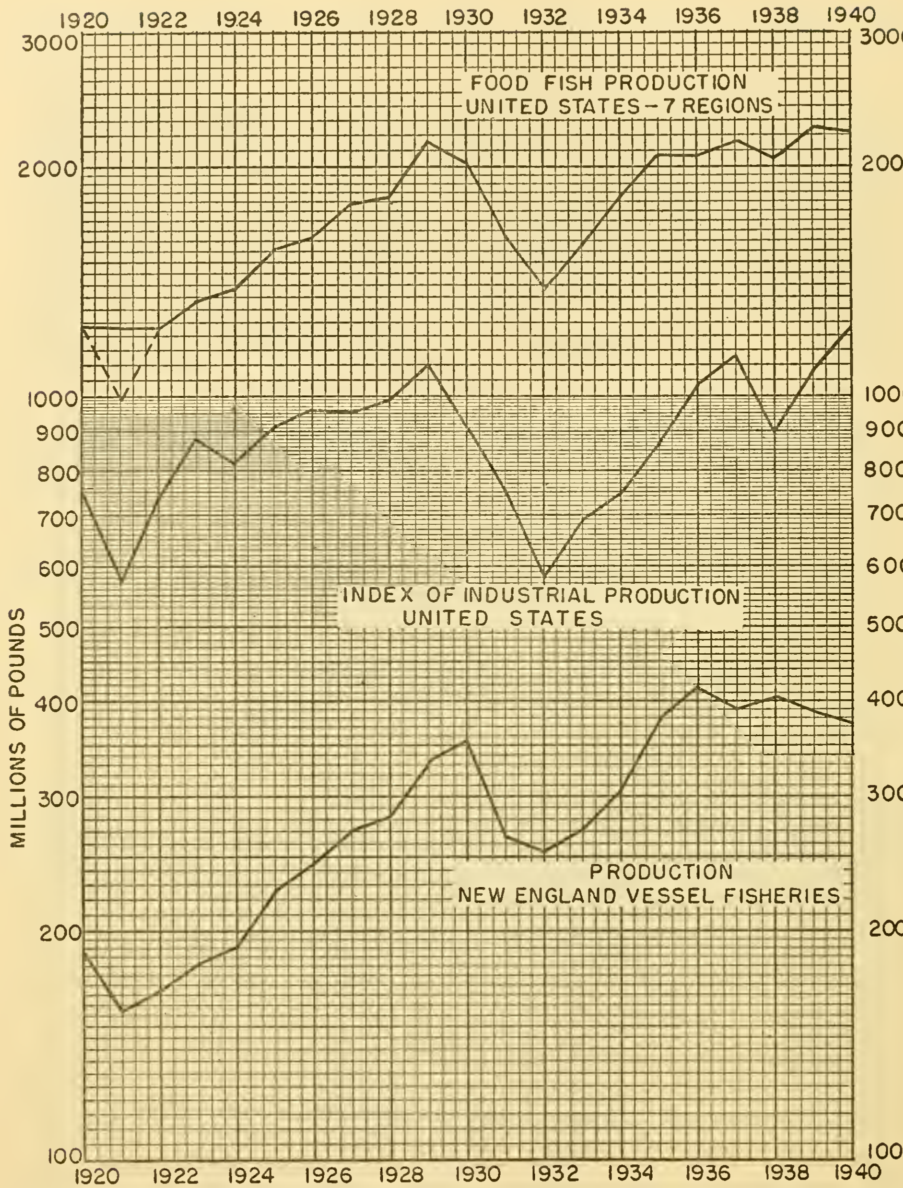

Fig. 9. Index of Industrial Production of the United States compared with total food fish production seven regions of the United States and with landings of New England vessel The correlation coefficient of fish production and the industrial index, as they stand, is r fisheries.

The correlation coefficient of fish production and the industrial index, as they stand, is r = + 0.74; the two curves diverge toward the right, indicating greater upward secular trend of fish than of industrial production, traceable to the introduction of filleting and other marketing improvements beginning in 1921, especially noticeable in the curve of vessel fisheries of New England where most of the improvement occurred. If the food fish curve is so adjusted as to remove the excess of this secular trend, its correlation coefficient with industrial production becomes r = + 0.82.

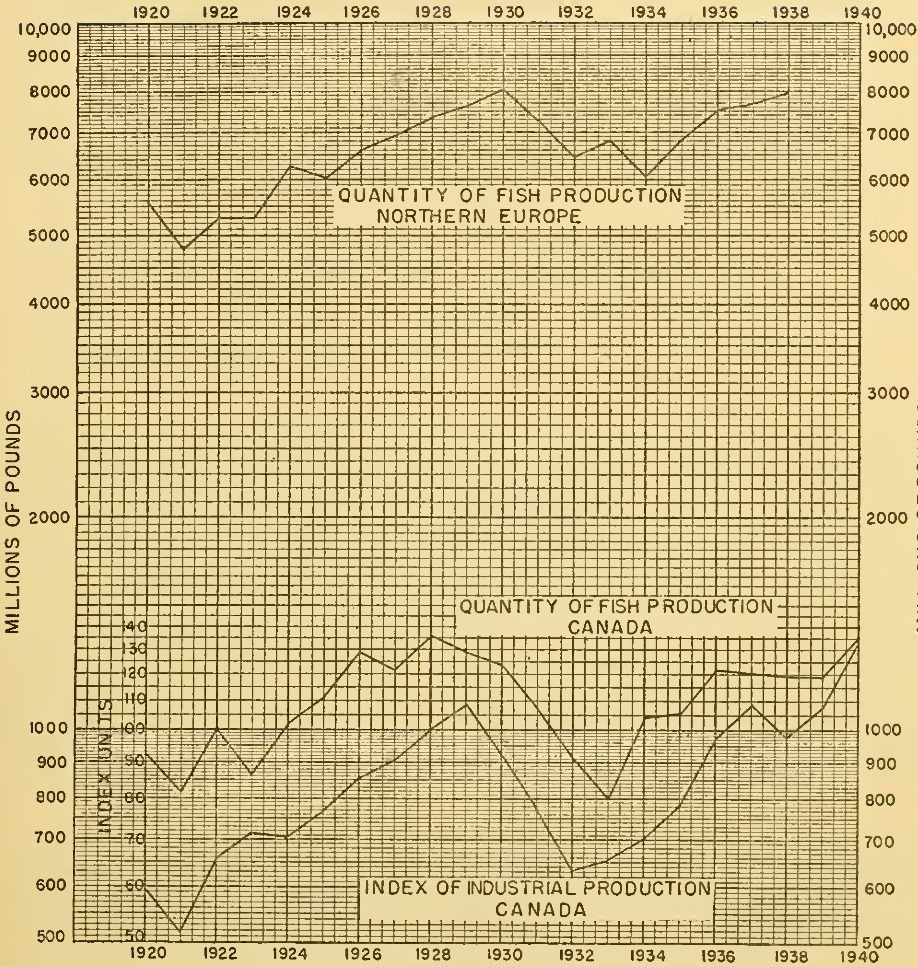

FIG. 10. Fish Production, Northern Europe, nine countries: England, Norway, Scotland, France, Germany, Holland, Sweden, Denmark, Ireland; (Cons. Perm. Int. pour l'Expl. de la Mer, Bull. Stat., Vol. XXVII, 1939); total fish production, Canada, and Canadian Index of Industrial Production. (Dominion Bureau of Statistics). The coefficient of correlation of the Canadian curves of fish production and the Index of Industrial Production is $r = +0.86$.

the United States. The top curve is a composite curve of all fish production of nine northern European countries. There is not available for comparison a composite international European index of industrial production curve. Nevertheless, the influence of the trade cycle is obvious in this curve, and notwithstanding the many fears for "exhaustion" of the fisheries in European waters, the volume at the end of two decades was greater than it was at the beginning. The depression is known to have struck with full force later in Europe than it did in the United States.

Comparison of Money Curves. Fig. 11 exhibits three pairs of money-curves; the lower of each pair is the actual money value in terms of year-by-year current buying power; the upper of each pair is the money converted to United States (or Canadian) dollars of constant purchasing power, 1926 = 100. *In the United States, the curve of money value of all food fish produced is an almost exact copy (on a smaller scale) of that of the national income.* In Canada the likeness is striking in comparison with the United States national income (a comparable curve for Canada not being available for the whole period). For the value of all United States fishery products, food and non-food, the curve of money values[49] in Fig. 4 shows, again, a faithful copy of the curve for United States national income.[50]

Fig. 3 presents, for the Atlantic-Gulf coasts only, the same categories of information on food fish as is contained in Fig. 4 for the whole country. Here again, in Fig. 3, we see the same now familiar patterns of goods and money behavior, but representing only a part, though a large part, of the whole, it does not conform quite so perfectly to the pattern of national indicators as does the national total.

Economic vs. Biological Determinants of the Quantity and Value of Production. In all the data so far presented, *no evidence is seen that abundance or scarcity of any kind, or of all kinds, of fish had any effect on the total quantity or value of the product of the food fisheries.* If a biological explanation were invoked to account for the failure of production to keep pace with growth of human population from 1887 to 1920 (Fig. 7), it would also have to account for the sudden increase of the supply at 1921 and the faithful following thereafter of the economically turbulent business cycle to 1940. There appears to be no biologically reasonable explanation of this behavior, nor is there any sign in the historical record that the many in-

49. Drawn to a slightly smaller scale on the abscissa or horizontal axis.

50. "National income" has been variously defined and reported in equally various series, from time to time revised and adjusted to new concepts of accounting. The data of U. S. national income plotted in Fig. 11, are those credited to the U. S. Department of Agriculture by Standard & Poor's Basic Statistics (1942). The Bureau of Foreign and Domestic Commerce (1947) has published three revised series running from 1929; our (bottom) curve, Fig. 11, agrees closely from 1929 onward with the new series, "National Income by Distributive Shares 1929-46" (place cited, p. 19). This series is the sum of all incomes of persons private, military, and government civilian, all farms and all unincorporated and incorporated enterprises, including inventory adjustments.

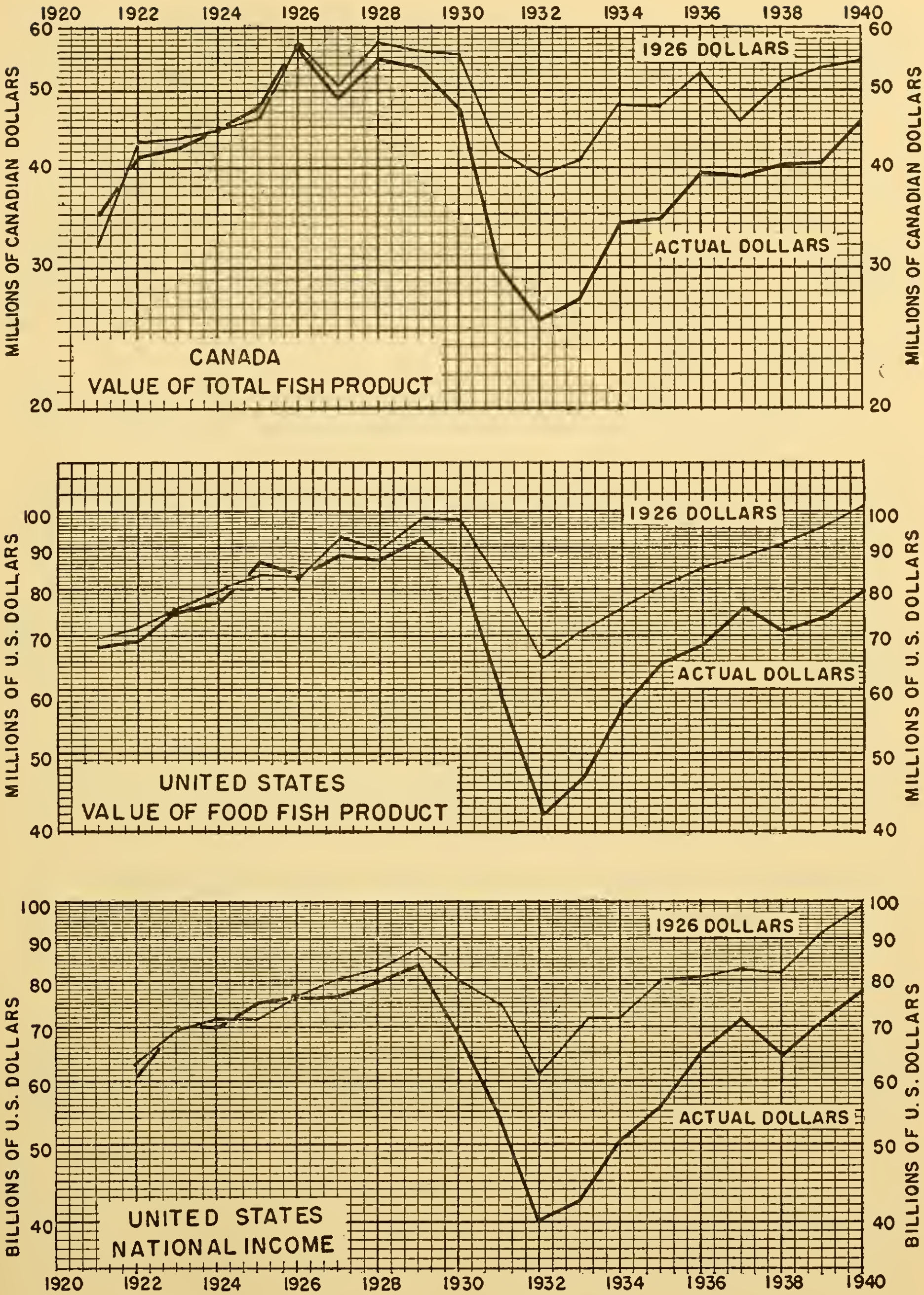

Fig. 11. Money value of United States food fish, and Canadian total fish products, and United States national income, 1921-1940. Heavy lines, dollars, United States and Canadian, respectively, of current purchasing power each year; light lines, dollars of constant purchasing power in terms of U. S. and Canadian, respectively, All Commodity Wholesale Price Indices, 1926 = 100. (Price indices, U. S. Bureau of Labor Statistics and Dominion Bureau of Statistics; U. S. National Income, U. S. Dept. of Agric.). See text for explanation. The coefficient of correlation of the United States value of food fish and the national income is r = + 0.94.

ternal changes in the fisheries (except the improved techniques of marketing) have had any effect on the total—the decline of the old "salt banker" fisheries, the rise and subsequent decline in halibut and haddock, the decrease in shad, alewives, oysters, lobster, whitefish, and other Lake species, the increase in the shrimp, tuna, salmon, flounders, crab, whiting, and rosefish, and the periodic fluctuations in abundance of all or nearly all of them, the introduction of new techniques of capture or the impact of legislation or regulation. These and many other changes are cancelled out in the averages and totals. *In the United States and Canada, and apparently in Europe as well, the pattern of behavior of fish production and value is typical of the business cycle.*

Mechanism of Accommodation of Supply to Demand. The historical data of production and values of all food fish in the United States indicate that without any central direction or conscious control, *the fisheries contain a self-regulatory mechanism which automatically adjusts and accommodates all the diverse productions just to supply all that can be sold and no more.*

The data also supplies an answer, which will appear below, to the interesting question, why, if total food consumption is a constant, or nearly so, is the quantity of fish produced so responsive to the pulse of prosperity and depression?

Price is the Regulator of How Much, Where, When, and What Kinds of Fish Will Be Produced, but not in the simple manner that might be supposed. Data of sufficient accuracy and immediacy are not generally available (or have not been assembled) to demonstrate the operation of price of fish extensively and throughout the country. However, Herrington (1946) gives an elegant demonstration of the price behavior of cod and haddock in relation to their own volume of production, and in relation to the prices and volume of competing beef cattle, hogs, and eggs. Cod and haddock are staple, non-luxury articles, produced in large quantities the year round, and sold competitively at auction in large organized markets (Boston, etc.), and the transactions are recorded as a continuous series. Herrington demonstrated that *short term* (quarterly average) prices and quantity of production of cod and haddock are negatively correlated ($r = -0.79$),[51] i.e., prices are up when volume is down, and vice versa. (Fig. 12, reproduced from Herrington.) He found (Fig. 13) little correlation between prices of fish and either the cost-of-living index for food ($r = 0.45$) or average prices of competing food, cattle, hogs, eggs, ($r = 0.48$); practically no correlation ($r = -0.05$) between annual average prices and annual production of cod and haddock (i. e., *long term*), which is contrary to what might be expected;

51. The correlation coefficient, r, varies from 1.0 perfect positive, to −1.0 perfect negative, correlation between two compared variables. Herrington indicates that in these calculations coefficients or r values of less than 0.50 have little significance.

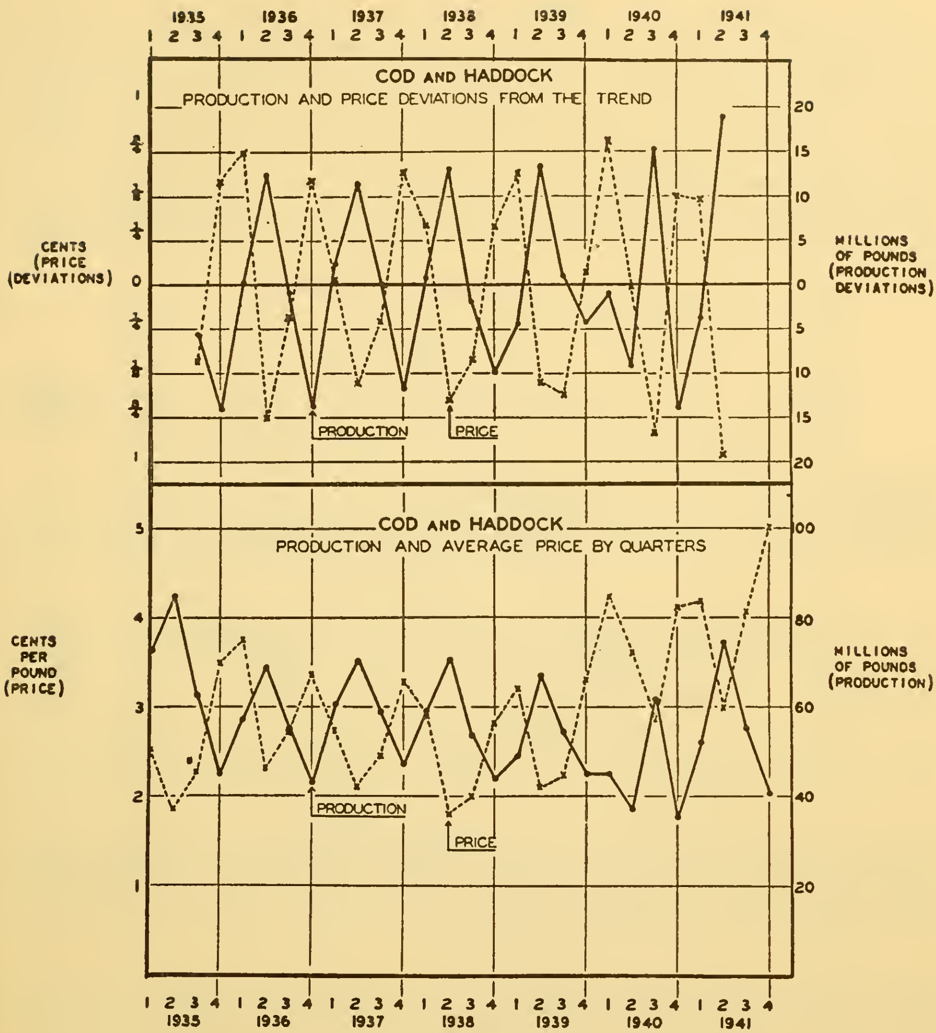

Fig. 12. Upper: Deviations in the production and price of cod and haddock from the annual trend. The trend was obtained by smoothing the quarterly figures by a moving average of four and two to remove the effect of seasonal variations. Lower: Production and average producers' prices of cod and haddock, by quarters. (Herrington, 1946).

and a much higher correlation (r = 0.68) between *production* of cod and haddock and average *price* of competing foods. In Figure 14 it is shown that between *price* of competing foods and *total value* of cod and haddock there is an even closer correlation (r = 0.77), and (Fig. 15) that there was a close negative correlation (r = −0.77) between the consumption (or production) of these fish and the relative price of fish (ratio of fish price to price of competing foods). It is necessary to refer the reader to Herrington's paper for details.

The meaning of all this, for our purpose here, is that as long as the supply of fish is adequate (as it is in cod and haddock) and the catch can be quickly increased as by making more trips with little or no increase in unit cost, when the prices of competing foods rise, causing improved demand for fish, the fishermen immediately catch enough more fish to supply the increased demand with little if any advance in price, rather than sell the same amount of fish as before but at a higher price. In following the short-

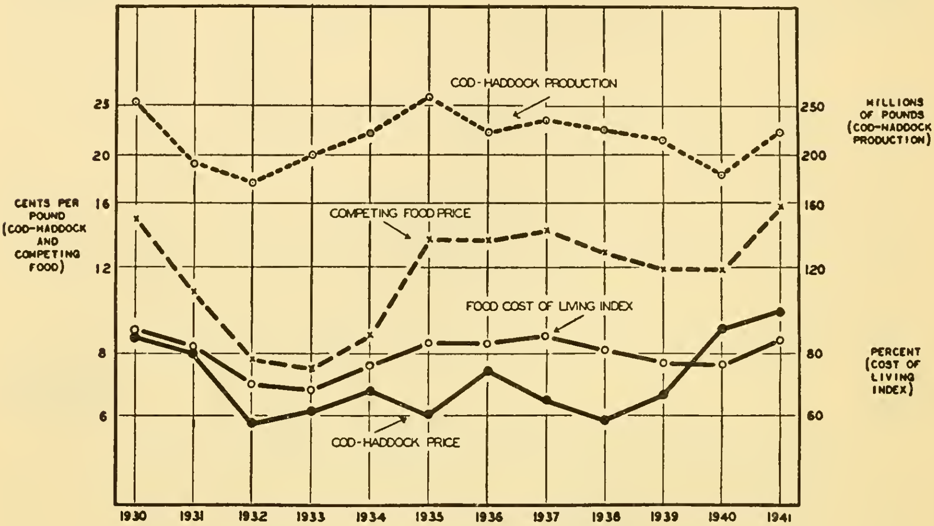

FIG. 13. The producers' annual average price of cod and haddock (in terms of fillet weight), compared to the annual production of cod and haddock; the average price of competing foods (beef cattle, hogs, and eggs) in terms of dressed weight and pounds; and the cost of living index for food. Plotted to logarithmic scales in order to provide an accurate comparison of the relative changes in values. (Herrington, 1946).

term responses of price to catch (Fig. 12), the fishermen are led to produce more fish over the long term when demand is greater and more fish is necessary from trip to trip to bring about the short-term reactions in price, and vice versa. The over-all resultant for the fisherman is that when prices of competing products are high, they catch more total fish for which they receive little, if any, increase in price, but more total money. On the contrary, when competing meat and egg prices decrease, demand for fish in the market "softens," i.e., less fish from trip to trip will depress prices, and fishing becomes less attractive; some fishermen quit fishing, those which remain work less, catch fewer fish and sell them at somewhat but not greatly reduced prices and receive less total money. The volume of meat and eggs is relatively constant from year to year, but their prices, as Herrington says and our curves show, are more variable and tend to determine the *volume* and gross income of fish production.

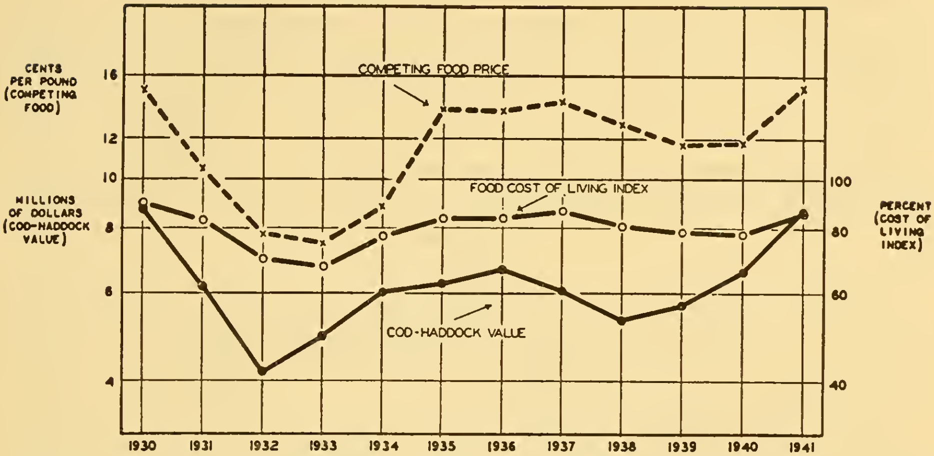

FIG. 14. The total annual value of cod and haddock to the producer compared to the average price of competing foods (beef cattle, hogs, and eggs) in terms of dressed weight and pounds, and the cost of living index for food. Plotted to logarithmic scales in order to provide an accurate comparison of the relative change in values. (Herrington, 1946).

The above observations are based on specific local fisheries, cod and haddock; for the whole country, Table 15 presents for comparison in parallel columns indices of production and prices of all food fish of the United States and of animal products of agricultural origin. As good a correlation as Herrington's with staple cod and haddock is hardly to be

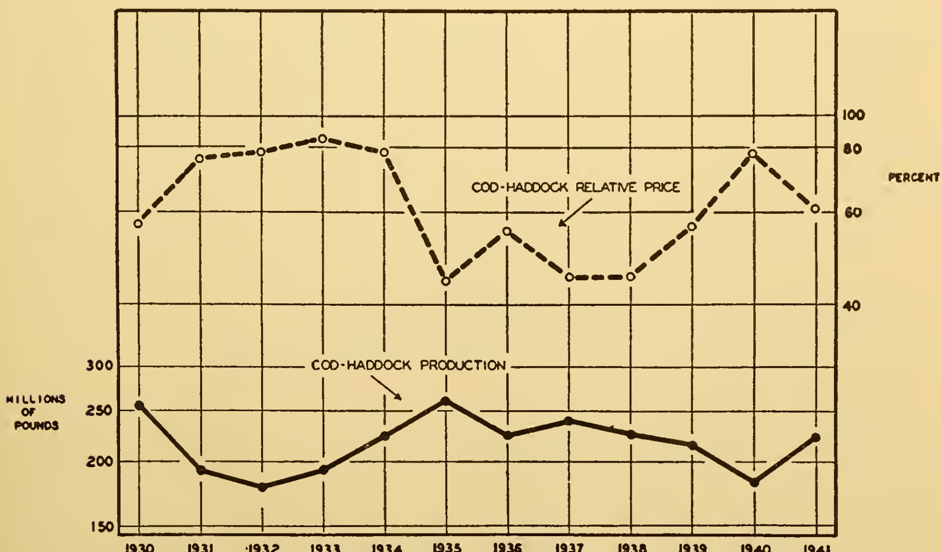

FIG. 15. The relative price of cod and haddock (producers' price of cod and haddock divided by the producers' price of competing foods), compared to the production of cod and haddock. Plotted to logarithmic scales in order to show the relative change in values. (Herrington, 1946).

expected of the total fish product of the country, containing many luxury and non-competitive items, and a marked growth factor as well. Nevertheless, the nature of the competitive interplay is discernible even here. The most nearly constant series are those of quantity of agricultural animal products and price of fish (mean deviations, 3.33, 3.31 and 6.87); the most variable series are those of prices of agricultural animal products and quantity of fish (mean deviations 22.4, 24.6 and 14.4).

TABLE 15

Cyclical Behavior of Production and Prices of Animal Products of Agricultural Origin and Food Fish of the United States (7 Regions)

Year	Production Indexes			Price Indexes		
	Livestock products *	Poultry and eggs *	Food fish †	Livestock products ‡	Poultry and eggs ‡	Food fish †
1925	96	93	97	150	162	103
1926	97	97	100	152	158	100
1927	98	102	112	148	143	100
1928	100	101	114	158	152	95
1929	99	100	134	161	161	88
1930	99	106	125	136	128	94
1931	100	101	101	99	99	98
1932	99	99	87	94	81	92
1933	103	100	99	72	74	86
1934	106	96	114	84	89	80
1935	93	92	129	115	116	76
1936	101	99	128	120	114	79
1937	98	101	133	127	110	79
1938	102	101	127	113	108	86
1939	106	108	140	108	95	91
1940	112	109	138	112	96	89
Mean deviation	3.33	3.31	14.4	22.4	24.6	6.87

* Average 1935-39 = 100. Bureau of Agricultural Economics.
† 1926 = 100. Calculated from data assembled in this study.
‡ Average Aug. 1909–July 1914 = 100. Bureau of Agricultural Economics.

Numbers of Fishermen. Table 38, Appendix, and Fig. 3 exhibit the total quantities of all kinds of fishery products in the Atlantic–Gulf regions, the total number of actual fishermen (so far as ascertainable) who produced it, their production per man and their incomes actual and in relative buying power per man. Table 39, Appendix, and Fig. 4 exhibit similar data for the United States (7 regions). These exhibits show for the United States (1) that over the 54-year period, 1887-1940, the United States production of all fishery products, food and non-food, has increased from around 1.5 billion pounds annual average in the 1890's to 3.5 billion pounds in the late 1930's; (2) that the number of fishermen engaged in producing the total yield has *decreased* from 140,000 in the 1890's and early 1900's to 100,000 in the 1930's; (3) that the number of fishermen engaged tends to follow the pulse of the business cycle, but with lower amplitude of change than that of quantity of production; (4) that the quantity of production per fisherman increased from about 10 to 12 thousand pounds per man in the 1890's and early 1900's to 30-odd thousand in the 1930's; (5) that the production per man (in the late period of good statistics) followed faithfully the business cycle, i.e., fishermen catch more fish per man in good times and less in bad times; (6) that the actual money income per man increased from around $300 per man at the turn of the century to $1,000 in 1929 and around $750 in the late 1930's; (7) that the relative purchasing power ("real") income increased from $525 in the early period to $1,000 in 1929 and the late 1930's; and (8) that fishermen's income is less deflated in bad times in terms of purchasing power for other goods than it appears to be in actual dollars and cents.

These relationships for the Atlantic–Gulf coasts are similar in nature to those of the United States, but quantitatively not quite equal. Here again, in the behavior of fishermen is seen the operation of the mechanism of automatic adjustment of production to demand. As long as men are free to enter or leave the fisheries, and find it relatively easy to do so (since requirements of capital and skill or experience are not great), *the number of men, each in pursuit of his own best interest, adjusts itself in such manner that each fisherman does about as well at fishing as he could do in employment at other occupations.* The real or purchasing power wages of industrial employment have increased during the past century at the rate of doubling about each 45 years, and *the proportionate incomes of fishermen have as faithfully followed the trend of industrial wages as volume and value of their products have followed the trend of the business cycle.*

Improvements in Efficiency and Their Effects. Such improvements in efficiency as have been made in the fisheries of seven regions of the country resulting in an average tripling of the quantity per man, and doubling the real value of the catch per man, have necessitated the retirement from fishing of a third of the labor force, notwithstanding a doubling of the human consuming population since 1890. Any further improvements in production per man whether in methods of catching or in abundance of fish that would enable fishermen to catch more fish per effort could be expected to have the same effect, i.e., produce technological unemployment, as long as demand remains unchanged. Therefore, it follows that *efforts to improve the lot of* *fishermen by increasing the abundance of fish would, if successful, decrease their number without increasing their average income.*

The Over-all Effect of the Business Cycle on the fisheries is shown in Table 16, wherein the relative magnitudes of all the variables are adjusted to make 1922-23 = 100.

TABLE 16

Atlantic and Gulf Regions Combined: Numbers of Fishermen, Quantities of Production, Values of Product, Total and per Fisherman, at High and Low Points of the Business Cycle. (1922-23 = 100 in all Cases)

	Average 1922-23	Average 1928-29	Average 1932-33	Average 1936-37
Number of fishermen	100	105.5	95.3	104.2
Total fish, quantity	100	103.8	86.9	119.8
Fish quantity per man	100	100.3	91.2	115.1
Price in actual money	100	106.2	64.4	71.9
Actual value total	100	117.2	56.4	85.2
Actual value per man	100	113.3	49.2	81.7
Price in relative money	100	116.0	97.8	116.0
Relative val. (1926) total	100	120.4	85.9	100.7
Relative val. (1926) per man	100	115.8	90.2	96.6

In adjusting upward or downward to meet the competitive conditions in the business cycle, the fisheries expand or contract a little all along the line. In good times more fishermen work more hours, catch more fish per man and more total fish, sell it for a moderately increased price, realize more total money and more money per man; in bad times fewer fishermen fish, those that do fish work less, produce less, in total and per man, sell it for less money per pound, realize less total money for it and less money per man, but what they do realize will buy more of other goods per dollar than it would in prosperous times.

The Regional Fisheries. The automatic self-regulation of production is seen in part in the mutual accommodation among and between the major regions of the country. The statistical history of the seven regions has been summarized for comparison of the early period, 1887-1908, with the late period, 1921-1940; in Table 17 the figures apply to the total produce of the fisheries, food and non-food, its value, the number of fishermen engaged and their income; in Table 18 the figures apply to food fish only. In these tables, both actually canvassed and the interpolated figures were included in the averages to prevent the distortion by the unequal distribution of the canvasses among the years of each period. In Table 19 the data for food fish are recapitulated in comparison with population for the two periods, for the Atlantic-Gulf and for the whole country.

TABLE 17

Fishermen * Engaged in the United States Fisheries; Annual Average, Quantities and Actual and Relative † Values per Man, of all Fishery Products, Food and Non-Food, by Regions, in Early and Late Historical Periods

Period	Number of fishermen; * annual average	Quantity of fish, annual average		Annual average value			
				Actual		Relative †	
		Total pounds '000	Per man pounds	Total dollars '000	Per man dollars	Total dollars '000	Per man dollars
New England States							
1887-1908	24,395	512,600	20,970	11,119	455	20,104	822
1921-1940	17,255	558,517	32,360	19,820	1,147	23,010	1,333
Per cent change	−29.5	+9.0	+54.3	+78.3	+152.0	+14.4	+62.2
Middle Atlantic States							
1887-1908	21,068	274,179	13,020	8,050	382	14,628	695
1921-1940	9,345	222,324	23,800	8,829	945	10,037	1,075
Per cent change	−55.6	−18.9	+82.8	+9.7	+147.3	−31.4	+54.7
Chesapeake States							
1887-1908	44,492	364,015	8,180	7,939	178	14,449	325
1921-1940	20,417	324,000	15,860	9,457	463	10,667	522
Per cent change	−54.1	−11.0	+93.9	+19.1	+160.0	−26.2	+60.6
South Atlantic States ‡							
1887-1908	14,545	90,953	6,260	2,310	159	4,114	283
1921-1940	11,370	275,420	24,220	4,638	408	5,306	467
Per cent change	−21.8	+203.0	+286.8	+100.8	+157.9	+29.0	+65.0
Gulf of Mexico §							
1887-1908	11,417	71,506	6,260	2,957	259	5,281	463
1921-1940	13,862	175,701	12,670	8,060	582	9,305	672
Per cent change	+21.4	+145.6	+102.4	+172.6	+124.7	+76.2	+45.2
Great Lakes ‖							
1887-1908	8,116	102,871	12,690	2,707	334	4,883	602
1921-1940	6,317	87,310	13,810	6,001	950	6,964	1,103
Per cent change	−22.2	−15.1	+9.1	+121.8	+184.5	+42.6	+83.1
Pacific Coast States							
1887-1908	12,475	156,767	12,560	5,536	443	10,023	803
1921-1940	19,204	965,945	50,300	20,782	1,083	24,301	1,265
Per cent change	+61.9	+516.0	+300.4	+275.5	+144.5	+142.4	+57.6
Atlantic and Gulf of Mexico ‡ and §							
1887-1908	115,920	1,313,253	11,320	32,375	279	58,576	525
1921-1940	72,249	1,555,952	21,530	50,803	703	58,352	808
Per cent change	−37.7	+18.5	+90.3	+56.9	+152.0	−0.4	+53.9

Period	Number of fishermen; * annual average	Quantity of fish, annual average		Annual average value			
				Actual		Relative †	
		Total pounds '000	Per man pounds	Total dollars '000	Per man dollars	Total dollars '000	Per man dollars
	United States ♯						
1887-1908	136,510	1,572,891	12,660	40,618	327	73,482	592
1921-1940	97,874	2,611,033	26,700	77,700	794	89,799	918
Per cent change	−28.3	+66.0	+110.8	+91.3	+142.8	+22.2	+55.1
	North Carolina						
1887-1908	9,180	64,763	7,054	1,375	150	2,486	271
1921-1940	6,104	148,486	24,300	2,112	346	2,405	394
Per cent change	−33.5	+129.3	+245.0	+53.6	+131.5	−3.3	+45.4

* Actual fishermen only, professional and casual, so far as could be ascertained in the record, exclusive of shoresmen and men on vessels and boats transporting.

† In terms of the All-Commodity Wholesale Price Index, 1926 = 100, U. S. Bureau of Labor Statistics.

‡ North and South Carolina, Georgia and East Coast of Florida; includes Lake Okeechobee, 1927 to 1940, inclusive.

§ West Coast of Florida and the other Gulf States.

‖ Excludes Lake Namakan, Rainy Lake and Lake of the Woods, Minnesota, 1927 to 1940 inclusive.

♯ Excludes Alaska and Mississippi River system, but includes (1927-1940 inclusive) Lake Okeechobee, Florida, Lake Namakan, Lake of the Woods and Rainy Lake, Minnesota.

TABLE 18

Annual Average Quantities, Actual and Relative * Values and Prices, of the United States Production of Food Fish (Non-food Items Excluded) by Regions, for Early and Late Historical Periods

Period	Annual average value		Annual average quantity	Annual average price	
	Dollars '000			Cents per pound	
	Actual	Relative *	Pounds '000	Actual	Relative *
	New England States				
1887-1908	10,380	18,782	391,708	2.65	4.80
1921-1940	19,690	22,859	552,113	3.59	4.14
Per cent change	+89.7	+21.7	+41.2	+35.5	−13.8
	Middle Atlantic States				
1887-1908	7,634	13,876	117,981	6.47	11.77
1921-1940	8,312	9,449	109,887	7.56	8.60
Per cent change	+ 8.9	−31.9	−6.9	+16.8	−26.8
	Chesapeake States (Maryland and Virginia)				
1887-1908	7,588	13,819	174,055	4.36	7.97
1921-1940	8,511	9,617	168,037	5.06	5.72
Per cent change	+12.2	−30.4	−3.46	+16.1	−28.2

Period	Annual average value: Dollars '000		Annual average quantity	Annual average price: Cents per pound	
	Actual	Relative *	Pounds '000	Actual	Relative *
	South Atlantic States †				
1887-1908	2,270	4,045	69,896	3.25	5.79
1921-1940	3,956	4,534	96,978	4.08	4.68
Per cent change	+80.0	+12.1	+38.8	+26.5	−19.2
	Gulf of Mexico ‡				
1887-1908	2,532	4,540	71,009	3.57	6.40
1921-1940	7,078	8,161	163,159	4.34	5.00
Per cent change	+180.0	+79.8	+129.8	+21.6	−21.8
	Great Lakes §				
1887-1908	2,705	4,886	102,817	2.63	4.75
1921-1940	5,940	6,886	85,064	6.98	8.10
Per cent change	+119.6	+41.4	−17.3	+165.4	+70.6
	Pacific States				
1887-1908	4,998	9,002	154,292	3.24	5.84
1921-1940	18,805	21,886	593,232	3.17	3.69
Per cent change	+276.6	+143.1	+284.5	−2.2	−36.8
	Atlantic and Gulf of Mexico †‡				
1887-1908	30,404	55,062	824,421	3.69	6.68
1921-1940	47,547	54,608	1,090,774	4.36	5.01
Per cent change	+56.4	−0.8	+32.3	+18.2	−25.0
	United States ‖				
1887-1908	38,092	68,950	1,081,530	3.52	6.37
1921-1940	72,448	83,590	1,772,542	4.09	4.72
Per cent change	+87.9	+21.2	+63.9	+16.2	−25.9
	New England Vessel Fisheries ♯				
1891-1908	4,079	7,425	203,552	2.00	3.65
1921-1940	8,894	10,458	292,386	3.04	3.58
Per cent change	+118.0	+40.9	+43.4	+52.0	−1.9
	North Carolina				
1887-1908	1,345	2,430	43,863	3.07	5.54
1921-1940	1,692	1,925	42,675	3.97	4.51
Per cent change	+25.8	−20.8	−2.7	+29.3	−18.6

* In terms of All-Commodity Wholesale Price Index, 1926 = 100, U. S. Bureau of Labor Statistics.

† North and South Carolina, Georgia and East Coast of Florida; includes Lake Okeechobee, 1927 to 1940, inclusive (less than 2% of quantity and value).

‡ West Coast of Florida and the other Gulf States.

§ Excludes Lake Namakan, Rainy Lake, and Lake of the Woods, Minnesota.

‖ Excludes Alaska and Mississippi River system; includes (1927-1940 inclusive) Lake Namakan, Lake of the Woods, Rainy Lake, Minnesota, and Lake Okeechobee, Florida.

♯ Based on continuous (except 1892, interpolated) annual record, 1891 to 1940.

TABLE 19

Production of Food Fish, Gross Weights per Capita of Population in Early Period, 1887-1908, and Late Period, 1921-1940

	Average Annual Population Millions	Average Annual Production Pounds '000 *	Average Annual Per Capita Pounds '000 Gross *
1. Population of Eastern † States and production of Atlantic, Gulf and Great Lakes.			
1887-1908	53.4	914,184	16.9
1921-1940	101.4	1,177,484	11.6
Per cent of change	+90.0	+29.1	−31.4
2. Population of United States and production of United States not including Alaska and Mississippi River System.			
1887-1908	72.1	1,063,710	14.8
1921-1940	122.4	1,772,542	14.5
Per cent of change	+69.8	+66.6	−2.3

* Gross fish weights as landed by fishermen.
† Twenty-six states east of the Mississippi River plus Louisiana and District of Columbia.

In considering the regions and sections of the country, it should be remembered that the greater part of Pacific food fish is canned and most of the canned fish product comes from the Pacific. The Great Lakes-Atlantic-Gulf regions are the main source of fresh and frozen fish, and most of the produce from these regions is distributed in these forms.

The most spectacular advance in production was, of course, the Pacific region, the rapid development of which began after World War I. The Pacific and Gulf of Mexico are the only two regions to show an increase in the number of fishermen, the Pacific increase being nearly three times that of the Gulf. The Pacific is the only region to show a lower average actual price of food fish in the late period than in the earlier, and, accordingly, a much lower relative or index price. These price changes are the result of a great increase in production of cheap fish, notably pilchard, the largest volume single item of the entire country in 1940, at a price of 0.56 cents per pound or one-eighth of the average country-wide price of all food fish in that year.

The regions which make the poorest comparative showing are the Middle Atlantic (New York, New Jersey and Delaware) and Chesapeake (Maryland and Virginia). These regions experienced the greatest percentage (over

50 per cent) decline in numbers of fishermen and (with the Great Lakes) are among the only three to show a diminished total volume of all fishery products, the smallest increase in revenue of all seven regions, and (except Pacific) the smallest increase in prices of all regions. These adverse changes mainly reflect the serious shrinkage of the alewife, shad, and especially the oyster fisheries, of which the latter (as edible meats) for many years was second only to menhaden in physical volume and by far the leading money value item of the fisheries of this country, now surpassed in both quantity and value by the salmons (considered as a group), and by the tunas, and equalled in quantity (of edible portions) and approached in value by the shrimp. There appear to be no large finfish resources in these regions other than menhaden.

The Gulf of Mexico region reflects in number of fishermen, volume of production, money value and prices the rapid rise of the shrimp fishery which had its real beginning with the introduction of the trawl net after 1908. Part of this growth of the shrimp fishery is also mainly responsible for the moderate improvement in the South Atlantic region. Both South Atlantic and Gulf reflect the expansion in the general fisheries of both coasts of Florida, the east coast of which is for statistical purposes in the South Atlantic region and the west coast in the Gulf. In money value (of food fish) the South Atlantic remains the least important region in the country, and in physical volume of production of food fish it is about the same as the Great Lakes, though, when menhaden is included, it is much larger.

Although the trend of the recapitulated figures for the New England region is not conspicuously different from that of the whole country, or of the whole Atlantic–Gulf region, the conditions and operations of the fishery they represent underwent an almost complete transformation as between the early and late periods. In 1887, of the total ground or bottom fish produced in New England (all salt fish converted to fresh weights), 71 per cent was cod caught in sailing vessels by hand line, and 82 per cent of the cod was salted; cod and haddock together were 86 per cent of the total ground fish; hake, pollock and halibut brought the total to 99 per cent, and one per cent consisted of flounders, whiting and redfish combined. In 1940, codfish was only 17.6 per cent, salt fish had disappeared from the statistics; flounders, whiting and redfish together had grown from one per cent of the ground fish in 1887 to 39 per cent. In 1945, this group constituted 43 per cent of the total ground fish and codfish only 22.5 per cent.

These and numerous other changes had no perceptible effect on the orderly progress of the total yield of the New England region or of the whole country. It is possible that biological changes in the relative abundance of different kinds of fishes had something to do with the change in composition of the catch; we know that economic and technical influences did. Salt fish lost favor with the public and took a place of minor importance, and the whole fishery lagged to 1921, while other foods were beginning to be packaged and more attractively presented. Sail gave way to power, salt gave way to ice; fuel and ice brought in new items of cost; fishing therefore diminished on distant, and increased on near-by banks where cod was less abundant, haddock more. In 1921, fillets and packaging made their appearance; much of the cod was too large for single-portion fillets, and its name was identified in the public mind with salt fish; cod fillets were therefore skinned to prevent identification, skins were left on haddock fillets to encourage identification; haddock thus acquired a 3 per cent advantage over cod in whole weight or 7 per cent on fillet; the trade turned to haddock; "quick" freezing made its appearance; chain stores began to sell fish, markets in the interior of the country were opened; production of haddock greatly increased and cod decreased as a result of the new demand.

Meanwhile (to show how regions interact with other regions), the Great Lakes fisheries were being more and more intensely prosecuted.

During the half-century considered in this study, the population of the mid-west grew to great proportions, and villages grew to cities at a time when ocean fisheries had little access to the market. A taste was established for small-sized fresh water "pan" fish of the lakes and rivers; the growing population and developing delicatessen popularity of whitefish, lake trout, perches, catfish, etc., put heavy pressure on the definitely limited supply of the Great Lakes and Mississippi River system, and biologists became alarmed by what seemed to them to be "depletion" or exhaustion of the Great Lakes. The course of actual events is an example of the automatic operation of economic-biological determinants.

In response to insistent demand, prices rose disproportionately to the diminishing supply so that the Great Lakes experienced the greatest rise in prices of all the regions of the country, and is the only region of the country to have a higher average price for its fish in terms of purchasing-power in the 1921-1940 period than in the pre-1908 period; the decrease in quantity of production in the Lakes was greatest (17 per cent) of the three regions (the others being mid-Atlantic and Chesapeake) to show an actual decrease in the amount of food fish in the late period as compared with the earlier; nevertheless, in the *increase* in total money value of the Great Lakes product, both actual and in purchasing power, and in the number of fishermen still supported in the late, as compared with the earlier period, the Great Lakes region (American side) is surpassed only by the Gulf (shrimp) and Pacific (pilchard, tuna, salmon, etc.). The percentage improvement in income in dollars of constant purchasing power per fisherman exceeds that of any other region. While the entire Atlantic-Gulf section of the ocean and coastal fisheries increased production of food fish by 32 per cent and received unchanged (—0.8 per cent) purchasing power in return for it, the Great Lakes received 41 per cent more purchasing power income for 17 per cent less food fish. These facts demonstrate that *insistent demand for a limited supply of fish* (or a limited supply of fish for which there is an insistent demand) *expresses itself in higher prices.* They also show that *depletion, or diminishing abundance of a species or of a whole fishery, is not necessarily disadvantageous to fishermen.* In the case of the Lakes, scarcity has produced a disproportionate rise in prices which was decidedly advantageous to the fishermen as a group.

Meanwhile, the Great Lakes have not been "fished out"; it may not be possible to prove by formal logic that *it is impossible to exhaust an extensive fishery for profit because the profit disappears before the fish does,* but it is obvious as a matter of economics that as a fish becomes scarcer rising prices must check sales of it as well as attract competition from other fishes; and also that increasing cost and diminishing returns per unit of effort must always check production at some point far short of extinction. To check the exploitation of a fishery it is not necessary that profits disappear; they need only decline to a point equal to or lower than that of some other comparable fishery or even of some other occupation not fishing. For men will not work without reward, nor will they work at one trade for less than they can earn from another.

As supplies in the Lakes and rivers became scarcer, rising prices checked sales and performed their classic function of rationing the product to those who were able and willing to pay, establishing after 1920 an equilibrium at a level of production some 17 per cent lower than it was from 1887 to 1908 based on the figures regularly published by the Federal Government (or 25 per cent lower if we use the figures of the International Board of Inquiry (1943) for the Great Lakes). The rising prices and scarcity of Lakes and river fishes became a powerful attraction to fisheries elsewhere, at first drawing imports from the Canadian side of the Great Lakes and from other Canadian lakes; they generated the whiting fishery at Cape Cod about the time of World War I and, this not being enough, they furnished part of the incentive for developing the redfish fishery of New England, the expansion of the sales of other ocean fish fillets and various fishes from both Atlantic and Pacific, and even the catfish production as far away as Lake Okeechobee, Florida. Undoubtedly, the shipment of whiting and redfish (both being in size and structure suggestive of small fresh water fishes) to the mid-west contributed to checking somewhat the rise of prices of Lakes and river fish and also of relieving the pressure on the supplies of fish in the lakes and rivers; in reverse, it is seen how events in the mid-west reacted on the New England fisheries and explain in part the rise in production of a group of species which in 1887 was only one per cent of New England production, and in 1945 was 43 per cent. These and many other *actions, reactions, increases, decreases and accommodations occurring between, among, and within the regions are resolved into an orderly overall national result which pursues its own course, subject only to the cycle of business activity, as if the local and regional behavior on the one hand, and the national total on the other, were two entirely unrelated sets of phenomena.*

The Patterns of Economic Behavior of Commercial Species. In Tables 53, 54, 55 and 56, Appendix, are set up quantities and values, both in descending orders of magnitude, and the corresponding prices, of the principal commercial species of fish of the United States and Alaska for four representative years or periods, the composite of 1889-92, the year 1908, the averages of 1929-30-31 and of 1938-39-40; the tables show for each year or period all species (or groups of closely allied species, as reported) each of which amounts to one per cent or more of the total of either quantity or value of all nine regions. These tables show some of the permutations which have come about in the composition of the national total catch from 1889 to 1940, as will be seen on inspection of the rankings of oysters, mackerel, alewives, shad, shrimp, rosefish, pilchard, etc.

The number of "species" which enter into the one-per-cent-or-more class increased from around 20 to around 30 during the 50-year period, the number of true biological species being in excess of these numbers, perhaps 50 during the later periods. However, if the species were strictly biological, a number of them, such as flounders, and perhaps the clams and catfishes, might separately be too small in quantity or value to "make" the list, as the mullet failed to do in the 1930 period, and the squeteagues failed in the 1939 period. Only that part of the pilchard production is here treated as food fish which actually was so marketed, the remainder being treated as non-food fish. Prices are arrived at here from quantities and values as reported in the records; it is quite likely that some of them are truly competitive prices, others as actually paid were almost purely arbitrary, such as wages paid to crews of vessels and traps on the basis of amount of catch, or a seasonally agreed upon price, and still others estimated by field canvassers. All, however, have been treated alike herein as true values, regardless of how arrived at, for calculating prices.

Since the predominant group which accounts for five-sixths of the volume and three-fourths of the value (as of 1938-40) of the national product is made up of between 25 and 30 species, it is clear that *variations in the* *quantity of any one species have little or no influence on the total.* If our attention is confined to food fish only, the leading species (in 1938-40) are 11.5 per cent of volume (pilchard) and 9.5 per cent of value (oyster). Even in these species at the top of the list great variations in quantity whether caused by nature or imposed by the regulations or resulting from catching by man can occur with little or no effect on the total. For example, if all the pilchard that are canned were removed from the list, and not compensated by production of any other fish, the total value (to all fishermen) column would be affected only 2.0 per cent, although, of course, the sardine fishermen would be seriously affected. If halibut production should be halved as of 1938-40, the volume of total food fish would be reduced 0.8 per cent and the money value (if the price of the remaining production of halibut did not rise in response to the scarcity) would be diminished by 1.9 per cent. In such events as these, which are continually occurring, the declines in production of particular species appear to be made up by increases in others, and the fishermen themselves (who catch the declining species) may be recompensed in part if not in full or even more, by the rise in price of what they catch, depending on the circumstances of each case, as we shall soon see.

The mechanism which we have already described of accommodation and automatic adjustment of production to market demand is facilitated by the large number of species comprised in the total, of which the increases, decreases, or (except in the most important species) total disappearance would have little or no perceptible effect on the national total. The total of meat, poultry, and fish is only 9.5 per cent of the United States dietary, and the total of food fish, round weights is only 14 per cent of the meat, poultry, eggs, and fish, or 1.4 per cent of the whole diet, and the largest volume species of fish (food pilchard) is 11.5 per cent of all food fish or 0.16 per cent of the whole diet, and all other species of fish still smaller. It seems certain that the percentage of any one food fish, even the greatest, is smaller than the probable error of determination of the total amount of food consumed. These facts have far-reaching implications in the field of legislation and regulation and all attempts to maintain prices and benefit fishermen by increasing or limiting production.

Economic Case Histories of Twenty-one Common Fishes. Just how particular fishes behave, and under the influence of what factors, is illustrated by the behavior patterns of the twenty-one common species of fish and shellfish mostly of the Atlantic-Gulf-Lakes outlined in tabular form in Table 20. Here the quantity and per capita production are given, the actual number of dollars received for the product, the equivalent number of dollars of 1926 purchasing power for all commodities, the corresponding actual prices and 1926 commodity index prices.

For the first time in this report there is used here an "All Food Fish 1926 Price Index." This index is exactly analogous to and derived in the same way as the All-Commodity Wholesale 1926 Price Index, except that instead of the weighted average price of all commodities, the composite price of all food fish of the Atlantic–Gulf regions in 1926 is taken as the base 100.

TABLE 20

Economic Behavior Patterns of Twenty-one Common Fishes; Quantities, Values, Prices, etc., in the Years or Periods 1889-92,* 1908, 1929-30-31 and 1938-39-40

		1889-92 * Composite	1908 †	1929-30-31 ‡ Average	1938-39-40 ‡ Average
Population, Eastern States, Millions §		47.50	64.00	87.00	94.00
Commodity Price Index, 1926 = 100 ‖		56.20	62.90	84.9	78.00
Average price, all food fish, Atlantic, Gulf and Lakes ♯		3.76	3.57	4.72	3.77
Food Fish Price Index, 1926 = 100 **		65.2	61.9	81.8	65.3
Bluefish	Quantity, lbs. '000	18,198	7,646	6,869	5,350
	Per capita, lbs.	0.38	0.12	0.08	0.06
Pomatomus	Actual dollars '000	727	506	560	330
saltatrix	Actual price, cents	3.99	6.71	8.15	6.17
	1926 dollars '000 ‖	1,292	805	660	423
Atlantic	1926 index price, cents ‖	6.56	10.67	9.61	7.90
	Fish price ratio ††	1.00	1.77	1.63	1.54
	Quantity, lbs. '000	13,875	8,156	12,173	15,668
Soft clams ‡‡	Per capita, lbs.	0.29	0.13	0.14	0.17
	Actual dollars '000	550	546	870	1,154
Mya	Actual price, cents	3.96	6.70	7.15	7.37
arenaria	1926 dollars '000 ‖	978	868	1,025	1,480
	1926 index price, cents ‖	7.07	10.65	8.42	9.44
Atlantic	Fish price ratio ††	1.00	1.78	1.44	1.85
	Quantity, lbs. '000	9,495	7,518	8,333	12,990
Hard clams ‡‡	Per capita, lbs.	0.20	0.12	0.10	0.14
	Actual dollars '000	1,141	1,300	2,231	1,782
Venus	Actual price, cents	12.02	17.30	26.78	13.72
mercenaria	1926 dollars '000 ‖	2,030	2,069	2,630	2,285
V. mortoni	1926 index price, cents ‖	21.38	27.50	31.65	17.58
Atl. and Gulf	Fish price ratio ††	1.00	1.52	1.78	1.14
Cod	Quantity, lbs. '000	163,912	102,107	103,864	109,474
Gadus callarias	Per capita, lbs.	3.24	1.60	1.19	1.16
Atlantic	Actual dollars, '000	2,656	2,696	3,044	2,662
	Actual price, cents	1.78	2.64	2.93	2.43
Salted converted	1926 dollars '000 ‖	4,725	4,288	3,590	3,415
(× 1.95) to	1926 index price, cents ‖	3.16	4.20	3.46	3.12
fresh gutted	Fish price ratio ††	1.00	1.56	1.31	1.36

		1889-92 * Composite	1908 †	1929-30-31 ‡ Average	1938-39-40 ‡ Average
Blue crabs, hard	Quantity, lbs. '000	7,001	38,531	65,323	77,025
	Per capita, lbs.	0.15	0.60	0.75	0.83
Callinectes	Actual dollars '000	111	427	1,108	1,367
sapidus	Actual price, cents	1.58	1.11	1.70	1.90
	1926 dollars '000 ‖	197	679	1,305	1,750
Atl. and Gulf	1926 index price, cents ‖	2.75	1.76	2.00	2.43
	Fish price ratio ††	1.00	0.74	0.86	1.20
Blue crabs, soft	Quantity, lbs. '000	6,057	10,302	6,599	5,795
Callinectes	Per capita, lbs.	0.13	0.16	0.08	0.06
sapidus	Actual dollars '000	347	359	603	526
	Actual price, cents	5.74	3.49	9.10	9.10
	1926 dollars '000 ‖	616	571	711	674
Atl. and Gulf	1926 index price, cents ‖	10.20	5.54	10.56	10.77
	Fish price ratio ††	1.00	0.64	1.26	1.58
Flounders	Quantity, lbs. '000	10,363	23,346	71,968	85,506
Various	Per capita, lbs.	0.22	0.44	0.83	0.91
	Actual dollars '000	257	588	3,066	3,188
Heterosomata	Actual price, cents	2.48	2.52	4.27	3.73
	1926 dollars '000 ‖	458	935	3,611	4,090
Atl. Gulf and Pac.	1926 index price, cents ‖	4.42	4.00	5.02	4.78
	Fish price ratio ††	1.00	1.07	1.37	1.51
	Quantity, lbs. '000	45,957	59,987	237,112	163,106
Haddock	Per capita, lbs.	0.97	0.92	2.72	1.73
Melanogrammus	Actual dollars '000	743	1,308	7,727	4,371
aeglifinus	Actual price, cents	1.62	2.18	3.25	2.68
	1926 dollars '000 ‖	1,322	2,078	9,105	5,605
Atlantic	1926 index price, cents ‖	3.03	3.47	3.84	3.44
	Fish price ratio ††	1.00	1.42	1.60	1.65
	Quantity, lbs. '000	12,170	34,441	49,593	46,181
Halibut	Per capita, lbs.	0.26	0.54	0.57	0.49
Hippoglossus	Actual dollars '000	754	1,562	4,810	3,404
hippoglossus	Actual price, cents	6.18	4.54	9.70	7.38
	1926 dollars '000 ‖	1,342	2,483	5,665	4,362
Atl. and Pac.	1926 index price, cents ‖	11.03	7.21	11.45	9.45
	Fish price ratio ††	1.00	0.77	1.25	1.19
	Quantity, lbs. '000	48,753	41,118	20,605	22,571
Lake herring	Per capita, lbs.	1.03	0.64	0.24	0.24
and ciscoes	Actual dollars '000	562	989	556	664
Leucichthys	Actual price, cents	1.15	2.40	2.70	2.95
artedi	1926 dollars '000 ‖	1,000	1,572	656	852
	1926 index price, cents ‖	2.05	3.82	3.17	3.78
Great Lakes	Fish price ratio ††	1.00	2.20	1.88	2.57
	Quantity, lbs. '000	12,890	12,024	10,685	9,717
Lake trout	Per capita, lbs.	0.27	0.19	0.13	0.10

		1889-92 * Composite	1908 †	1929-30-31 ‡ Average	1938-39-40 ‡ Average
Cristivomer	Actual dollars '000	508	800	1,428	1,664
namaycush	Actual price, cents	3.94	6.65	13.37	17.10
	1926 dollars '000 ‖	903	1,272	1,682	2,132
Great Lakes	1926 index price, cents ‖	7.01	10.58	15.74	21.95
	Fish price ratio ††	1.00	1.78	2.71	4.34
	Quantity, lbs. '000	30,789	15,279	12,708	11,989
Lobsters	Per capita, lbs.	0.65	0.24	0.15	0.13
Homarus	Actual dollars '000	862	1,931	3,367	2,152
americanus	Actual price, cents	2.80	12.60	26.50	17.96
	1926 dollars '000 ‖	1,534	3,070	3,968	2,760
Atlantic	1926 index price, cents ‖	5.00	20.10	31.22	23.00
	Fish price ratio ††	1.00	4.73	7.54	6.40
	Quantity, lbs. '000	10,229	12,103	54,460	38,838
Mackerel	Per capita, lbs.	0.27	0.19	0.63	0.41
Scomber scombrus	Actual dollars '000	733	848	2,027	1,057
Atlantic	Actual price, cents	7.20	7.00	3.72	2.72
	1926 dollars '000 ‖	1,304	1,348	2,388	1,355
Salted converted	1926 index price, cents ‖	12.80	11.12	4.38	3.49
(× 1.35) to fresh	Fish price ratio ††	1.00	1.02	0.41	0.38
	Quantity, lbs. '000	20,759	33,703	29,884	36,690
Mullet	Per capita, lbs.	0.44	0.53	0.34	0.39
Mugil	Actual dollars '000	388	908	949	1,258
cephalus, etc.	Actual price, cents	1.87	2.70	5.18	3.43
	1926 dollars '000 ‖	690	1,444	1,118	1,614
Atl. and Pac.	1926 index price, cents ‖	3.32	4.28	3.74	4.40
	Fish price ratio ††	1.00	1.52	1.35	1.83
	Quantity, lbs. '000	169,293	148,872	82,791	80,092
Oysters ‡‡ §§	Per capita, lbs.	3.56	2.33	0.95	0.85
Ostrea	Actual dollars '000	13,985	12,035	10,554	7,638
virginica	Actual price, cents	8.26	8.09	12.75	9.41
	1926 dollars '000 ‖	24,900	19,140	12,430	9,790
Atl. and Gulf only	1926 index price, cents ‖	14.70	12.85	15.01	12.22
	Fish price ratio ††	1.00	0.94	1.08	1.04
	Quantity, lbs. '000	367	570	573	731
Pompano	Per capita, lbs.	0.01	0.01	0.01	0.01
Trachinotus species	Actual dollars '000	36	71	112	160
	Actual price, cents	9.70	12.45	19.55	21.88
	1926 dollars '000	63	113	132	205
Atlantic	1926 index price, cents ‖	17.24	19.83	23.00	28.00
	Fish price ratio ††	1.00	1.35	2.00	2.25
"Sea trout"	Quantity, lbs. '000	20,925	49,868	33,179	31,890
(squeteagues,	Per capita, lbs.	0.44	0.78	0.38	0.34
weakfish)	Actual dollars '000	709	1,777	1,403	1,224
Cynoscion	Actual price, cents	3.39	3.56	4.23	3.84
regalis and	1926 dollars '000 ‖	1,261	2,825	1,653	1,570
nebulosus	1926 index price, cents ‖	6.02	5.67	4.98	4.93
Atl. and Gulf	Fish price ratio ††	1.00	1.11	0.99	1.13

		1889-92 * Composite	1908 †	1929-30-31 ‡ Average	1938-39-40 ‡ Average
	Quantity, lbs. '000	41,645	27,641	14,830	12,192
Shad	Per capita, lbs.	0.88	0.43	0.17	0.13
Alosa	Actual dollars '000	1,764	2,113	1,887	979
sapidissima	Actual price, cents	4.24	7.64	12.72	8.04
	1926 dollars '000 ‖	3,140	3,360	2,222	1,255
Atl. and Pac.	1926 index price, cents ‖	7.54	12.15	14.98	10.30
	Fish price ratio ††	1.00	1.90	2.39	1.90
	Quantity, lbs. '000	8,225	19,080	101,674	148,784
Shrimp	Per capita, lbs.	0.17	0.30	1.16	1.57
	Actual dollars '000	142	494	3,516	5,173
Peneus	Actual price, cents	1.73	2.59	3.45	3.48
setiferus, etc.	1926 dollars '000 ‖	253	785	4,140	6,640
	1926 index price, cents ‖	3.08	4.11	4.07	4.46
Atl. and Gulf	Fish price ratio ††	1.00	1.58	1.59	2.01
	Quantity, lbs. '000	3,160	3,657	2,856	3,620
Striped bass	Per capita, lbs.	0.07	0.06	0.03	0.04
	Actual dollars '000	274	314	417	335
Roccus	Actual price, cents	8.67	8.59	14.6	9.26
saxatilis	1926 dollars '000 ‖	488	499	492	429
	1926 index price, cents ‖	15.45	13.75	17.23	11.85
Atl. and Pac.	Fish price ratio ††	1.00	1.05	1.34	1.07
	Quantity, lbs. '000	12,401	7,723	10,537	4,004
Whitefish	Per capita, lbs.	0.26	0.12	0.12	0.04
	Actual dollars '000	519	525	1,657	707
Coregonus	Actual price, cents	4.18	6.80	15.70	17.60
clupeiformis	1926 dollars '000 ‖	924	835	1,952	906
	1926 index price, cents ‖	7.45	10.80	18.52	22.40
Great Lakes	Fish price ratio ‖	1.00	1.71	3.00	4.20

* Composite totals for New England 1889, South Atlantic and Gulf 1890, Middle Atlantic 1891, Pacific 1892; Lakes 1890 interpolated between 1885 and 1893, all from U. S. Fish Commission.

† U. S. Bureau of Census, Fisheries of the United States.

‡ Average of three years, U. S. Bureau of Fisheries (1929-31), U. S. Fish & Wildlife Service, 1938-40.

§ States east of Mississippi River and Louisiana (27 states) and District of Columbia; non-decennial years interpolated.

‖ All-Commodity Wholesale Price Index, U. S. Bureau of Labor Statistics (averages for the periods). The "1926 dollars" and "1926 prices" are in money of constant purchasing power in terms of this index.

♯ Non-food products excluded.

** Food fish price index is the relative price of all Atlantic-Gulf-Lakes food fish referred to average price in 1926 (5.77 cts./lb.) = 100.

†† Fish price ratio is the ratio of the price of the specified fish to the average price of all Atlantic-Gulf-Lakes food fish for the same period. The actual ratios are adjusted to make 1890 = 1.00 so that deviations above or below 1.00 in the subsequent periods indicate that the price of the specified fish is increasing or decreasing relative to fish prices generally.

‡‡ Net Meats. For oysters, the number of pounds originally shown in the government reports (calculated uniformly at 7 pounds per bushel) have been revised to conform to actual experienced recoveries in the various states (U. S. Senate (1940), Rept. 1203, 76th Cong., 3d Sess.)

§§ Seed oysters have been excluded 1902 and later; prior to that year they were not consistently shown separately.

This fish price index is fully weighted, since the 1926 price is the total value divided by the total number of pounds of all food fish produced (in the Atlantic–Gulf regions) in that year. The price of any particular fish in any particular year, divided by the food fish price index for that year gives a price for that fish in terms of the general level of all food fish prices of the Atlantic–Gulf for that year. In the table, the fish price index is adjusted to make 1890 = 100 in every case. If, in a series of years, this food fish index price remains constant at 1.00 for any particular fish, then the price of that fish merely moved with the price of fish generally; if the index subsequently to 1890 increased or decreased, the price of that fish varied accordingly with respect to the general average price movement of all fish, i.e., it had a trend of its own. Similarly, change or constancy in the price of a particular fish in terms of the All Commodity Wholesale Price Index indicates whether the price of that fish is doing better or worse than or following the general average of all commodities.

The behavior patterns of individual species are highly diverse, each governed by its own peculiarities and circumstances. The production of codfish (salt fish converted to and included as fresh weights, distorting the price in 1890) decreased sharply from 1890 to 1908 and thereafter remained about constant, but between 1908 and 1940 declined from 1.6 to 1.2 pounds per capita of a growing population; the apparent value of the total codfish product is nearly unchanged over the entire period, but its exchange value for other goods was only about three-fourths as much in 1940 as in 1890. Diminished production of cod per capita did not serve to support the prices, or, demand from an increasing human population was not sufficient to maintain a price that would command increased production. Haddock, however, which in edible qualities, both esthetic and dietetic, is almost indistinguishable from cod, and yields the same percentage of edible flesh, behaved much better. With a volume of production in the latest period of three times that of the earliest, and nearly twice per capita of population, actual prices of haddock increased by 60 per cent, advancing about 60 per cent more than fish prices generally and since 1908 keeping up with all-commodity index prices. *While codfish was losing ground in price on a 30 per cent decline in per capita production, haddock prices increased on a doubled per capita production,* and the purchasing power of the proceeds of haddock production increased more than fourfold. The price of haddock was lower than that of cod in the early period but surpassed it in about 1928. See p. 402 for conditions affecting prices.

The catch of eastern mackerel (*Scomber scombrus*) was in 1940 nearly four times what it was in 1890 (salt converted to fresh), but only about 50 per cent greater per capita. Yet actual price was in the 1940 period less than 40 per cent of what it had been in 1890 or 1908, and index prices relative to all commodities and to all fish were down to a third of the earlier figures. The actual money value for 39 million pounds of mackerel in 1940 was increased by less than 50 per cent over what it had been for 10 million pounds in 1890, i.e., by a fourfold increase in quantity, and the purchasing power of the total money received by fishermen was approximately the same in 1940 as it had been in 1890. The loss of popularity of mackerel may be due to the diminishing demand for salt fish, and also to its fat content as a fresh fish.

These examples of economic behavior of well known large-volume common food fish clearly demonstrate that the *total revenue of a fishery is not necessarily increased with increasing abundance or production of fish nor, as we have already seen, is it necessarily diminished by decreasing abundance.* If fish become more abundant and the fisherman tries to increase his income by catching more fish, prices may react disproportionately downward to such an extent that total actual money and purchasing power of the proceeds may be and often are smaller on the increased catch.

Neither are deficiency of supply and diminution of production per capita necessarily and of themselves sufficient to assure countervailing higher prices, though they may and in some instances they do. The total production of shad dropped in the late period to less than a third of what it was in the early period and, per capita, to less than a sixth; prices of shad increased at about double the rate of increase of general fish prices, the actual dollars received were cut to a half, and purchasing power to little more than a third in 1940 of what it had been in 1890 and 1908. We can only surmise what would have happened to the shad fisherman's income if the efforts to restore the original abundance of shad had been successful.[52]

On the other hand, flounders (collectively of several species usually sold as "sole") have yielded greatly increased amounts, both absolute and per capita, at rising prices, with twelve times as many actual dollars in 1940 as in 1890, and more than nine times as much purchasing power.

The pompanos, although never abundant, about doubled in production between 1890 and 1940 along with human population, but actual price more than doubled and relative buying power price has increased more than 60 per cent and the fisherman can buy more than three times as much other goods with the proceeds of the catch.

Mullet has behaved well since 1890, the production keeping pace with growth of population, at advancing prices, actual and relative to other commodities and to all fish, and with three times the actual money proceeds and twice the purchasing power. The "sea trouts" (squeteagues or weak-

52. We are dealing here with national totals and yearly averages; effects might be quite different locally and seasonally. For example, if the production of shad should be increased in North Carolina or South Carolina in March, the effect might be much more favorable than if it occurred in Delaware in late May.

fish) taken together behaved with the average of all food fish and yielded to the fishermen about a constant amount of purchasing power except in the "bumper crop" period of 1908.

In other cases, scarcity (in the presence of insistent demand and absence of substitutes) does definitely express itself in higher prices. The volume of production of lobster was reduced to 40 per cent in total amount, and one-fifth per capita, over the 50-year period 1890-1940. Actual price increased more than sixfold, and prices relative to all commodities and to all food fish both increased five to sixfold; actual dollars of revenue doubled, and purchasing power of the total dollar income of the fishermen for lobster increased by nearly 50 per cent. The lake trout is a very close parallel to the lobster in its pattern of behavior; production down by a fourth, actual price up four times, commodity index price up three times, and fish index price up four times, actual money value threefold, and purchasing power more than twice. This pattern also applies to whitefish and the Great Lakes fishes generally, and accounts for the remarkable comparative showing of the Great Lakes regional behavior. (Tables 17 and 18.)

Why it is that with a comparable amount of production and percentage decline in both lobster and shad, the price of lobster should be increased sixfold, that of the shad only doubled, the amount of money for the lobster should be doubled and that for the shad be halved, and the purchasing power of the total proceeds from the sale of lobster be increased by nearly 50 per cent, while that for shad be reduced to a little more than a third? The shad can be easily substituted for by many other kinds of fish, and appears to be declining in popularity along with the other heavy fat fishes, such as the mackerel. The lobster is socially elegant, without any rival or substitute unless spiny lobster or crayfish be considered a rival. It is biologically a slow grower, limited in quantity, and is in definite demand; indeed, perhaps the nature of the demand is such that it is more likely to be wanted at a high price than it would be at a low price. The difference in behavior of shad and lobster is obviously in public esteem or demand. It is evident that the choicer species of fish from the Great Lakes must enjoy a prestige and special demand similar to those for lobster, though the reasons why they do are not obvious. These facts, of which only a few are here presented as examples, clearly demonstrate that the welfare of fisheries and fishermen is not simply a matter of abundance of fish, and could not be provided for with any assurance by the maintenance (if that were possible) now proposed, of each species simultaneously at some level of abundance which somebody considers optimum. The one element which is indispensable to the welfare of the fisheries is demand for their products.

The oyster and the shrimp call for special consideration here, since the two are or may be the most important fishery products of North Carolina.

Each is unique of its kind in having no interchangeable substitute; both are, to an extent, luxury items, and have differed markedly in economic behavior.

The *Oyster* has undergone the most serious economic deterioration in market importance of all the major United States fishery products. Table

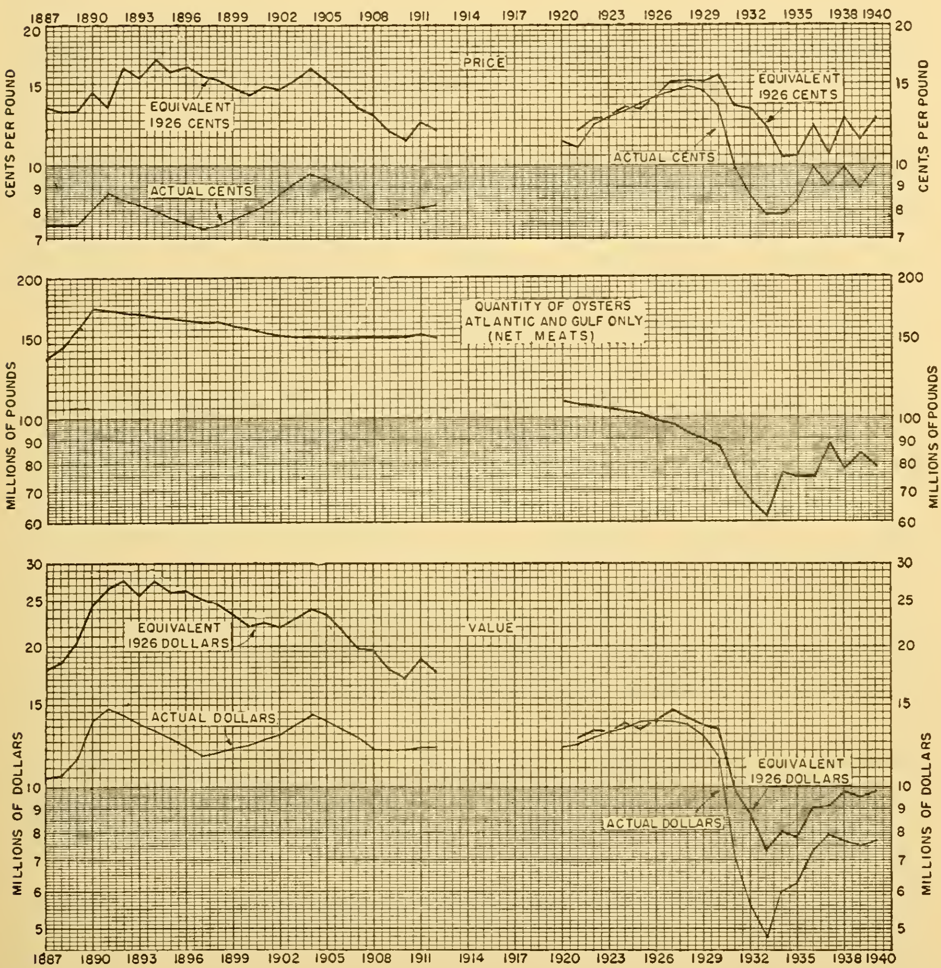

FIG. 16. Market oysters, exclusive of seeds, Atlantic and Gulf coasts only, 1887-1940. Inadequate statistical record 1912-1920.

57, Appendix, and Fig. 16 exhibit the statistical history of total oyster production of the five regions which make the Atlantic and Gulf coasts. These series were arrived at by interpolation in each region in the void years and the regions combined in the same manner as the main tables and graphs of fish production, the early period extending from 1887 to 1912, the late from 1921 to 1940.

For many years toward the end of the last century and the first decade of this, the net weight of edible meats of the oyster exceeded even the gross weight of any other product of the fisheries except menhaden (which is not considered edible), see Table 53, Appendix; in 1890 its value was 38 per cent of that of all food fish and four times that of its nearest rival, the five Pacific salmons combined; it exceeded the combined values of all salmons, cod, shad, clams, mackerel, lobster, haddock, halibut, and sea trouts. The oyster production of the Atlantic–Gulf regions continued until the period of meager statistics at the time of World War I, as by far our most important United States fishery. By 1920 it had already decreased sharply, and from then onward production expressed as per capita of the Eastern States declined steadily to about 24 per cent as much, in the 1938-40 period, as it had been in 1890, and, expressed as total quantity of production of the Atlantic–Gulf regions, to 47 per cent of what it had been in 1890 and 54 per cent of what it had been in 1908.

In 1890 the oyster was the highest priced of all major fishery products of the country (i.e., of all which amounted to one per cent or more of the total quantity or value); in 1908 the oyster ranked third; in 1930 and 1940 fifth and fourth, respectively; prices of oysters, actual as well as relative to other commodities and to fish generally did not rise consistently; for a short period during the prosperity boom of the 1920's they were up, but in the 1930's they reacted to the pre-1908 level. Actual money value of the total production in 1940 was 55 per cent of what it was in 1890 and the purchasing power equivalent of the total money value in 1940 was 39 per cent of what it was in 1890 and 51 per cent of 1908. The behavior is therefore a long continued decline in volume, absolute and per capita, at prices which have not risen in response to the diminishing supply, for a rapidly increasing population with improving standard of luxurious living. In this respect the economic behavior of the oyster resembles that of the shad, but on a much larger scale.

Insufficiency or depletion of supply does not seem adequate to explain the persistent decline in the production of oysters. If biological scarcity alone had set the limit to production, then prices should have risen as they did rise sharply for Lakes fishes, lobsters, etc., when these were in short supply; a three or fourfold increase in prices would have provided the incentive for extension of oyster production by cultivation on old bottoms or, failing that, the opening of new territory, of which there appears to be a plenty south of Chesapeake Bay.

The decline in production of oysters combined with the failure of prices to rise suggests that something happened to demand in the years following 1912, for an examination of the available data on oyster production indicates that the peak was reached in about that period, though *per capita* production had already been declining for twenty years or more.[53]

The history of production, values, and prices of oysters in the Atlantic–Gulf regions is recapitulated in more detail in Table 21, on which the following observations are made:

1. In only one region (Gulf) did total quantity of production *increase* in the latest over the earliest period (+86 per cent). This region shows the greatest *decrease* in price of all the regions (−32 per cent in actual price, −53 per cent in 1926 money price).

2. Mid-Atlantic and South Atlantic regions show intermediate declines in volume (−51 per cent and −34 per cent respectively) between earliest and latest periods; these regions show little change in actual prices (0 per cent and +4.8 per cent) and intermediate declines in 1926 money prices (−27 per cent and −28 per cent).

3. The region to show the greatest decrease in production of all regions (−67 per cent), Chesapeake, shows the least adverse (except New England) percentage change in price between earliest and latest periods (+25 per cent actual, −16 per cent in 1926 money).

4. New England appears in its almost constant 1926 money price to have been most successful between earliest and latest periods in adjusting its marketing operations to current demand (quantity −50 per cent; actual price +44 per cent, price in 1926 money, +1 per cent). Practically all oysters from this region are cultivated and marketing is under control.

5. There are only faint signs of the effects of the inflationary boom in the third period (1920-1930), which affected other luxury products of the fisheries.

6. Marked regional differences in price level have persisted over the years; South Atlantic cheapest, and in rising order, Chesapeake, Gulf, New England and Mid-Atlantic.

These relationships of quantities to prices and money values indicate that even the diminishing production was exerting pressure on market demand in all regions and in the whole eastern part of the country sufficiently to cause decrease in prices and in purchasing power of the total net proceeds of sales; the decline of 67 per cent in production in the largest producing region, the Chesapeake, was not sufficient to prevent decline in prices.

Possible Explanations of the Market and Price Behavior of Oysters. It is not necessary to seek a single factor or "cause" of the adverse change

53. Per capita production of oysters, Eastern, bushels.

1880	.444	1920	.160
1890	.421	1925	.155
1897	.347	1929	.121
1904	.297	1935	.111
1908	.288	1940	.136

TABLE 21

Oysters: Recapitulation * by Regions † and by Historical Periods of the Production, Values and Prices of Market Oysters (Exclusive of Seed) || 1887-1940

Periods	New England	Mid-Atlantic	Chesapeake	South Atlantic	Gulf of Mexico	Total † Atlantic and Gulf
I. Production of Edible Meats ‡	Pounds ('000 omitted), annual average.					
1887-1899	15,850	30,890	96,700	7,200	8,460	159,100
1900-1912	17,610	30,640	69,200	15,550	17,350	150,400
1920-1930	7,738	26,020	44,960	7,070	13,490	99,278
1931-1940	7,875	15,080	32,079	4,751	15.757	75,542
II. Value	Dollars ('000 omitted), annual average.					
1887-1899	1,686	3,920	5,848	304	752	12,510
1900-1912	2,122	3,970	4,790	596	1,313	12,791
1920-1930	1,491	4,590	4,957	410	1,501	12,950
1931-1940	1,206	2,037	2,392	213	964	6,812
III. Relative Value §	Dollars ('000 omitted), annual average.					
1887-1899	3,230	7.570	11,210	582	1,440	23,970
1900-1902	3,240	6,360	7,680	956	2,100	20,500
1920-1930	1,458	4,490	4,850	401	1,468	12,660
1931-1940	1,586	2,680	3,150	280	1,267	8,960

Periods	New England		Mid-Atlantic		Chesapeake		South Atlantic		Gulf of Mexico		Total † Atlantic and Gulf	
IV. Prices, actual and relative §	Cents per pound, annual average.											
	Act.	Rel.	Act.	Rel.	Act.	Rel.	Act.	Rel.	Act.	Rel.	Act.	Rel.
1887-1899	10.6	20.3	13.5	25.8	6.0	11.6	4.2	8.1	8.9	17.1	7.9	15.1
1900-1912	12.0	19.3	13.0	20.7	6.9	11.1	3.8	6.2	7.6	12.1	8.5	13.6
1920-1930	19.3	18.9	17.6	17.3	11.0	10.8	5.8	5.7	12.0	11.7	13.2	12.9
1931-1940	15.3	20.1	13.5	17.8	7.5	9.8	4.4	5.8	6.1	8.1	9.0	11.9

* Each historical period is made into a continuous series by interpolating the years not canvassed; the averages are those of the actual canvasses and the interpolated figures.

† Atlantic and Gulf coasts only, Pacific coast excluded.

‡ Recovery of edible meats per bushel of oysters recalculated by Fish & Wildlife Service from the statistical record (originally reported uniformly as 7 pounds per bushel), on the basis of actual yield in the respective regions.

§ Relative values and prices are in money of constant purchasing power in terms of the All-Commodity Wholesale Price Index, 1926 = 100, Bureau of Labor Statistics.

|| Seed not consistently shown, and therefore not consistently excluded in the above table for the years before 1902.

in the oyster fishery; the behavior of the oyster trade is undoubtedly the resultant of the interaction and cooperation of many factors concerning which we have little factual data. It has already been noted that the increases in United States fishery production have occurred chiefly in the mass production, mechanized fisheries. The mollusk fisheries have depended on extensive use of human labor to dig, dredge, or tong the product from the mud or water, and it has been only recently that power dredges have been introduced or significantly improved; until 1948 power propelled craft were prohibited in North Carolina for dredging oysters. A great deal of hand labor is used to cull oysters and to shuck them, both in plants and restaurants, little of which has been successfully mechanized. The increased cost of production occasioned by increased labor wages could be aggravated by diminished yield per day's work on depleted natural rocks. The consequences of these adverse effects would be a dilemma for management to decide whether to cut prices to maintain volume or to maintain prices and let volume decrease, or to do some of both. Where, as seemingly in oysters, costs have advanced sharply, management may have no freedom of choice but to let volume diminish since it cannot reduce prices to stimulate sales.

The *Shrimp* fishery is largely a development of the past forty years, since 1908, when the otter trawl came into use for shrimp. From 8 million pounds, whole weight, in 1890 annual production rose to 19 million pounds in 1908. In 1938-40, production was 7.8 times what it had been in 1908, while oyster production had declined 46 per cent in the same period. Notwithstanding the increasing volume of shrimp, prices increased, the 1938-40 average price being twice the 1890 price and 34 per cent higher than 1908; shrimp fishermen received more than ten times as many total dollars for the catch with 8½ times as much other commodities at wholesale with the proceeds in 1938-40 as in 1908. The fish price ratio (the ratio of shrimp prices to the average prices of all food fish) doubled over 1890 and increased 33⅓ per cent from 1908.

When judged by all the standards of measurement of a species that we have, the shrimp appears to have many advantages: being a luxury delicacy item, its price is not determined by bare competition as a staple item of food; it is easily subject to economical mass capture; its net edible portion is a high percentage of the total weight; it requires little in the way of preparation for market and that not expensive; it is well adapted to canning and freezing, as well as to the fresh fish market; it can be prepared for the table in many ways; and the demand so far seems unlimited. Biologically it is enormously fecund, reaches commercial size in the same year in which it is hatched, and appears to subsist on the most prevalent of aquatic foods, the organic detritus and its immediate derivatives on the bottom.

The *Blue Crab,* another crustacean, is, in a more modest way, a growing resource of the South, and has many of the favorable biological and economic characteristics of the shrimp. Its potentials do not appear to be as large, its habitat is more restricted, and more labor is required to catch and prepare it for market. It should be very resistant to exploitation. Its yield of edible flesh, however, is small in proportion to its bulk and its cost rather deceptively high. As soft crabs, the species has made no progress statistically since 1890 or 1908; as hard crabs, its 1938-40 volume was ten times 1890 and twice 1908 at prices about constant in terms of buying power.

We have considered the possibility that the decline in oyster production and failure of prices to rise is caused by competition from shrimp and possibly crab, the former of which can be produced and sold at lower cost. It may be significant that the rapid rise of the shrimp and the crab coincides and is concurrent with the decline in the oyster. Table 22 shows the parallel history of oysters, shrimp, crabs, and the sum of all three, in certain typical

TABLE 22

Production and Values of Oyster, Shrimp and Blue Crab, Atlantic and Gulf Coasts, 1890-91, 1908, 1929-31, and 1938-40

	Oyster *	Shrimp †	Crab ‡	Total
	Quantity, net edible, pounds '000			
Composite 1890-91	169,293	4,112	7,037	180,293
1908	148,872	9,450	15,656	172,978
Avg. 1929-30-31	82,791	50,837	16,744	150,372
Avg. 1938-39-40	80,092	74,392	16,579	171,063
	Quantity, pounds per capita of Eastern States §			
Composite 1890-91	3.56	0.09	0.15	3.80
1908	2.33	0.15	0.24	2.72
Avg. 1929-30-31	0.95	0.58	0.19	1.73
Avg. 1938-39-40	0.85	0.80	0.18	1.82
	Value, actual dollars '000			
Composite 1890-91	13,985	142	458	14,585
1908	12,035	494	780	13,309
Avg. 1929-30-31	10,554	3,516	1,711	15,781
Avg. 1938-39-40	7,638	5,173	1,893	14,704
	Value, dollars '000, 1926 purchasing power			
Composite 1890-91	24,900	253	513	25,966
1908	19,140	786	1,240	21,166
Avg. 1929-30-31	12,430	4,141	2,017	18,588
Avg. 1938-39-40	9,790	6,630	2,428	18,848

* Net edible meats market oysters, corrected for average yield per bushel each State.
† Net edible portions of shrimp, raw, taken as 50% of reported round weights.
‡ Net edible portions of crab taken as 14% of reported round weight of hard crabs and 100% of soft crabs.
§ 26 States east of the Mississippi River, plus Louisiana and District of Columbia.

years, by total quantities and quantities per capita, and by values in both actual and 1926 dollars, allowances being made for the edible percentages of the three products. As oysters decreased in quantity, shrimp and crabs increased so that the total of all three is nearly but not quite constant; they have not kept pace with growth of population; the total actual money value of all three was constant (at least in the four representative periods), but the purchasing power of the proceeds decreased with the decreasing value of the dollar.

As is readily seen, the spectacular rise of the shrimp fishery, viewed alone, appears to be a great step forward for the fisheries industry; actually, it appears to be a shift from the oyster and mainly inter-regional, from one portion of the fisheries to another, with a decline in pounds, a standstill in actual dollars and decline in dollars of constant purchasing power and with no visible effect on the total national curves which, as said at the beginning of this Section, are determined by demand, and not by supply.

RESUME OF QUANTITATIVE FISHERY ECONOMICS

The total quantity of food fish produced in the United States is the total of the sales of all the retail outlets throughout the country; it does not appear to be determined or appreciably affected by the variations in abundance of any species, or of all species of fish, or by any other biological influence in the water. The out-take from the waters everywhere appears to be small in comparison with photosynthetic productivity per square mile, the area fished, and the fertilizers in the water; and compared also with the yield of agriculture. The yield of the United States fisheries appears small in comparison with that of numerous other fishing areas of the world.

The greater part of the fish produced in the United States, as elsewhere, is human food; the average commercial retail weight of all kinds of food consumed per year per capita of United States population is nearly constant (1909-1940) at 1,520 pounds (average annual deviation ±2.0 per cent); about 9.5 per cent of the total is meat, poultry and fish; fish (whole as landed) is about 14 per cent of this group; in gross weight it is slightly more, and in net edible, considerably less, than one per cent of the whole diet.

The total production of food fish (Atlantic-Gulf-Great Lakes-Pacific regions) over the 54-year period 1887-1940 considered as a whole, increased, though not uniformly in proportion to population; in rate of increase, fisheries lagged behind population from about 1900 to 1921; with introduction of improvements (filleting, packaging, quick freezing, chain store merchandising, etc.), fish production increased faster than population from 1921 to 1940, so that the production per capita for 1935-40 was slightly higher than for any earlier period of record.

Production in the older fisheries of the Atlantic–Gulf regions also increased, but not in keeping with the rate of increase of the population of the eastern States; the annual per capita eastern production at no time after 1921 equalled that of 1908 and earlier. Production of the Great Lakes was about 17 to 25 per cent (depending on what set of statistics is used) less in the inter-war period than it was in 1908 and earlier.

The increased United States production of food fish as a whole has been sold at decreasing real prices.

The average annual price to fishermen for all food fish in current money was about 16 per cent higher in the late (1921-40) period than in the earlier (1887-1908); real prices, however, were diminished, i.e., a given quantity of a cross section of all food fish could only be exchanged for 26 per cent less of a cross section of all (about 900) commodities in the late (1921-1940) than in the early period (1887-1908); for other foods, food fish had exchange value less by 27 per cent in the late than in the early period.

In the Atlantic–Gulf regions, even though per capita production of food fish was less in the late period, average prices underwent almost exactly the same percentage decrease as did those of the whole country; with an increase of 32 per cent in total pounds of production, the total real value in terms of other commodities, because of lower prices, was unchanged (—0.8 per cent).

The increased yield of all fish has been produced by fewer fishermen (number assignable to food fish not separately ascertainable). The number of fishermen reached its peak about 1900-1902 with 145,000 for the country, and 124,000 for the Atlantic–Gulf regions; by the 1930's the national total had decreased 28 per cent to 100,000 and the Atlantic–Gulf decreased by 43 per cent to about 70,000. The average weight of catch per fisherman had doubled in the late (1921-1940) as compared with the early (1887-1908) period, and tripled on comparison of the early 1890's with the late 1930's. Improvements in efficiency made it possible to supply the requirements of an increased population despite the reduction of nearly one-third in the number of fishermen.

The average individual income nearly doubled (in purchasing power) for the smaller number of United States fishermen between 1900 and 1940; that of the Atlantic–Gulf regions increased by about 60 per cent. On the whole, the fisherman's reward for his labor, though not comparable in amount, increased at about the same rate as did wages of industrial skilled labor. Improvement in efficiency, or catch per man, apparently does not increase the income of fishermen, but compels a reduction in their number; the number of fishermen engaged appears to adjust itself automatically to that which can just produce the amount of fish required by the market.

The curve of total quantity of food fish produced year by year follows that of the index of industrial production which is typical of the business cycle; the volume of fish production in Canada follows the Canadian index of industrial production; production of the nine leading countries of Northern Europe appears to have followed up to 1938 the European cycle of business activity. The value of the fisheries has faithfully followed the curve of national income in both the United States and Canada. Both the quantity and value of fish produced are determined solely by the economic factor of demand.

The interaction of cost of production of a highly perishable product for a limited and inelastic market attended by extremely sensitive prices appears to constitute an automatic self-regulatory mechanism by which the total quantity of product is adjusted to supply the existing total demand by mutual accommodation of surpluses and deficiencies, or abundances and scarcities, between, among, and within the various regions, localities, and specific fisheries of the country; by the immediate reaction of prices to change in supply, the mechanism regulates the total and apportions the productive effort among the fishermen who engage in whatever fisheries appear to be most profitable in terms of quantity and price from place to place and time to time, or enter or quit the fisheries, as appears to their best interest. In this way the fishing effort of the whole country is modulated in amount and distributed over all the opportunities in all localities and regions.

Suggestive indications are found in the statistical record that there may also be natural and automatic biological accommodations among the species of fish in the water; that the competitions, rivalries, and depredations among species are such that, as the populations of some species decrease, those of other species increase up to the limit of their basic food supply, in accord with some aquatic equivalent of the Malthus law of human populations. Gross historical changes in the composition of some of the product of the older fisheries (such as those of New England) are consistent with such a theory.

In following the pulse of prosperity and depression, the fisheries product, or at least the dominant part of it, pursues an opportunist course in the market. When competing meat and eggs are high priced, the quickly responsive fisheries produce enough more fish to meet the increased demand with some but not great increase of fish prices; when competing products are cheap, the fisheries quickly retrench operations so as to reduce production but not seriously reduce prices. Hence, in both quantity and total value, but only to a limited extent in prices, the fisheries follow the typical course of the business cycle; in a depression, fewer fishermen work, and those engaged catch fewer fish and sell them at slightly lower prices and less total money; on the return of better demand the entire series of adjustments is automatically reversed.

From a recapitulation of the regional statistical history of the country there are chosen two regions, New England and the Great Lakes, as examples of the operation of interregional economic determinants. In the New England region, the codfish in 1887 accounted for 71 per cent of the ground or bottom fish and 82 per cent of this was salted; cod, haddock, hake, pollock and halibut combined accounted for 99 per cent of all, the remaining one per cent being flounders, whiting and redfish combined. In 1940 cod was 17.6 per cent and the last mentioned three had risen to 39 per cent and in 1945 they were 43 per cent. These changes may in part reflect biological changes in the fishery populations; in another part, the interplay of many economic forces in the market, a part of which was the competitive situation in the inland Lakes and River regions.

In the mid-west increasing demands from a growing population bore down on the limited supplies of fresh water fish; heavy fishing yielded smaller returns per effort, and prices rose disproportionately, so that in the Lakes region the percentage improvement in income in dollars of constant purchasing power per fisherman exceeded that of any other region; it was the only region of the country to receive a higher average price in terms of purchasing power in the 1921-40 period than the pre-1909 period, that is, 41 per cent more purchasing power for 17 per cent less fish, while the entire Atlantic–Gulf section of the ocean and coastal fisheries increased production of food fish by 32 per cent and received unchanged (—0.8 per cent) purchasing power money for it.

These events indicate that insistent demand for a limited supply of fish expresses itself in higher prices; that diminishing abundance of a species or of a whole regional fishery is not necessarily disadvantageous to fishermen. It also appears impossible to exhaust a fishery for profit, since rising prices check sales and attract competition of other fishes (as in this case the fillets of haddock, cod, flounders, whiting and redfish from New England) and rising costs and diminishing returns must check production of the particular fishery at some point far short of extinction of any species.

The accommodation of production to market demand is greatly facilitated by the large number of species. Tabulations in descending order of magnitude of quantity and value of the leading species for four representative periods (1890, 1908, 1930, and 1940) show that great commutations have occurred and continue to occur in the relative contributions of the many species to the total product of the country; that the total as of 1940 consists of some 30 or more species which severally account for one per cent or more of the value; that no species has been economically dominant to such an extent that even drastic changes in its abundance have had any discernible effect on the total quantity or value of the total food fishery product.

A study of the case histories of 21 species, mostly of the Atlantic–Gulf regions, shows that they behave in a great diversity of economic patterns. In some species (lobsters, lake trout) diminished production was attended by greatly increased price and total real value in terms of purchasing power; the total real value remained unchanged on a threefold increase in mackerel, and also on a 50 per cent decrease in Lake whitefish; in several species (halibut, flounders, pompano, hard crab), with increased production prices also increased or were maintained with increase in total value; in shad, lake herring, bluefish, on decreasing production prices were insufficient to maintain total values which accordingly decreased.

Strong demand is the only factor which is invariably beneficial to the fisherman. Increased value may be realized from smaller or larger or unchanged quantity of fish according as demand makes it so; increase in quantity of production without increase in demand, or a corresponding decrease in other fish, is certain to result in lower prices and lower total revenue to the fishermen.

A comparison is made of oyster, shrimp, and crab, and the total of all three. The production of oysters decreased by 50 per cent from 1890 to 1940, and the price did not rise sufficiently to compensate; total real value declined to 40 per cent of the early value. Shrimp production increased 18 times, price doubled and money value in terms of buying power increased 26 times. The blue crab also enjoyed a similar but not such great economic exaltation. Contrary to widely expressed concern at the decline in abundance of oysters, the signs indicate that the oyster industry is suffering from a weakening of demand and perhaps also excessive costs in the heavy employment of labor and the penalty for failure or inability to mechanize; that the shrimp with many advantages of lower cost of production by mass methods, less need for hand labor, high yield of edible portions, and brisk demand at rising prices is providing serious competition which the oyster industry has been unable to meet. The total of oysters, shrimp, and crab has held constant in both quantity and actual money and has declined in real money value, despite the increase in human population.

III. ECONOMICS AND MARKETING OF NORTH CAROLINA FISHERIES

Production and Primary Marketing

THE HISTORICAL AND STATISTICAL RECORD

Ranking of North Carolina among the States in Value of Production. The ranking in value of production of the several fish producing States in five historical periods is shown in Table 23. The shifting in relative position of the States irrespective of the total of production of all the States (which is controlled only by demand under the influence of the business cycle) clearly exhibits the trend of historic movements. Among the eastern and southern States, the rise of Florida and Louisiana and the decline of Maryland, Delaware, and Connecticut are conspicuous. North Carolina among all the States, as well as among the eastern States, lost rank slightly but on the whole has remained in about the same relative position at 11th to 14th place (16th in 1930) and, if the Pacific States and Alaska are excluded, from 9th to 12th.[1]

Totals of All Fish and Fishermen and All Food Fish since 1880. Table 24 exhibits the totals of the entire canvassed record, 1880-1945, of the quantities and values of North Carolina production of all fish and the numbers of fishermen. The number of fishermen engaged was about the same in 1939 and 1940 as it was in 1889 and 1890; the average number for the 20-year period, 1921-1940 was 33.5 per cent less than it was in the 22-year period, 1887-1908 (Table 17); the year 1902 is the peak (of the years canvassed) in number of fishermen (also the peak year in production of numerous species). In this Table 24, calculated equivalents of the money in constant purchasing power (1926 = 100) are shown, and the prices in both actual and constant value money; also shown are calculations per fisherman of pounds of fish and the values of the product in both kinds of money. In interpreting the data in this table it should be remembered that where the total of all fishery products is considered, the great fluctuations in quantity, money value, and prices are due largely to the menhaden, which amounted to little before 1900; it should also be noted that the fisher-

1. The quantity and value of menhaden has been taken herein to be that credited to the State by the Federal Government.

TABLE 23

Ranking of the States in Value of Fish Production ||

Rank	1880 State	1880 Value dollars (000)	1892 State	1892 Value dollars (000)	1908 State	1908 Value dollars (000)	1930 State	1930 Value dollars (000)	1940 State	1940 Value dollars (000)
1	Mass.	7,960	Mass.	7,531	Alaska	11,048	Mass.	16,289	Calif.	20,159
2	Md.	5,222	Md.	6,461	Mass.	7,095	Calif.	12,473	Mass.	15,756
3	N.Y.	3,918	N.Y.	5,041	Va.	4,716	Alaska	10,043	Alaska	10,612
4	N.J.	3,104	Va.	3,642	N.Y.	4,594	Wash.	8,335	Wash.	6,676
5	Va.	2,997	N.J.	3,626	Wash.	3,513	Va.	7,487	Fla.	5,005
6	Me.	2,743	Calif.	3,045	Fla.	3,389	N.J.	7,474	La.	4,952
7	Alaska	2,662	Alaska	2,411	Md.	3,306	N.Y.	5,084 ‡	Va.	4,858
8	Calif.	1,861	Me.	2,226	Me.	3,257	Fla.	4,646	N.Y.	4,392 *
9	Del.	998	Conn.	1,871	N.J.	3,069	Conn.	4,519	N.J.	2,957
10	Conn.	933	Fla.	1,340	Conn.	2,982	Me.	4,329	Ore.	2,742
11	N.C.	846	N.C.	1,028	Calif.	1,970	Md.	3,985	Me.	2,606
12	Mich.	716	Wash.	935	N.C.	1,776	Mich.	2,963	Md.	2,599
13	R.I.	697	Mich.	934	R.I.	1,752	R.I.	2,287	Mich.	2,022
14	Fla.	643	Ore.	868	La.	1,569	Ore.	2,256	N.C.	1,865
15	Ore.	605	R.I.	726	Mich.	1,473	La.	1,960	Ohio	1,349
16	Ohio	518	La.	681	Ill.	1,436	N.C.	1,836	Wis.	1,138
17	Wash.	418	Ohio	619	Ore.	1,356	Ohio	1,252	Conn.	1,060
18	La.	393	Pa.	495	Wis.	1,067	Wis.	839	Texas	993
19	Pa.	320	Wis.	399	Ohio	840	Texas	777	R.I.	956
20	Wis.	253	Texas	314	Ga.	701	Miss.	740	Miss.	623
21	S.C.	212	Del.	251	Miss.	556	Del.	653	Ala.	562
22	N.H.	177	Miss.	246	Del.	541	Ga.	536	Del.	475
23	Texas	128	S.C.	203	Pa.	513	Minn.	388	Ga.	381
24	Ga.	120	Ala.	155	Texas	446	Ala.	315	Minn.	312
25	Ala.	119	Ga.	124	Ala.	387	Pa.	282 §	Ill.	297
26	Ill.	60	N.H.	91	S.C.	288	S.C.	253	Pa.	266 †
27	Ind.	32	Ill.	24	Ind.	223	Ill.	97	S.C.	266
28	Miss.	22	Ind.	22	Minn.	192	Ind.	81	N.H.	105
29	Minn.	5	Minn.	6	N.H.	53	N.H.	69	Ind.	65

* Including $175 (000) from Great Lakes
† Including $263 (000) " " "
‡ Including $150 (000) " " "
§ Including $279 (000) " " "
|| Figures for 1880, 1892, 1930 and 1940 from U. S. Fish Commission, Bureau of Fisheries and Fish & Wildlife Service; Figures for 1908 from U. S. Bureau of Census.

TABLE 24

North Carolina Fisheries: All Fishery Products, Food and Non-Food, and Fishermen, 1880-1945

							Per Fisherman		
Year	Quantity * Pounds '000	Actual * Value Dollars '000	Price † Cents	1926 ‡ Relative Value Dollars '000	Relative Price ‡ Cents	Fishermen * Number	Pounds	Actual † Dollars	Relative ‡ Dollars
1880	32,902	846	2.57	1,301	3.96	4,729	6,960	179	275
1887	44,809	773	1.72	1,380	3.08	6,103	7,340	127	226
1888	42,720	776	1.82	1,360	3.18	6,465	6,620	120	210
1889	44,063	950	2.16	1,667	3.79	7,070	6,236	134	236
1890	50,604	1,028	2.03	1,829	3.61	7,303	6,925	141	250
1897	62,963	1,316	2.09	2,822	4.48	9,918	6,345	133	285
1902	66,071	1,740	2.63	2,955	4.47	11,159	5,920	156	265
1908	99,891	1,767	1.77	2,810	2.81	9,210	10,850	192	305
1918	210,080	2,979	1.42	2,268	1.08	6,198	33,950	480	366
1923	94,364	2,414	2.53	2,400	2.52	6,195	15,240	390	388
1927	143,396	2,760	1.92	2,891	2.02	6,249	22,940	442	463
1928	141,122	2,624	1.86	2,713	1.92	6,063	23,270	433	447
1929	216,314	2,536	1.17	2,660	1.23	5,975	36,270	424	445
1930	168,939	1,856	1.10	2,149	1.27	5,205	32,450	356	412
1931	98,161	1,088	1.11	1,490	1.52	5,248	18,680	207	284
1932	86,214	827	.96	1,275	1.48	4,933	17,480	168	259
1934	163,462	1,672	1.02	2,231	1.37	5,355	30,560	312	417
1936	219,879	2,735	1.24	3,387	1.54	6,902	31,820	396	491
1937	112,755	1,658	1.47	1,922	1.70	6,619	17,045	250	290
1938	198,764	1,950	.98	2,480	1.24	6,905	28,800	282	359
1939	224,457	1,890	.84	2,450	1.09	7,005	32,100	270	350
1940	170,581	1,865	1.09	2,372	1.39	7,113	23,970	262	333
1945	198,169	5,495	2.77	5,192	2.62	7,456	26,600	736	697

* As canvassed by U. S. Fish Commission, Bureau of Fisheries and Fish & Wildlife Service.
† Calculated.
‡ Calculated: equivalent number of dollars or cents of constant purchasing power in terms of the All-Commodity Wholesale Price Index, 1926 = 100, U. S. Bureau of Labor Statistics.

men cannot be separately identified for the different fisheries. Table 25 exhibits the quantities, values, prices, etc., of all North Carolina food fish only; in both summary tables the regularities that are monotonously observed in the fishery statistics of the whole country and all its regions are again observed here in North Carolina; i.e., the total production and values, prices, number of fishermen, and their production and income per man conform to the pulse of the business cycle—post-World War I, low; 1927-1929, high; 1932, low; 1936-1937, high, and over-all upward trend of the fishermen's income, subject to the cyclic influences. Here, as elsewhere, it is to be noted that real income did not diminish as much as apparent income in the depression year of 1932. For the over-all comparison of the early period (1887-1908) with the late (1921-1940), see Tables 17 and 18, wherein it appears that the improvement of the average dollar value, actual and relative, in the later over the earlier period was somewhat less than that for the Atlantic–Gulf regions or for the whole country; and that quantity of production per man greatly increased mainly by reason of the rising menhaden fishery.

In food fish, however, the State did not increase its production in the later over the earlier period; in fact, its average production was 2.7 per cent less from 1921 to 1940 than it had been from 1887 to 1908;[2] the increase of 29 per cent in price and 25.8 per cent in actual dollars was not enough to make up for the inflation of money that occurred, so that the buying power of the proceeds of primary sale of all the food fish produced by the State as an annual average from 1921 to 1940 was 21 per cent less than it had been for the average of 1887-1908; even when menhaden is included in both periods, the annual average buying power of fish production for the average of all commodities was less by 3 per cent in the period 1921-1940 than it had been from 1887 to 1908 (Table 17). The development of the menhaden industry, principally in the late period, in its entirety was not enough to compensate the fish industry of the State for the inflation of money in the absence of any increase in the volume of food fish production. If the new expenses were deducted for marine engines, fuel, and lubricants, which replaced sail, it is likely that the fisheries would be worth very decidedly less in net money value to the State than they were fifty years ago.

This fact does not speak well for the North Carolina fisheries when considered in connection with the 155 per cent increase in population of the State from 1,400,000 in 1880 to 3,572,000 in 1940; the increase in ratio of urban to rural population and the development of a superb network of roads over which distribution of fish over the entire State could be effected.

2. Based on the averages of the two series after the vacant years in each have been filled in by interpolation (Table 18).

TABLE 25

North Carolina Fisheries; Food Fish Only; Quantities, Values, and Prices, 1880-1945

Year	Quantity * Pounds '000	Actual Value * Dollars '000	Price † Cents	1926 Relative Value‡ Dollars '000	Relative Price ‡ Cents
1880	32,902	846	2.57	1,301	3.96
1887	30,052	755	2.51	1,347	4.58
1888	28,875	759	2.63	1,330	4.61
1889	35,310	939	2.66	1,648	4.67
1890	38,194	1,011	2.65	1,798	4.71
1897	51,653	1,296	2.51	2,780	5.38
1902	47,209	1,708	3.63	2,900	6.16
1908	42,401	1,693	3.99	2,691	6.35
1918	30,150	1,669	5.54	1,271	4.21
1923	31,074	2,089	6.72	2,075	6.68
1927	44,409	2,301	5.18	2,411	5.43
1928	41,820	2,193	5.25	2,268	5.42
1929	43,824	1,817	4.15	1,906	4.35
1930	34,887	1,301	3.73	1,507	4.32
1931	30,284	993	3.28	1,360	4.49
1932	31,738	752	2.37	1,160	3.65
1934	56,811	1,317	2.32	1,758	3.10
1936	69,790	2,136	3.06	2,644	3.79
1937	51,049	1,439	2.82	1,667	3.26
1938	51,946	1,524	2.93	1,939	3.73
1939	42,489	1,334	3.14	1,730	4.07
1940	40,989	1,379	3.36	1,754	4.28
1945	56,636	4,521	7.98	4,275	7.54

* Canvassed.
† Calculated.
‡ Calculated: equivalent number of dollars or cents of constant purchasing power in terms of the all-commodity wholesale price index, 1926 = 100, U. S. Bureau of Labor Statistics.

Composition of the Catch: Principal Species in the Various Years. The series of data in the Tables, 68 to 90, Appendix, show in detail the composition in descending order of magnitude in both quantity and value of all North Carolina species of food fish, each of which amounted to as much as one per cent of either quantity or value in each of the canvassed years from 1880 to 1945. It can be noticed that in 1880 more than 70 per cent (see "cumulative" columns) of both quantity and value were made up of shad, alewives, mullet, and oysters; that in 1923 the 70 per cent group had grown from four to eight species, being then, in quantity, alewives, oysters, gray trout, shad, croaker, spot, mullet, and shrimp, while in value it is this same group but with croaker, spot, and shrimp giving place to spotted trout, striped bass, and bluefish; and that the downward drift of shad, oysters, and scallops is offset by the rise of shrimp, crab, croaker, and spot. If the species which make up in each year, say, 70 per cent or more of the quantity are arranged in parallel columns for the twenty-three canvassed years, and another set aranged of those which made up 70 per cent or more of the value, it will be seen that great commutations occurred and that no two years are the same in composition for either quantity or value, that no pattern of change is clearly discernible, and that few generalizations can be made. It can be observed, however, in these "descending order" tables for North Carolina, as in those for the whole country (Tables 51 to 56, Appendix), that there is a tendency for the main bulk (say 70 per cent) to be made up of a larger and larger number of species. In 1880 in North Carolina, 70 per cent of the quantity and value was in four species, alewife, mullet, shad, and oysters; in 1887, 70 per cent of the quantity was two species, alewife, and shad, and 70 per cent of the value was in three, alewife, shad, and mullet. From 1923 to 1945 the quantity was made up of from five to eight or nine species and the value rather more, i.e., from eight to ten. This increase in number can hardly be ascribed to the exploitation of more species to supply a larger demand, for the total production did not increase (average food fish 1921-1940 is 2.7 less than average of 1887-1908); also, when compared year by year there is seen to be no relationship between number of major species and quantity or value of product. To some (though not a large) extent the change has resulted from an actual biological diminution of abundance of the anadromous shad (and perhaps alewives) and the substitution therefor of other species. The striped bass, also anadromous, has not diminished.

The composition of the catch in the later years is (as in New England and other parts of the country) radically different from what it was in the early years; the declines are generally in those species which have a poor economic behavior pattern, and the newcomers or newly dominant species are those which have the best behavior patterns, i.e., those for which demand supports price on increasing production. In the pre-1900 period the bulk of both quantity and value consisted of alewives, shad, mullet, oysters, and sea trout. In the post-1920 period shrimp, crab, spot, and croaker play an increasingly prominent part. That is to say, the catch is made up, from time to time, of whatever affords the fishermen the largest return for their labor.

Statistical History of the Economic Species. Table 91, Appendix, is the statistical history of quantity and value of each of the principal useful species of fish and shellfish in North Carolina. The series are, of course, not continuous but, even so, their fluctuations show a remarkable tendency to establish maxima in the years of good business, 1902, 1927-1929, 1936-1937, for in 1936-1937 records or high peaks were established by bluefish, butterfish, carp, clams, crabs, croakers, flounders, king whiting, menhaden, mullet, oysters, spanish mackerel, spot, sea trout (squeteague), and striped bass. It does not appear likely that nature would be so obliging as to bring about the peaks of biological abundance in all of these species in years when business is unusually good. The conspicuous cases of persistent change are downward in alewives, shad, and scallops; upward in catfish, crabs, croakers, flounder, harvestfish, shrimp, and spot. The others hold about steady. Considering the ability of North Carolina to produce fish when the market wants them, it appears that abundance of fish (in those months of the year when they are present at all) is hardly the limiting factor to the magnitude and money value of the State's fishing industry.

Comparison of Prices by Species in North Carolina and Elsewhere. In order to ascertain how North Carolina's fishery products compare in quantities, values, and prices (to fishermen) with the same species produced outside the State, data have been compiled for eight species and presented in Table 26. Limited though the data are, they clearly show that studies of data more finely subdivided in time and place, i.e., for subdivisions of a year and for smaller localities, can be significantly revealing in a number of ways. They show that in shad, flounders, and soft shell crabs, North Carolina fishermen have consistently received a higher price than the average of all that was produced elsewhere. In the case of the shad and soft crabs this difference is undoubtedly in the season of abundance—North Carolina is able to offer these products before they become plentiful as the season advances further north, but it should also be noted that the North Carolina production of shad shrank from 16 per cent of all shad in 1890 and 1908 to 10 per cent in 1930 and 8 per cent in 1939; the greatest shrinkage in production occurred in the season of normally highest price; the price behavior of shad was therefore somewhat better in North Carolina than it was for the country as a whole.

In earlier years the State received proportionately more for mullet, but in later years this advantage seems to have been lost (perhaps because of earlier salting and later discontinuance of salting); the price of hard crab is about the same as the national average. In the cases of bluefish and oyster, the prices have been, from the beginning of our record, decisively and consistently to the disadvantage of the State. North Carolina's percentage of the total national production of oysters is inconsequential, and the season is shorter—later beginning and earlier ending than that of the more northerly states; the volume of bluefish production is characteristically erratic, the State's part varying from 10 to 25 per cent of the national total. Since about 1908 North Carolina has received about the national average price for a very small percentage of the total production of shrimp and hard crabs or crabmeat.

TABLE 26

Comparison of North Carolina with the United States, Exclusive of North Carolina, in Quantities, Values, and Prices of Commercial Varieties of Fish

		1890		1908		1930 ‡		1940 §	
		N.C.	U.S. Ex-N.C.	N.C.	U.S. Ex-N.C.	N.C.	U.S. Ex-N.C.	N.C.	U.S. Ex-N.C.
Shad	Quan.	5,768,000	35,877,000	3,942,000	23,699,000	1,323,000	13,507,000	897,000	11,295,000
	Value	306,015	1,458,000	373,000	1,740,000	233,274	1,644,000	140,462	839,000
	Price	5.30	4.07	9.47	7.35	17.60	12.17	15.70	7.42
Oyster	Quan.	4,992,508 *	164,300,000 †	4,159,320	144,713,000	2,178,221	80,613,000	1,057,000	79,035,000
	Value	184,919	13,790,000	227,300	11,808,000	164,280	10,390,000	74,664	7,563,000
	Price	3.70	8.39	5.46	8.19	7.55	12.88	7.06	9.56
Mullet	Quan.	3,585,000	17,174,000	5,070,000	28,633,000	2,509,000	27,375,000	2,742,000	33,948,000
	Price	97,243	290,757	175,000	733,000	86,371	862,629	104,818	1,153,000
	Value	2.71	1.69	3.45	2.56	3.44	3.15	3.82	3.40
Flounder	Quan.	49,000	...	403,000	22,943,000	696,000	71,272,000	659,000	84,847,000
	Value	894	...	16,000	572,000	47,050	3,018,950	37,020	3,150,980
	Price	1.82	...	3.97	2.49	6.77	4.23	5.62	3.72
Shrimp	Quan.	144,000	8,081,000	371,000	18,709,000	845,000	100,829,000	4,512,000	144,272,000
	Value	5,435	136,565	9,000	485,000	28,429	3,487,571	141,095	5,031,905
	Price	3.77	1.69	2.42	2.59	3.36	3.46	3.13	3.48
Crabs soft	Quan.	...	...	277,000	10,027,000	347,000	6,252,000	194,000	5,601,000
	Value	...	...	33,000	326,000	52,091	550,909	29,194	496,806
	Price	...	...	11.91	3.25	15.10	8.82	15.05	8.86
Bluefish	Quan.	1,345,000	14,003,000	1,256,000	6,391,000	717,000	6,152,000	1,102,000	4,248,000
	Value	33,603	603,397	45,000	461,000	35,870	524,130	60,883	269,117
	Price	2.50	4.31	3.58	7.22	5.00	8.53	5.52	6.34
Crabs hard	Quan.	...	...	113,000	38,151,000	1,290,000	64,033,000	3,564,000	73,461,000
	Value	...	...	1,100	419,900	19,792	1,088,208	68,662	1,298,338
	Price	...	...	0.97	1.10	1.54	1.70	1.93	1.78

* Average 1889-90. † Composite 1889-91. ‡ Average 1929-30-31. § Average 1938-39-40.

In these price relationships the effects of terrestrial latitude and the succession of seasons are clearly evident in giving the State the much desired "corner" or advantage in the market for those items (shad, soft shell crab) which occur in the early spring in North Carolina when they fetch the highest prices before they become plentiful farther north. Such advantages as these should obviously be pressed for all they are worth. In the case of the oyster the seasonal factor is probably reversed to the disadvantage of the State. A further, more extensive and detailed study of these factors as they affect all of the State's fishery produce should yield valuable results.

Statistical History of the Menhaden. Table 58, Appendix, is a historical record of the commercial menhaden fishery of all regions from 1880 to 1945. The money values are those reported by the Government agency but are rather nominal than competitive, being the seasonal figures used by boat owners in settling with the crews.

NORTH CAROLINA FISHERIES GEOGRAPHICALLY CONSIDERED

The production of North Carolina food fish (i.e., not including menhaden) for several years has been in the neighborhood of 40 to 60 million pounds annually, worth, before World War II, around $1,500,000, and in 1945 about $4,500,000. These quantities and values with efficiency could be handled by a small number of dealers, say, a dozen or so. The problem, however, is made difficult by the geographical configuration of the coast.

The fisheries of the State are spread over a coastline about 300 miles long, not considering indentations. This coastal area is cut by several deep estuaries running inland for distances of 60 to 75 miles from the Outer Bank so that north-south transportation is difficult.

The whole coastal region divides itself naturally into three productive areas:

a. *Northern Production Area,* from the Virginia line inland to Pamlico River, and along Outer Bank to Ocracoke; it includes the fishing counties of Currituck, Camden, Pasquotank, Chowan, Bertie, Dare, Hyde, and Beaufort, and the fishing communities, Elizabeth City, Manteo, Colerain, Edenton, Belhaven, and Washington. The water in the sounds (Currituck, Albemarle, Roanoke, Croatan, and the northern part of Pamlico) becomes less salt or brackish with increasing distance north and west of Ocracoke Inlet. Accordingly the characteristic species undergo change in the same sense, i.e., in western Albemarle Sound and Chowan River, the production is mostly anadromous shad and alewives (early spring), striped bass, and the fresh water catfish, and carp (especially in Currituck), while seaward and offshore in Dare County and southward in the sound to Washington and Belhaven, the catch is the more general salt water varieties, including oysters, crabs, shrimp, bluefish, the trout, croaker, mullet, etc.

This area is traversed by the Norfolk Southern Railroad, connecting with Charlotte, Raleigh, and Norfolk, and by the Atlantic Coast Line connecting with Tarboro and Rocky Mount. The railroad is used more for transportation of fish in this area than in the more southerly areas.

b. *Central Production Area,* from Pamlico River in the north to New River in Onslow County, embraces the most important fisheries of the State—Pamlico, Craven, Carteret, and Onslow Counties, containing the fishing communities of Oriental, Vandemere, New Bern, Morehead City–Beaufort, Marshallberg, Sealevel, Atlantic, and Swansboro. This region is mostly tidal salt water, under the influence of Beaufort and Bogue Inlets, as well as that of Ocracoke Inlet, and receives little fresh water from rivers. In addition to the general assortment of the more salt water species (little of the fresh water or anadromous shad, alewives, striped bass, etc.), this is the principal center for menhaden fisheries and menhaden conversion plants. The season in this section is mainly fall—August to November.

This region is served by the Norfolk Southern Railroad, connecting New Bern with Washington and Norfolk, and by the Atlantic and East Carolina Railroad from Beaufort to Goldsboro and Raleigh. However, the greater part of the transportation of fish from this area is by truck.

c. *Southern Production Area,* Pender, New Hanover and Brunswick Counties; the three fishing communities are at Hampstead, Wilmington and Southport. This, being the more southerly part, shows the increasing influence of warmer water, but also the effects of the Cape Fear River with again some anadromous species. There are no alewives, few shad or striped bass, or sea trouts, but there are important fisheries for shrimp, mullet, and menhaden. Production of oysters is small in this area.

Primary Marketing. Although the producer-dealers at the shore are a part of the marketing and distribution mechanism, their relations with the fishermen are so close that their operations are best considered here in connection with production; the distributor-dealers, wholesalers, retailers, etc., are considered later. Primary marketing is done by what may be called here producer-dealers i.e., dealers who perform the function of receiving fish direct from the fishermen and passing the product on to the next stage of marketing. In most cases the actual physical work performed by these dealers is washing where necessary, weighing, packing, icing and shipping, beheading shrimp, and shucking oysters. Places of business usually consist of an enclosed building on a pier with ice-crusher, sorting tables and the like, and scales. In some of the larger establishments there are small mechanical refrigeration plants, mechanical ice crushers, processing rooms for shucking oysters and clams, beheading shrimp, etc. Some of them operate also retail markets for local trade, and a few of them restaurants.

The services performed by these coastal producer-dealers also include selling, which may be to wholesale commission merchants in the large northern cities, to other inland distributor-dealers, wholesalers, retailers, or, to some extent, to truck pedlars. In many cases the producer-dealers own outright or participate in the ownership of boats, pound nets, and other gear, and through this ownership they share in the profits of the catch in addition to their interest in the catch as merchants after they have received it.

It is customary in all three areas for the producer-dealers to advance credit to fishermen, usually for the purchase of fishing equipment, but occasionally for other things, such as family groceries and expenses. These transactions take the form of "advances" by the dealers on future catches of the fishermen. Ordinarily there is no formal evidence of indebtedness securing the loan, and usually no interest. In general, the understanding is that the dealer will deduct, with the approval of the fisherman, a reasonable sum from the catch weekly until the debt is discharged, the fishermen agreeing in turn to sell all of his catch exclusively to the lending dealer so long as any part of the loan is outstanding. We have no exact data on the extent of this practice. In the war and immediate post-war years, with prices high and amounts of money unprecedentedly large, we were informed that the amount of this kind of indebtedness was and is at a minimum, probably fewer than 10 to 20 per cent of the fishermen being in debt the last two or three years.

The mode of fixing prices paid by the producer-dealers to the fishermen is a subject which itself deserves extensive research and consideration, but which is beyond the scope of this Survey. We have acquired some information on this subject, but not sufficient to justify any general conclusions. In the northern area, during the busy season, boat fishermen are informed daily by the dealers the prices which will be paid, and settlement is made weekly on the basis of these daily prices. In the central area it seems to be the practice for all the dealers to settle weekly for about the same prices. How these prices are arrived at is not entirely clear to us, but at any rate it appears that the fishermen themselves do not always know what prices they are to receive until after the fish have been delivered and shipped. We have already commented on this subject in general terms in the section of this report entitled "Economics of the Fisheries—General and Qualitative—Production."

Difficulties of Marketing Imposed by Geographical and Seasonal Influences. So far as quantity is concerned, the fish produced in North Carolina could be handled more efficiently and at lower unit cost by ten or a dozen dealers; actually 127 dealers were reported in North Carolina in 1946.

Table 27 shows distribution of fishermen, quantities and values of their product, the number of dealers, etc., among the three geographical regions and for the whole coastal region of the State.

TABLE 27

Geographical Distribution of Production and Fishermen; Average 1936-1940, inclusive; Dealers, 1945

	Northern * production area	Central † production area	Southern ‡ production area	All areas
Number fishermen	2,309	3,315	1,281	6,905
Pounds food fish only	23,165,000	22,152,000	6,161,000	51,478,000
Values all fish, incl. menhaden	$657,823	$1,110,342	$250,911	$2,019,077
Values food fish only	$657,353	$ 711,373	$195,545	$1,564,271
Values per fisherman all fish	$ 285	$ 335	$ 196	$ 292
Number dealers (1945)	41	72	14	127
Value per dealer food fish	$ 16,000	$ 9,880	$ 13,960	$ 12,320
Pounds food fish per dealer	565,000	308,000	440,000	406,000

* Virginia line to and including Pamlico River and Outer Bank to Ocracoke.
† Pamlico, Craven, Carteret and Onslow Counties.
‡ Pender, New Hanover and Brunswick Counties.

Not only is the State physically cut up badly by sounds and rivers into regions among which there is very little interchange of fish, but seasonally also the product is so distributed that scarcities in some regions cannot be made up by abundances in others. The spring migrations of anadromous fishes in the northern section, i.e., shad, alewives, striped bass, etc., cannot economically be used to fill in the off-season in the Morehead–Beaufort region. This combination of unfortunate circumstances brings about the existence of a very large number of producer-dealers, each one handling the produce of a small number of fishermen during a limited season, and at a small amount of money value, making for general inefficiency and high costs, as we shall see later.

The small scale of operations makes mechanization of operations impracticable, and also discourages the manufacture of by-products; it also makes it impracticable for any one shore dealer to offer to the retail trade of the State and the other near-by southern States a continuous and dependable supply of the natural assortment of seafoods available in the State, to carry on aggressive sales promotion and development of consumer markets, or to compete with those dealers (in Norfolk, Baltimore, etc.) which offer not only State but out-of-State products.

Such an operation might conceivably be conducted at some central point, such as New Bern, Greenville, or Washington, which could draw on all sources in the State, from Colerain and Manteo, Morehead City to Atlantic, and Southport to Shallotte, and at all seasons of the year.

An operation of this kind would, in fact, be that of a distributor-dealer, the functions of which are discussed later in this report.

PRIMARY DISTRIBUTION OF NORTH CAROLINA SEA PRODUCTS

Shipments by Producer-Dealers to Fulton Market, New York. (*Commission Sales*). It has been said that the coastal dealers in North Carolina and the South generally follow the easiest (and least profitable) method of marketing by shipping the bulk of the product to the Fulton Market in New York. This matter was investigated thoroughly; it was found that shipments to Fulton Market, considered as a part of the whole production, were of minor importance, though the study revealed certain other significant facts. In order to ascertain the size and composition of North Carolina shipments and how they compared with those of the other southern States, parallel data were assembled for the four principal South Atlantic States, North Carolina, Maryland, Virginia and Florida (entire State).

Procedure. In the New York office of the Fish & Wildlife Service, with generous cooperation of the executives in charge, the data were taken from the daily records of arrivals of fish in New York by months and by principal species of fish and shellfish from the four southern States, Maryland, Virginia, North Carolina, and Florida, for the seven years, 1940 to 1946, inclusive. The weights of clams and oysters included were those of net edible portions. These data were then recapitulated in various ways.

(a) Table 28 recapitulates, by months and by the four States, the totals of finfish and shellfish. In the seven-year annual average shipments of fin- and shellfish from the four States to Fulton Market, North Carolina ranks lowest with 2,963,639 pounds, Maryland, 3,109,000, Virginia, 4,718,000, and Florida greatest with 8,690,500 pounds. This table shows some striking differences in the seasonal cycles of shipments. In North Carolina, there are two finfish peaks, March-April (shad) and September-December. The shellfish peak is August-November, mostly shrimp. The curves for the four States are of decidedly different shape because of the effects of seasonal influences and varieties available for shipment. A comparison of these columns will reveal many interesting relations: the progress of the spring season; the reverse relations of maxima in Maryland and Florida (summer maximum in Maryland, winter in Florida); the Virginia minimum and North Carolina maximum in finfish in October, and the North Carolina shellfish (shrimp) maximum in the same month; and the Florida maxima in both fin- and shellfish in December and January. Of the four States

TABLE 28

Average Monthly Receipts of Fish and Shellfish in Pounds at Fulton Market, New York, from North Carolina, Maryland, Virginia and Florida, from 1940 to 1946, inclusive

	North Carolina		Maryland		Virginia		Florida		Total Four States	
	Fish	Shellfish	Fish	Shellfish	Fish	Shellfish	Fish	Shellfish	Fish	Shellfish
JANUARY	99,356	21,229	29,282	17,608	269,293	49,525	1,139,804	721,976	1,537,735	810,338
FEBRUARY	65,192	13,954	57,473	17,488	402,821	53,485	850,638	384,440	1,376,124	469,367
MARCH	205,607	13,789	208,589	11,450	487,316	42,641	485,149	230,159	1,386,661	298,039
APRIL	150,924	27,877	513,277	21,895	1,145,712	41,816	320,630	131,750	2,130,543	223,338
MAY	28,292	23,801	472,201	94,941	644,257	121,435	65,092	149,115	1,209,842	389,292
JUNE	47,721	27,034	211,874	166,339	149,850	114,448	32,737	160,177	442,182	467,998
JULY	21,670	60,564	179,673	188,115	122,260	80,153	47,968	221,975	371,571	550,807
AUGUST	44,815	238,436	106,509	205,225	115,356	97,324	84,409	253,937	351,089	794,922
SEPTEMBER	158,090	368,201	83,573	134,767	112,361	80,187	114,777	215,023	468,801	798,178
OCTOBER	422,648	382,974	83,820	69,607	98,827	59,514	179,914	340,435	785,209	852,530
NOVEMBER	139,311	233,264	115,657	24,056	122,033	53,130	390,143	500,754	767,144	811,204
DECEMBER	117,774	51,116	77,760	17,829	211,314	42,949	974,309	695,192	1,381,157	807,086
Twelve Months	1,501,400	1,462,239	2,139,688	969,320	3,881,400	836,607	4,685,570	4,004,933	12,208,058	7,273,099

NOTE: The totals in Tables 28 and 29 disagree by reason of differences in non-specified "other" items in the original data which cannot now be discovered and corrected.

TABLE 29

Average Annual Receipts of Fish at Fulton Market, New York, from North Carolina, Maryland, Virginia and Florida from 1940 to 1946, inclusive

	North Carolina	Maryland	Virginia	Florida
	Pounds	Pounds	Pounds	Pounds
Albacore	124	217	1,371	183
Alewives	2,228	3,106	1,869	28
Amberjack	916	24	28	14,705
Bluefish	278,823	38,764	10,671	950,934
Bluefish, frozen	...	...	57	6,321
Bonito	11,763	63,014	68,714	594
Bonito, ocean	...	...	542	...
Butterfish	11,248	87,501	301,302	428
Carp	27,288	57,419	174,764	696
Catfish & bullheads	5,985	52,212	14,134	674
Crevalle (jacks)	...	...	...	1,078
Croaker	67,656	632,463	1,139,897	112
Drum, black	1,828	1,998	890	812
Drum, red (channel bass)	9,208	1,678	3,384	3,354
Eels, common	48,853	55,940	67,228	28,337
Flounders (fluke)	9,132	29,608	80,080	405
Harvestfish (angel)	257	...	100	...
Hickory shad	6,509	580	454	707
Hogfish	557	...	...	...
Jacks, unclassified	12,113	432	577	16,494
Kingfish (king mackerel)	4,302	...	591	740,963
King whiting	27,817	2,489	6,192	8,723
Mackerel	1,703	194,976	542,539	...
Mullet	227,960	4,657	7,230	660,542
Mullet, frozen	1,757	157	...	24,216
Permit	225	...	...	11,768
Pigfish	1,321	71	...	321
Pompano	11,774	23	162	56,113
Scup (porgy)	2,836	69,436	599,003	2,480
Sea bass	42,833	61,655	291,498	61,598
Sea trout (gray)	33,356	72,063	175,423	7,547
Sea trout (spotted)	65,196	617	7,921	187,870
Shad	256,261	26,341	56,197	18,860
Sharks	867	1,153	612	262
Sheepshead	675	142	...	27,802
Spanish mackerel	16,649	871	3,231	1,589,670
Spanish mackerel, frozen	...	...	...	6,457
Spot (lafayette)	227,971	2,069	27,319	1,510
Striped bass	42,026	470,952	98,589	692
Sturgeon	2,666	950	2,119	5,006
Thimble-eyed mackerel	...	20,126	4,810	...
Tuna	16	3,721	350	268
Other	53,000	184,125	190,300	246,714
Total fish	1,515,699	2,141,550	3,879,948	4,685,244

TABLE 29 (Continued)

	North Carolina	Maryland	Virginia	Florida
	Pounds	Pounds	Pounds	Pounds
Shellfish				
Clams, hard	35,207 *	3,819 *	115,838 *	...
Clams, hard, shucked	...	...	...	7
Crab meat	65,257	51,714	40,235	342,001
Crabs, hard	700	242,385	265,277	...
Crabs, hard, cooked	...	...	...	32
Crabs, soft	40,370	480,352	237,060	104
Oysters, shell	...	258 *	1,343 *	...
Oysters, shucked	58	97,549	33,293	145
Scallops, bay	13,621	64	963	37,472
Shrimp (prawn)	1,303,269	9,860	1,860	3,431,672
Shrimp (prawn), frozen	...	767	...	74,932
Shrimp (prawn), cooked	...	...	...	52
Squid	924	16,308	104,802	28
Other	3,959	76,083	121,621	121,379
Total shellfish	1,463,365	979,159	922,292	4,007,824
All species				
Total fish	1,515,699	2,141,550	3,879,948	4,685,244
Total shellfish	1,463,365	979,159	922,292	4,007,824
	2,979,064	3,120,709	4,802,240	8,693,068

* Oysters and clams as edible meats (calculated).

NOTE: The totals in Tables 29 and 30 disagree by reason of differences in non-specified "other" items in the original data which cannot now be discovered and corrected.

combined, the maximum of finfish and the minimum of shellfish both occurred in April.

(b) Table 29 is a recapitulation by species as annual averages for seven years (1940-1946) of shipments to New York from the four South Atlantic States (Florida both coasts). This table, too, reveals some interesting relations. Florida leads in bluefish, king mackerel, mullet, spanish mackerel, spotted sea trout, crabmeat, bay scallops, and shrimp; Virginia leads in butterfish, carp, croaker, eels, flounders, mackerel, scup, sea bass, gray trout, hard crabs, hard clams, and squid; Maryland, in striped bass and soft shell crabs; North Carolina in shad and spot; the State ranks second in bluefish, mullet, shrimp, and clams. None of the South Atlantic States ship any important quantities of oysters to Fulton Market.

(c) The above two tables can be considered representative, since they are the average of two pre-war years, four war years, and one post-war year, seven in all. However, since the total production of these States was canvassed in only two of those years (1940 and 1945) it is not possible to compare the average shipments to Fulton Market with the seven-year average production, by totals and by species. This comparison is made for the year 1945 in Table 30, which breaks the averages down in various ways, showing, for each State the percentage its shipment of each species is of that State's production of that species and of all species; the percentage each State's shipment of each species is of the four-State totals of that species; the percentage of North Carolina shipments of the State's total production, etc. As examples, croaker constituted 13.65 per cent of the total combined shipments to New York of all four States, 82.30 per cent of all of the croaker came from Virginia, and this was 35 per cent of all of Virginia's shipments to New York; North Carolina shipped 1.51 per cent of the four-State total of croaker; this amount was one per cent of North Carolina's production of croakers and was 1.71 per cent of all of the States' shipments of all species to New York. North Carolina shipped to Fulton Market 40.3 per cent of its production of bluefish, 31 per cent of the eels, 13 per cent of the soft crabs and butterfish, 12 per cent of the shad, and 11 per cent of the production of shrimp. Forty-eight per cent of the State's shipments of all fish to Fulton Market was shrimp, 10 per cent was bluefish, 9 per cent each of spot and mullet. From all the four States (last column) the principal species which went to New York were bluefish, butterfish, soft crabs, sea bass, gray trout, shrimp, spanish mackerel, and striped bass. These are the choice, high-priced species of the South Atlantic.

The total shipments to Fulton Market of these four southern States were a small part of production; in 1945 North Carolina shipped to Fulton Market *only 4.44 per cent of its production of food fish;* Maryland, 5.22 per cent; Virginia, 4.06 per cent; Florida, 7.35 per cent; all four States together, 5.31 per cent. The total shipments to Fulton Market from all four States together was only about 8 per cent of the annual receipts of that market from all points in 1945.

Comparison of Prices of North Carolina Fish at Morehead City and at Fulton Market, New York. Records were not available in New York of the values of the actual shipments of the various species from the South which would make it possible to compare prices in New York with those received by fishermen in the South. Advantage was taken of published general daily level of prices of the Market Information Service, Fish & Wildlife Service, for the various species in Fulton Market for comparison with the current prices at Morehead City, N. C., on certain days from October 7 to Nov. 12, 1946. The data are shown in Table 31.

TABLE

Receipts of Fish at Fulton Market,
North Carolina,

	North Carolina				Maryland		
	Quantity pounds	Per cent of total N.C. production of each species	Per cent of total N.C. shipments all species to N.Y.	Per cent of four States, total of each species to N.Y.	Quantity pounds	Per cent of total Md. shipments all species to N.Y.	Per cent of four States, total of each species to N.Y.
Bluefish	252,286	40.3	10.07	21.16	43,202	1.60	3.62
Butterfish	3,740	12.5	0.15	1.00	18,744	0.70	5.0
Clams, net	48,076	9.6	1.92	35.70	2,800	0.10	2.05
Crabs, hard	.....	....	....	....	211,785	7.85	67.80
Crabs, soft	23,280	12.6	0.93	3.21	485,832	18.00	67.00
Crab meat	77,466		3.09	16.90	48,940	1.81	10.67
Croakers	42,813	1.00	1.71	1.51	458,342	17.00	16.20
Eels	36,033	31.00	1.44	22.10	28,771	1.07	17.65
Flounders	9,079	0.80	0.36	9.00	74,372	2.76	73.70
Mullet	221,027	6.80	8.82	28.50	.....	....	....
Oysters, shucked	238	0.10	0.01	1.25	115,235	9.26	60.60
Sea bass	20,180	10.60	0.80	4.43	34,160	1.27	7.50
Sea trout, gray	14,850	0.30	0.59	3.73	73,028	2.71	18.32
Sea trout, speckled	30,441	6.10	1.22	18.67	2,190	0.08	1.34
Shad	106,179	11.60	4.24	39.00	37,848	1.41	13.90
Shrimp	1,213,250	11.40	48.40	27.60	375	....	....
Spanish mackerel	5,467	1.10	0.22	0.23	.....	....	....
Spot	230,657	3.70	9.20	67.60	4,983	0.18	1.45
Striped bass	27,433	4.50	1.10	5.85	345,307	12.80	73.60
Other	138,597		5.48		710,709	26.40	
Total	2,501,092		99.91	12.06	2,696,578	100.0	12.40

Since the amounts of goods from Morehead City sold at these prices are not known, it is not possible to arrive at true weighted average prices or mark-ups; a non-weighted average of the above prices is 12½ cents at Morehead City and 40 cents at Fulton Market, a mark-up of 320 per cent.[3] These mark-ups are only the second step of the distribution process (the first being between fishermen and coastal producer-dealer); the products are still subject to at least one other, the retail (or restaurant) mark-up before the consumer acquires the product, and possibly two or more. These

3. Government controls of prices under OPA were lifted by Executive Order of the President on October 15, 1946.

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New York, from Maryland, Virginia, and Florida, 1945

Virginia			Florida			Total		
Quantity pounds	Per cent of total Va. shipments all species to N.Y.	Per cent of four States, total of each species to N.Y.	Quantity pounds	Per cent of total Fla. shipments all species to N.Y.	Per cent of four State total of each species to N.Y.	Quantity pounds	Per cent each species of four State shipments to N.Y.	Per cent of four States production of each species shipped to N.Y.
10,413	0.16	0.87	887,561	9.97	74.40	1,193,462	5.76	44.5
351,715	5.31	94.00	1,200	0.02	0.32	375,399	1.82	13.2
82,288	1.22	60.40	1,446	0.02	1.06	134,610	0.65	5.9
100,465	1.51	32.20	.....	....	....	312,250	1.91	0.6
216,333	3.26	29.80	72	....	....	725,517	3.50	19.5
26,850	0.41	5.86	305,406	3.42	66.60	458,662	2.21	
2,327,785	35.10	82.30	120	....	....	2,829,060	13.65	4.5
68,171	1.03	41.80	30,033	0.37	18.40	163,008	0.79	9.0
17,359	0.26	17.20	.....	....	....	100,810	0.49	4.0
9,700	0.15	1.25	545,569	6.11	70.70	776,269	3.25	2.0
74,299	1.12	39.10	.....	....	....	189,772	0.91	5.3
301,544	4.55	66.20	99,831	1.11	21.90	455,715	2.20	17.0
304,473	4.59	76.40	6,329	0.07	1.59	398,680	1.92	13.5
2,700	0.04	1.66	127,684	1.43	78.40	163,015	0.79	3.1
109,736	1.62	40.30	18,610	0.21	6.84	272,373	1.32	3.6
12,900	0.19	0.29	3,175,709	35.60	72.10	4,401,734	21.30	18.1
.....	....	....	2,327,124	26.10	99.70	2,332,591	11.27	20.3
104,980	1.58	30.80	700	0.01	0.20	341,275	1.69	3.1
96,212	1.45	20.50	242	....	0.05	469,194	2.26	11.0
2,414,911	36.40		1,380,844	15.45		4,641,951	22.35	
6,632,834	99.95	31.96	8,907,980	99.89	42.70	20,738,444	100.26	6.8

final mark-ups of course vary, but are often 100 per cent or more. Moreover, the finfish are whole, and subject to a loss of around 60 per cent of weight on dressing.

The heavy hand of excessive distribution costs in the fisheries is seen here quite plainly. Compare these costs with those of agricultural products already given in Table 7 (page 344) and Fig. 2 (page 346), in which it is shown that (as of 1940) the farmer received the average of 42 per cent of the *retail* price of all foods, or 40.3 per cent in the case of pork products; in Fulton Market, the Morehead City fishermen received, in 1946, only 31 per cent of the New York *wholesale* price; if the fish is again marked up 100 per cent

TABLE 31

Prices at Fulton Market, New York City, and for the Same Species on the Same Days at Morehead City, North Carolina, Autumn of 1946

Species		Oct. 7	Oct. 8	Oct. 15	Oct. 16	Oct. 23	Nov. 1	Nov. 4	Nov. 12
Bluefish	Morehead	12	12	12					
	Fulton Mkt	40	42	20					
Lg. mullet	Morehead	11	11	11	11			12	
	Fulton Mkt	15-16	20	20	16-18			18	
Pompano	Morehead	30	30	30					
	Fulton Mkt	75	75	75					
Spot	Morehead	.04	.04					.03	
	Fulton Mkt	10-12½	14					.08	
Lg. shrimp	Morehead	25		25					
	Fulton Mkt	73-75		65-68					
Med. shrimp	Morehead	12	12	12	12		12	12	12
	Fulton Mkt	58-60	58	53-56	58		55	55-58	53
Sm. shrimp	Morehead	.08	.08		.08	.08	.08	.08	
	Fulton Mkt	30-33	40		45-50	40-45	45-50	45-50	
Sp. mack.	Morehead		12						
	Fulton Mkt		26-28						
Snapper bluefish	Morehead			.07					.07
	Fulton Mkt			15					22

at retail, the fisherman would receive only 15.8 per cent of retail as against the livestock grower's 40.3 per cent for pork. The standard commission in Fulton Market is 12½ per cent; the return to the shippers, therefore, must have been 40 per cent less 12½ per cent, or 35 cents, from which cartage, icing, etc., would still have to be deducted. If these are a total of 5 cents per pound, the return would still be 30 cents to the shipper of which the fisherman received 12½ cents, or 40 per cent of the wholesale, not retail, price.

The data for Fulton Market are probably more favorable to the fisherman percentagewise than those of any other market. That Fulton Market is the cheapest market is indicated by the fact that North Carolina ships only 4½ per cent of its fish there; in almost any other market the fish must command a higher price, and therefore the fisherman's share would be a smaller per cent.

Shipments to Other Commission and Brokerage Markets. So far we have considered only Fulton Market, New York City, not only because it is the largest and most important consumer fresh fish market in the country, but because statistics are available at that point. It is known that substantial quantities of North Carolina fishery products are shipped to dealers in Baltimore, Washington, and Norfolk, but we are unable to obtain any factual data on these shipments. Through all of these commission and brokerage markets North Carolina fish undoubtedly reach many points in the eastern United States, and at least some of it returns to the consumer market in North Carolina after having passed through the hands of these out-of-State distributing agencies.

Sales to Truckers. The producer-dealers also find outlets for some of their produce direct to truckers who as principals purchase the fish at the seacoast point, transport it to the up-State markets and sell direct to retailers, restaurants, institutions, and even wholesalers or distributor-dealers. Some of the truckers hold close to the coast; others serve sections of up-State North Carolina, the eastern part of the State being more frequently visited with more variable service from the truckers than the western part which is usually not visited oftener than once a week by a trucker. Where these truck operators have several trucks, they can and do send to different localities and buy whatever varieties are available at each, and in this manner broaden the assortment which they are able to offer the inland customers. These truckers learn the needs of their customers from experience and seek out enough sources of supply to fill these needs. Prices are negotiated on the spot at the coastal producer-dealer's place of business, and the products are purchased on inspection or by sample.

The truckers mark up from $1.00 to $5.00 per box; they strive to average $2.00. Sometimes the trucker is able to get a discount of $1.00 to $2.00 per box under what the coastal producer-dealer charges his other customers.

Inland Consumption, Distribution and Marketing

THE POTENTIAL MARKET

The operations of producer-dealers and, to some extent, of the independent trucker salesmen, being inseparable from the productive functions at the shore, have been considered in connection with the fishermen. The mechanics of distribution as such must now come under consideration, in preparation for which we examined the nature and measure of the potential market in North Carolina and the neighboring States.

North Carolina and Neighboring States as Market for their Own Products. Size and characteristics of the population of North Carolina and neighboring States favoring or not a market for seafoods are shown in the following table:

TABLE 32

	Population (1940)	Per cent rural	Per cent negro	Production of food fish pounds (1945)	Pounds per capita * 1945 production	Pounds per capita * 1940 production
North Carolina	3,571,000	72	27.4	56,636	15.8	11.5
South Carolina	1,900,000	75	42.8	10,856	5.7	4.7
Tennessee	2,916,000	65	17.5	.....	..	..
Georgia	3,124,000	66	35.12	21,937	6.8	4.1
Total	11,511,000	69	29.5	88,889	7.7	5.5
Virginia	2,678,000	65	24.8	163,325	61.0	47.3
Grand total	14,189,000	68	28.6	252,214	17.8	13.3

* Census estimate of civilian population in 1945 is approximately the same as total population enumerated in 1940.

The natural characteristics of the region which are favorable to seafoods are as follows: of the States making up the region (North Carolina, Tennessee, South Carolina, and Georgia), three are coastal; all have excellent roads reaching every potential market place; the median age of the people is the youngest in the country and therefore they consume more protein and their habits should be more readily changeable than they are in most other parts of the country. Disfavoring the market for fish are the following factors: the very large per cent rural (places of less than 2,500 people) population; of all the States the lowest percentage of foreign born and mixed parentage (less than one per cent), and of religious groups which require or restrict fish in the dietary (Catholics, Jews, each less than one per cent in all four states); the mild climate and long, hot summers.

When examined in the light of national figures, it is seen that Virginia produces about three times as much fish per capita of her own population as the national average production of the national population (around 22 pounds), and allowing for the somewhat higher than average consumption that is expected of a coastal State, Virginia still finds it necessary to export a large part of her production. North Carolina production per capita of her own population is one-half to three-fourths of the national average, South Carolina and Georgia around a fifth and a fourth, respectively, and Tennessee, none (except a small amount of fresh water fish). If the four States, North Carolina, Tennessee, South Carolina and Georgia (three of them coastal) consumed an amount equal to national average per capita, they would require two or three times their present combined commercial production.[4] In edible portions, North Carolina produces about six pounds per year per capita of her own population.

North Carolina must market, in North Carolina and elsewhere, the 95 per cent of her production not shipped to Fulton Market in New York. We know that North Carolina *imports* substantial quantities of fresh and frozen fish from Gloucester and Boston, Mass., New York, Baltimore, Norfolk, and Florida. Quantitative data of State imports and exports are not available, but observations of menus collected in restaurants and hotel dining rooms at Chapel Hill, Durham, Raleigh, Greensboro, Winston-Salem, Rocky Mount, and even New Bern, Edenton, Morehead City, and Wilmington revealed frequent appearances of items not produced in North Carolina—"ocean perch" (redfish from Gloucester, Mass), "scrod" (haddock or cod) fillets from Boston or New York; Chesapeake oysters, Maine lobster. The last was served at Morehead City and redfish ("ocean perch") at Chapel Hill, Edenton, and New Bern. "Quick frozen" shrimp, almost certainly not produced in North Carolina, was served at a popular restaurant in Morehead City. It is probable that other species which are produced in North Carolina are also imported, such as spanish mackerel, red snapper, and mullet (Florida) and probably croakers and certainly oysters from Chesapeake Bay.

The invasion of the State by out-of-State production of fresh and frozen fish is apparently favored by (1) the traverse of the State by three main trunkline railways (Southern, Seaboard, and Atlantic Coast Line), connecting with Florida, Chesapeake Bay, and the New England States, and the Norfolk Southern connecting Norfolk with Raleigh and Charlotte; (2) the availability (especially to chain stores) of standard package from elsewhere and unavailability in North Carolina; (3) the lack of central and dependable sources of all North Carolina products at all times; and (4) general lethargy of the North Carolina fisheries industry.

The Outlook for the Market in North Carolina and Neighboring States considered in the light of all the pros and cons: North Carolina does not have a large market already developed, nor a spontaneous or easy potential market, but within her own borders she has an accessible population which could consume twice the State's present production. Parts of neighboring States, northern and western South Carolina, northern Georgia and eastern Tennessee, with much smaller or no fishery resources of their own, are another potential and accessible market which could take, without overloading, as much North Carolina seafoods as all of North Carolina now takes, or even more.

Survey of North Carolina Consumers' Habits and Preferences in the

4. Allowance must of course be made for an unknown amount of canned seafood products brought into and consumed within the State.

Use of Seafoods.[5] Three representative cities of North Carolina having women's colleges with Departments of Home Economics were chosen for a survey of consumer habits and preferences of seafoods in the fall of 1946. The Heads of the respective Home Economics Departments, Mrs. Margaret Edwards, assisted by Miss Evelyn Sharpe, of The Woman's College, at Greensboro, Mrs. A. E. Bloxton of East Carolina Teachers College, at Greenville, and Miss Ellen Brewer of Meredith College, at Raleigh, supervised and directed the surveys in their respective cities. The actual field work was done by advanced undergraduate students who were majoring in Economics. These students made personal inquiries at the homes of consumers on the use of seafoods.

	Population (1940)	Miles from coast	Number of homes visited
Greenville	13,674	21 (Washington)	216
Raleigh	46,897	150 (Morehead City)	124
Greensboro	59,313	230 " "	150
Total	118,884		490

In what follows it should be recalled that OPA controls were in effect until October 15, 1946, when they were abolished by executive order of the President. It is also to be observed that the totals of answers to questions may be more or less than 490 by reason of duplications of answers, or no answers.

a. *Frequency of Serving.*

	Greenville		Raleigh		Greensboro		Total	
		Per cent		Per cent		Per cent		Per cent
More than once a week	55	25	11	9	14	9	80	16
Once a week	109	50	57	46	62	41	228	47
Less than once a week	50	23	48	39	57	38	155	32
Never	2	1	8	6	17	11	27	6
	216		124		150		490	

Noteworthy in the above tabulation is the fact that in the total of the three cities housewives who serve seafood once a week outnumber any other group. Almost twice as many families serve seafood less than once a week as serve it more than once a week. Frequency of serving diminished with distance from the coast.

b. *Relative Popularity of Different Seafoods.* The combined preferences of the three cities surveyed were:

5. This Survey was directed by Dr. C. A. Kirkpatrick and the following is condensed and summarized from his report.

Trout	232	Croaker	17
Oysters	200	Crab	17
Shrimp	87	Mullet	16
Butterfish	49	Spot	14
Flounder	47	Shad	11
Mackerel	37	Bass	10
Perch	23	Rock	10

c. *Offerings by Varieties at Four Commercial Eating Places.*

Greensboro-Winston-Salem Area
Oct. 15—Nov. 30, 1946.

Variety	Times appearing on menus				
	Cafeteria	Restaurant	Hotel	Hotel	Total
Shrimp		129	5	111	245
Oysters		77		77	154
Crab		28	5	100	133
Sp. mackerel	1	55	17	8	81
Trout	10	17	22	26	75
Spot	5	14	8	4	31
Haddock	13	12		2	27
Perch	5	8		11	24
Bass	15			9	24
Lobster		22			22
Rock		7	9	3	19
Blue		5	12	2	19
Sole		4		12	16
Pollock	16				16
Whiting	14				14
Shad roe		4	8	1	13
Scallops			4	8	12
Red snapper		3	1	8	12
Cod				10	10
Butterfish		9			9
Flounder	6			2	8
Halibut		6	2		8
Salmon		1	4		5
Weakfish			2		2

NOTE: During this same period in this same area, a public school served fish for lunch each Friday, and a college served fish three times and oysters three times.

d. *Types of Retailers Patronized.* In all three cities, the fish market is most frequently patronized. The number of sources is greater than the number of housewives interviewed because some consumers buy from more than one type. The patronage picture is below:

	Greensboro	Raleigh	Greenville	Total
Chains	23	42	17	82
Independent Grocery Stores	42	20	53	115
Retail Fish Markets	84	75	161	320
	149	137	231	517

e. *Forms in Which Seafoods Are Purchased.* Fillets and frozen packages are not bought extensively, frozen packages accounting for less than 10 per cent of the total expressed preferences. Purchase of finfish in the round form is about five times as great in Greenville as up-State. Fillets and frozen packages are in greater demand in Raleigh and Greensboro.

	Finfish
Dressed	344
Whole	102
Fillet	69
Frozen package	51
	566

f. *Amount of Fish per Portion.* The amounts of seafood bought differ very little in the three cities for one meal for one person. About one-half pound of whole fish is purchased for each individual.

	Finfish pounds	Shellfish pints or pounds
Greensboro	.54	.35
Raleigh	.54	.31
Greenville	.60	.37
Average	.57	.35

g. *Preference for Particular Sources.* Of the 490 housewives interviewed, only sixty expressed a preference for seafood from some particular geographical source. Many of those sixty offered no, or weak, support for their preferences. Nineteen said they preferred North Carolina fish because it was fresher. Twenty preferred fish or shrimp from many other places for many reasons. Twenty-one persons expressed a preference for the Chesapeake oyster because it has a whiter color, contains less grit, is a larger oyster, and is firmer. The darker color of the North Carolina oyster is its most unfortunate characteristic. Unquestionably, many persons in addition to the twenty-one buy the Chesapeake in preference to the North Carolina oyster, for the testimony and practices of most North Carolina seafood dealers corroborate the twenty-one housewives. No retailer interviewed displays North Carolina oysters in his store. Very few buy them, and those only to sell to commercial eating places which need to meet competitive prices.

h. *Method of Cooking.* Seafood is prepared in about the same ways by housewives of all the three cities. Frying, baking, and broiling are the most common methods of cooking.

	Greensboro	Raleigh	Greenville	Total
Fry	119	102	202	423
Bake	63	45	49	157
Broil	43	49	48	140

TABLE 33

Edible Portions and Costs to Consumer of Common North Carolina Fishes

Variety	Price per pound	Average gross weight * (oz.)	Average net weight † (oz.)	Waste (per cent)	Market cost	Number servings and size	Cost per serving	Method of preparation
Butterfish	$.35	5.3	3.4	36	$.12	1.0 serving 3.4 oz.	$.12	Fried
Spot	.35	9.7	5.1	47	.21	1.6 servings 3.2 oz.	.13	Fried and broiled
Speckled trout	.60	20.3	8.7	57	.76	2.6 servings 3.3 oz.	.29	Broiled and baked
Gray trout	.40	15.0	7.5	50	.38	2.1 servings 3.5 oz.	.18	Fried and broiled
Spanish mackerel	.50	18.8	12.0	36	.59	4.0 servings 3.0 oz.	.15	Broiled and baked
Rock bass	.50	18.8	9.1	52	.59	2.7 servings 3.4 oz.	.22	Broiled and baked
Croaker	.35	20.7	7.7	63	.45	2.3 servings 3.4 oz.	.20	Broiled, fried and baked
Mullet	.35	17.5	7.6	57	.38	2.3 servings 3.3 oz.	.17	Fried and baked
Flounder	.35	17.0	9.7	43	.37	2.8 servings 3.5 oz.	.13	Fried and baked
Shrimp (headless large)	.80 (40 shrimp)	16.0	8.0	50	.80	4.0 servings 2.0 oz. (10 shrimp)	.20	Boiled
Oysters	.90 (30 oysters)	16.0	16.0	0	.90	6.0 servings 2.7 oz.	.15	Fried

* Finfish weights are for individual whole fish.
† These weights are for edible portions.

i. *Market-to-Table Study.* One concern of the housewife is the question of just how much edible food can be had from a whole fish. When she buys a fish in the rough, the retail price she pays is, of course, for the entire fish, including what will be edible and what will become waste. The amount of this waste determines her true cost per serving.

To get some figures on quantity and costs of edible portions of fish bought in the rough, the food classes at Woman's College in Greensboro bought four fish each of nine popular varieties, a quantity of shrimp, and some oysters. These eleven varieties were weighed individually as purchased, then they were prepared for cooking and the amount of waste recorded. Finally, the items were cooked, divided into servings, and the cost per serving computed. The prices are of October, 1946.

MECHANISM OF DISTRIBUTION [6]

Distributor-Dealers. Because of the great diversity of kinds of fish available to the market, their sizes, grades, seasons of abundance, etc., and because of the public taste, which varies from place to place, it is the function of the distribution mechanism to perform the exceedingly complex service of assembling from the many points of production the many kinds of seafoods, sub-dividing and transporting them to the many markets. In North Carolina it is the function of the distributor-dealers not only to distribute North Carolina production, but to reach often far beyond the State into Florida, New England, and other distant sources and to bring fresh, frozen, packaged or not, but preferably fresh seafood products of many kinds into the State to wholesalers, institutions, and retailers. By adding the function of storage of perishable products to their other services, they are able to provide a certain stability and continuity of supply of the highly variable assortment of production from many fluctuating sources wherein scarcities of one kind are made up by abundances of others.

In 1946, nine of these distributor-dealers were reported as operating in North Carolina: Charlotte, 1; Elizabeth City, 1; Washington, 1; Greensboro, 1; Swansboro, 1; Hampstead, 1; Wilmington, 3. Some of these distributor-dealers in North Carolina acquire fish from as far away as Canada and the Gulf of Mexico; frequently their sources are the producer-dealers on the North Carolina coast, but they may also buy from other distributor-dealers. Their sources of supply may change with the seasons. The North

6. Based on report of field survey made by Dr. C. A. Kirkpatrick in the fall of 1946. Dr. Kirkpatrick made inquiries in the following fifteen towns and cities in North Carolina: Asheville, Charlotte, Greensboro, Raleigh, Winston-Salem, Burlington, Fayetteville, Greenville, Hickory, Salisbury, Laurinburg, Morganton, Tarboro, Oxford and Whiteville. Dr. Kirkpatrick's report, being based on a limited coverage, is mainly qualitative and descriptive, and is here rearranged so as to conform to the general style and design of this Survey.

Carolina distributor-dealers handle mostly round fish, shucked oysters and beheaded shrimp. There are indications of a preference for sealed tin pints of oysters as a standard package, and a general dislike for or distrust of frozen seafoods. Most of their purchases are by description written or telephoned.

Capital requirement of distributor-dealers is substantial, not only for plants, trucks, and other fixed assets, but also for substantial amounts of working capital. From 80 to 90 per cent of the North Carolina distributor-dealers' sales are to retailers (fish markets and grocery stores); most of the remaining 20 to 10 per cent are to commercial buyers, restaurants, cafeterias, hotels, schools, hospitals, and other institutions. Most of the sales of these distributor-dealers are within a radius of 100 miles but especially for certain particular items often much more remote. Much of the sales effort of distributor-dealers is exerted by telephone call because of its speed and economy.

Personal salesmen are employed to some extent, though the expense of personal selling has tended in recent years to minimize it. A frequently used and convenient device is the weekly price quotation, to which is usually attached a business reply card for the customer's use. This method is employed effectively for hotel dining rooms, restaurants, institutions, and the like.

In the post-war period, 1946-47, the distributor-dealers in North Carolina were not in full agreement on the need and future for quick frozen packaged goods. Some of them hold that quick freezing is impracticable because (1) there is not a large enough volume of seafood, and (2) there is not year-round operation. Other dealers are enthusiastic and have installed freezing facilities of their own. These hope to see more and more retailers install frozen food cabinets. At the time of this Survey, however, no distributor was financing freezer cabinets for his retail customers.

Only a few of the distributor-dealers in North Carolina operate their own retail fish markets. While distributor-dealers ordinarily do not do manufacturing operations, they do a certain amount of dressing and cleaning of fish for commercial and institutional buyers, i.e., restaurants, hotels, hospitals, etc.

Distributor-dealers' prices are thought of in terms of dollar mark-up per box, rather than in per cent of the buying or selling price. It is universal practice in North Carolina to add a fixed or nearly fixed identical number of dollars per box, regardless of the cost of the fish. Thus, whether the 100-lb. box of fish costs $6.00 or $20.00, the distributor-dealer will add from $2.00 to $5.00 for his initial mark-up. His direct cost may be from $2.00 to $3.50 per box, representing the wooden box, ice, labor, and transportation; if this out-of-pocket cost is $3.00, and he is able to mark up the box by $5.00, he is left a profit of $2.00 per box.

There are indications that the distributor-dealers' selling prices are more constant than their buying prices, and dealing as they do in large volumes, their margins of profit are small. Most of the distributor-dealers have one price list for retailers, commercial and institutional buyers without distinction. Transportation is not a separate charge and prices within delivery range are uniform.

Wholesalers. Wholesalers in general perform the same services as do distributor-dealers, but on a smaller scale and in a more localized area. They patronize fewer and nearer suppliers, generally those in North Carolina and Virginia, who are likely to be distributors, dealers, truckers, or occasionally producer-dealers. What the wholesaler needs and seeks is a small number of reliable suppliers who can and will assure him of volume and variety at competitive prices. He tends to buy continuously and throughout the year from the same sources, while other larger distributor-dealer competitors may shift from one source to another with changing seasons.

Like the distributor-dealers, the wholesalers buy their fish in the round, shrimp beheaded and oysters in gallon cans. Purchases of frozen fillets and frozen shellfish are infrequent. These items are stocked only for commercial and institutional buyers who specify them.

Purchasing by wholesalers is mainly by telephone and by description or grade, except when the supplier is a trucker, in which case their purchases are on inspection. Likewise, their sales are frequently by telephone and both buying and selling prices are largely arrived at by negotiation.

The customers of wholesalers are about 90 per cent retailers and 10 per cent commercial and institutional buyers within a radius of 50 or 60 miles. Most wholesalers have retail departments or markets which account for from 20 to 50 per cent of sales, sometimes more.

Wholesalers often operate trucks, or fleets of trucks, with driver-salesmen covering regular fixed routes, a long route once a week, a short route twice a week. The driver-salesman, on each visit, takes orders for delivery on the next visit. One typical wholesaler has four trucks and each of the four makes four trips a week through his territory. Another wholesaler covers various parts of his area from two to six times per week. The mailing of price lists is not practiced by wholesalers; advertisements feature only the retail part of the business.

Wholesalers do not favor frozen products, nor do they encourage their retail customers to install deep freeze cabinets.

In pricing their goods, the wholesalers, like the distributor-dealers, think in terms of adding a fixed number of dollars per box of fish, regardless of the cost. Some wholesalers apply the mark-up rigidly to all kinds of fish;

others tend to treat each transaction as an isolated case for individual consideration in the manner of a "horse trading" type of business.

Excess merchandise is cleared out by marking down the prices; on the whole, buying prices tend to change more frequently than selling prices.

Retail Outlets are of three principal kinds: (1) Retail fish markets; (2) Independent grocery stores; (3) Chain food stores.

a. *Retail Fish Markets* in North Carolina depend on distributor-dealers in the State or in Virginia for most of their seafoods—Wilmington, New Bern, Morehead City, Elizabeth City, Charlotte, etc., and Norfolk or Hampton, Virginia. There were in 1939 in North Carolina 206 retail fish (seafood) markets whose sales were $676,000.[7] Sometimes these markets are supplied by the local wholesaler, and truckers are counted on heavily in eastern and central parts of North Carolina.

Finfish are almost always bought in the round, shrimp beheaded, and oysters in gallon cans. Some frozen fillets are purchased in 5- and 10-pound packages, but small branded quick frozen packages are not stocked to any great extent as they are not in great demand from consumers. An occasional market buys shellfish in the shell.

Household consumers account for 85 to 90 per cent of sales of retail fish markets; the remainder is to commercial and institutional consumers. Sales by retail fish markets are largely on Fridays and Saturdays by custom and tradition rather than by religious requirements.

In general, the impression received in this Survey was that retail fish markets are more active and aggressive merchandisers of fish than their competitors in independent retail grocery stores. Quality and condition of merchandise is better protected, displays and arrangement are better. Open displays rather than closed cabinets are used and personal salesmanship is generally good.

At the time of this inquiry, the movement to install facilities for handling small quick frozen packages in retail fish markets was gaining momentum. Some of these markets own freezer cabinets and stock medium priced brands. Fresh fish purchased whole is dressed at no extra cost.

In pricing, retail fish markets, like the distributor-dealers, wholesalers, and truckers add a constant rather than a percentage mark-up to the products dealt in. In the course of a year the margin must be sufficient to cover cost and profit, but in the manner of arriving at the mark-up, the fish trade, whether of truckers, distributor-dealers, wholesalers or retail markets, differs from nearly all other merchandising trades.

It is perhaps worth while to recite here the reasons given by wholesale and retail dealers for this practice in arriving at prices. It was said that when the retail price rises to 50 cents per pound or higher for fish, strong

7. U. S. Census of Retail Trade.

resistance arises; when a retailer is forced to carry a complete assortment, the article which costs the retailer 12½ cents and is marked up to 25 cents is still within the reach of many, but the article which costs 35 cents if marked up to 70 cents will not sell. Hence, runs the argument, the mark-up should be high percentagewise on the low cost varieties and less on the costlier ones. One distributor-dealer thinks that the retailer should set his selling price at twice his cost up to 12½ cents per pound, but when the cost reaches 25 or 30 cents he should add 10 cents per pound.

The number of cents mark-up added by retail fish markets usually ranges from 9 to 15 cents. Two markets add 10 cents to all fish. Almost all markets reduce prices when speedy clearance is imperative. A few markets try to keep retail prices in even nickels, which means that selling prices change at longer intervals than their buying prices. A fish costing 12 cents is priced at 25 cents. Even if the cost price rises to 17 cents, the 25 cent selling price is continued up to a cost of 18 or 19 cents, when a selling price of 30 cents is established.

Typical examples of the price structure of North Carolina species of fish are shown in the following table:

TABLE 34

Sample Prices in North Carolina Retail Fish Markets. October–November, 1946

	Cost price	Selling price	Mark-up in cents	Per cent on selling price
Spot	$.12	$.25	$.13	52
Mullet	.19	.35	.16	46
Mullet	.18	.32	.14	44
Croaker	.16	.28	.12	43
Spot	.19	.30	.11	37
Flounder	.23	.35	.12	34
Speckled trout	.30	.45	.15	33
Speckled trout	.35	.50	.15	30
Oysters—stand.	.73	1.00	.27	27
Oysters—select	.79	1.05	.26	25
Spot	.18	.24	.06	25
Shrimp—medium	.50	.65	.15	23
Shrimp—medium	.55	.70	.15	21
Oysters—stand.	.69	.85	.16	19
Oysters—select	.75	.90	.15	17

b. *Independent Retail Grocery Stores* operating fish counters sell about 90 to 95 per cent of their fish to domestic household trade. In 1939 there were in North Carolina 3,754 combination (groceries-meats) food stores;

their total sales were $83,121,000.[8] They were not observed to be outstanding as merchandisers of fish. The arrangement and display are considered advertising and the importance of personal salesmanship is largely disregarded. A few retail stores own frozen food cabinets and stock a variety of brands of frozen foods. Most, but not all, independent grocers who handle fish dress the fish for customers at no charge.

Pricing does not reflect keen analysis of what prices should be. Independent stores usually add to delivered buying price, regardless of kind and prices, 10 to 15 cents per pound for finfish, 10 to 20 cents per pound for shrimp, and 15 to 25 cents per pint of oysters. If the goods do not move at these prices after a day or two, or late on Saturday, the prices are marked down to little or no margin.

The following table indicates typical prices in independent retail grocery stores:

TABLE 35

Sample Prices in North Carolina Independent Retail Grocery Stores, October–November, 1946

	Cost price	Selling price	Mark-up cents	Per cent on selling price
Croaker	$.12	$.25	$.13	52
Croaker	.13	.25	.12	48
Speckled trout	.26	.49	.23	47
Gray trout	.17	.30	.13	43
Mullet	.18	.30	.12	40
Gray trout	.18	.30	.12	40
Oysters, select	.62	.90	.28	31
Speckled trout	.28	.40	.12	30
Spot	.13	.18	.05	28
Oysters, standard	.62	.85	.23	27
Spot	.26	.35	.09	26
Speckled trout	.38	.50	.12	24
Blackfish	.23	.30	.07	23
Shrimp, medium	.60	.75	.15	20
Oysters, standard	.72	.85	.13	15

c. *Chain Stores.* There are said to be between 150 and 250 retail chain store grocery stores in North Carolina, selling an estimated minimum of about 100,000 pounds of seafood per week. These chain stores perform a typical chain store operation in the State. Unlike retail fish markets and independent grocers, they prefer standardized products handled and priced in a uniform manner. In general, this type of merchandising has been of great value to the fisheries of the whole United States, and while they seem

8. U. S. Census of Retail Trade.

not to have made as much progress in North Carolina as they have in some other parts of the country, their effectiveness here is nevertheless apparent. The sales effort and merchandising in North Carolina are typical of chain store operations. Display is usually good. Seafood is mentioned at least once a week in the store's newspaper advertisements. Many chain stores are adding facilities for handling quick frozen packaged goods, whether of the chain store's own brands or other brands. It is probably the chain stores that are most instrumental in bringing into North Carolina the frozen packaged goods, such as redfish, or "ocean perch," haddock fillets, pollock, halibut, etc., from the New England States, and other fishes from Chesapeake Bay, Florida, Gulf of Mexico, and even the west coast. Standardized packages of these products produced on a large scale greatly simplify the chain store merchandising operations.

In pricing, the chain stores are the only type of fish retailers in the State to deal with mark-up in terms of per cent (usually 25) on selling price.

These stores also conduct scientific merchandising studies of their territories. A recent example was a spot check made by the Southern Chain Store Council of variety and drug stores in Raleigh and Charlotte which serve meals. The data from such studies are used to guide the operating policies of the chain stores in these cities.

d. *Institutions.* Institutions such as college dining rooms, hospitals, prisons, etc., are consumers rather than dealers. Most of their purchases are from local wholesalers or from retailers of any of the three classes described above. The one characteristic of the institutional trade is absolute insistence on certainty of delivery at the specified times. Institutions buy almost invariably once a week and specify usually that the seafood be dressed or prepared to be cooked on arrival. Standing orders for a certain quantity of fish for each Friday are often placed, the variety of fish not designated but left to the discretion or opportunity of the supplier. In some cases special arrangements are made for frozen product in order to insure unfailing delivery.

Price Structure from Fisherman to Consumer. In lieu of a needed survey of the price structure, Dr. Kirkpatrick constructed Table 36, which is intended to represent typical prices at the various points in the distribution system in October-November, 1946.

Here, again, as in shipments to Fulton Market, the fisherman's share of the final price is much less than the farmer's share for farm products. Perhaps the two are not properly comparable in such simple terms. It is not necessary to invoke any principle of right-and-wrong to decide whether the first producer is "entitled" to a larger share of the final proceeds than the "middle men"; the fact is, as everywhere evident in the fisheries, fish

TABLE 36

Some Prices from Fisherman via Trucker and Wholesaler to Consumer, October–November, 1946

	Fisherman	Producer-Dealer	Trucker	Wholesaler	Retailer
Spot	$.06	$.14	$.15	$.17	$.30
Spot	.06	.15	.17	.22	.32
Spot	.06	.22	.23	.26	.35
Mullet	.11	.20	.21	.35	.45
Speckled trout	.17	.34	.35	.38	.50
Speckled trout	.17	.32	.33	.37	.50

is cheaper at the source than meats, but costs more to distribute, so that most or all of the first advantage is lost.

Functions, Practices and Attitudes Common to the Distributive Mechanism as a Whole. Storing in some manner, even for short periods, is an essential function of the distributive mechanism for such varied, fluctuating, and perishable products as seafoods. Packing in ice serves for short periods and, combined with alert management of purchases and sales, enables the larger distributor to provide an approximately steady and dependable supply of seafoods to the trade, with occasional disappointment or complaint.

For longer terms, freezing (as well as permanent preservation by canning, etc.) serves to carry over from in-season to out-of-season trade.

Stability and Dependability of Supply. The preparation of frozen edible portions in standardized branded packages is not merely an improvement on, or a new facility in, an existing business, but a revolutionary change in method of meeting the demands of the market. If adopted it would completely change the nature of the distributor's business. It is probably for this reason that all dealers, especially the truckers, distributor-dealers, and wholesalers, are generally skeptical of or unfriendly to the frozen package business. These dealers are geared and prepared by experience and skill to perform the complicated task of assembling highly variable supplies from many places, and regularizing, stabilizing, and channeling them to all the final outlets. The standardized frozen package makes much of this service unnecessary.

At the time of this Survey, no producer-dealer on the coast in North Carolina was processing seafood and offering it in small packages, either frozen or not, for retail distribution.

It is probably demonstrable that no method of freezing (or any other preservation) provides fish which is quite the equal of strictly fresh at the shore. Frozen package fillets are inferior to this, but the choice to the consumer inland is not between strictly fresh fish at the shore and frozen package fish at his home; it is rather between none or what the trade can supply as "fresh" fish, on the one hand, and as frozen branded product on the other. To the steward of the restaurant at, say, the Carolina Inn at Chapel Hill, the purchase of 50 or 100 pounds of fish, involving $15 or $20 for a Friday menu is not a matter of great importance as such; nor is it a matter of great importance which of a dozen kinds of fish he serves; it is, however, a matter of great importance that whatever kind it is, and whether from Gloucester, Palm Beach, or Morehead City, it arrive on time without fail, and be of a quality that is acceptable to his guests, so that, at the last minute, he will not have to shop locally to meet an emergency and print a different menu. A truck from Southport or Morehead City with fish caught yesterday would no doubt be welcome if it could be depended upon without fail, but weather has its influence and fish are not always abundant at the right place and time, and trucks cannot arrive at each of the restaurants, hotels, and retail outlets in North Carolina on Thursday afternoon for deliveries of 25 or 50 pounds of fish. As things are, the steward at the hotel feels safer to fill out the return card printed order blank for a shipment of some kind of fish from Baltimore or Norfolk.

It will be obvious from the above brief consideration that in North Carolina, dependability is first in order of importance, quality is second, and price is third; everybody in the distributing mechanism from wholesale distributor to retailer and restaurant steward is concerned with establishing a dependable source of supply. It is perhaps the greatest economic weakness of the entire fisheries establishment of North Carolina that it has been and is now unable to offer the trade of its own State even the minimum of dependability. Near proximity in miles to the coast is of relatively little importance in competition with trunkline railroads running north and south which can bring standardized packages of even fresh fish products into the State from distant points.

Airborne Seafood Marketing. The ease with which seafoods lose their prime flavor and appeal, and the importance of the esthetic motive in the choice of foods suggest that airplane transport could be of great value in the fisheries. The subject has been explored in detail by Larsen, Reitz, and Burgum at Wayne University, Detroit (1948) East-west airlines extend from Elizabeth City, Morehead City, and Wilmington into and beyond the middle and western parts of the State. Whether costs are such that they could compete for the North Carolina market and whether, if they could, the local and seasonal fluctuations would still leave a large unsolved problem of distribution, will all require a more detailed analytical study than this general Survey.

Standardizing and Grading. Not mentioned above in the rank of desirability is the need for dependable quality standards and grading. The establishment of certainly the more elementary forms of standardization, such as that of size grading, and the separation of species is essential in good merchandising. Unfortunately, a good many complaints were heard among the retailers, and especially institutions and restaurants, that the goods received were not only not dependable as to quality, but were not standardized as to size or even the identity of the species in the shipment.

Market Information. There appear to be no facilities for communication of market information between the sources of supply and the distributing markets in North Carolina. There are in the State (1948) only four members of the National Fisheries Institute, the only trade association in the United States which undertakes to represent the fisheries industries in all of their branches. There are no regular or associate members at all in North Carolina of the Oyster Institute of North America, which was organized in 1935 by the Oyster Growers and Dealers Association of North America, Inc. There is no State or local trade paper or trade association through which information can be disseminated concerning abundance, scarcity, or prices of North Carolina seafoods, or of any other seafoods. There being no local trade associations, there are of course no forums or media through which fishermen and dealers can meet for discussion of their common problems and of course no organized representation of the fisheries interests in matters legislative and regulatory. Such information as is obtained apparently is communicated by telephone or telegraph from the markets at Norfolk, Baltimore, New York, etc., and from Florida. Price lists sent by mail have little meaning concerning the current State production or demand. No sources of information are available concerning the quantity or value of seafoods brought into North Carolina or shipped out to other States.

Concluding Comments and Recommendations

Although nature has endowed North Carolina, in the sounds and on the offshore continental shelf, with an excellent physical setting for a good though perhaps not great fishery, the State has not made any progress to speak of in increasing the total quantity and value of its food fisheries since our first record in 1880; the only important progress has been in the menhaden fishery. The average annual production of food fish in the twenty-year period 1921-1940 was less than it was in the period 1887-1908, and while the average price for the total production of food fish rose to yield 26 per cent more dollars in the late period, those dollars would only buy 21 per cent less of commodities generally than would the proceeds of sale of the total production of the earlier period. Even the menhaden fishery, which has come into existence mainly since 1908, has not been sufficient to bring the exchange value of the total fish product up to what it was in the earlier days, or to prevent the State from slipping backward slightly in rank among the States in value of total fish production.

During the sixty-year period from 1880 to 1940, the size, distribution, and accessibility of the population of North Carolina have all changed in a direction more favorable to fish than they were formerly. The population of the State increased 155 per cent and was slightly more urban; the six leading cities in the State, all small towns in 1880, had multiplied 8½ times in population by 1940.

In 1880, facilities for preservation, transportation, and distribution of fish to the inland communities were still crude and primitive. By 1940, the one hundred county seats and those of the neighboring States were connected by a magnificent network of hard surface graded highways suitable for auto truck transport; ice was everywhere available; mechanical refrigeration and dry ice, frozen food lockers and deep freeze cabinets were coming into widespread use. Airplanes connected the principal coastal points with interior markets. The income and standard of living of the people had enormously improved. All of these changes should be favorable to the distribution and consumption of fish.

The State has an assortment of seafoods which includes two of the five ranking money value fish items in the United States, oyster and shrimp; it was among the largest producers of the bay scallop before the catastrophic decline along with the eel grass; it also has spanish mackerel, bluefish, gray and spotted trout, striped bass, shad, sea bass, clams, blue crab, pompano, king whiting, white perch, and catfish, all of which are among the choicest seafoods in the country. It can almost be said that the State does not have any coarse or trash fish, for croakers, spot, mullet, and flounders all have excellent edible qualities, and the alewives are perhaps the best of all the herrings.

Except the shad and, in a qualified sense, the oyster and the scallop, none of the species mentioned so far as we know show any signs of "depletion," or biological scarcity; the production of most of them rises and falls with general economic prosperity and depression or with changes in relative popularity of different species. The shad is probably at a permanent biological disadvantage and may never be as abundant or important as it was in former years; the scallop may come back when and if the eel grass does, and wild oysters may never support an expanding fishery but they can always be brought back by culture. In quality the wild oyster taken from overworked rocks and crudely prepared may be, as reported, inferior in size, grittiness, grading, etc., yet none of these things is fundamental; no reason has come to light why North Carolina oysters, with the will, incentive, and effort of the oystermen, cannot be produced in quantity and be of as high quality as oysters from any other source.

The State lies between the sub-tropical winter fishery of Florida and the summer fishery of Chesapeake Bay and points north; its fauna is of the nature of both; it has the "fancy" species of Florida, and it has the spring seasonal shad and soft crab before they arrive farther north. For these early seasonal species and a few others the State receives a better price than does the northern competition; for some other species the State receives a lower price than the average of other States. In the oyster, the State seems to be at an economic disadvantage in the later opening and earlier closing of the season and receives a lower price than the average of the rest of the country.

For the total of all food fish produced, the State receives slightly less (avg. 1938-39-40 = 3.13¢) per pound than do the fisheries of the entire Atlantic and Gulf (3.53¢), or of the whole country (3.45¢). The average price received by North Carolina for all food fish is less than half that received by stock growers of the United States for farm animals; the price received by the fishermen in North Carolina is a much smaller share of the final price paid by the consumer than the farmers' share in the final consumer price of farm animal products of the United States. With inefficiency and high cost of distribution the consumer pays more and the fisherman gets less in proportion to actual cost of production than their counterparts in agricultural food production.

The number of fishermen in North Carolina was about the same in 1940 as it had been in 1890; on the twenty-year annual average between the two world wars, the number decreased by a third from the average of 1887 to 1908; the income per fisherman had increased but not sufficiently to compensate for the inflation of money, so that the fishermen could buy, with what they received from fishing as an average, slightly (3 per cent) less in the late than in the early period. The fishermen and dealers of the State have no trade association or trade paper for the interchange of ideas or legislative representation; the State has no members in the national Oyster Producers and Dealers Association and there are only four (all corporate) members of the National Fisheries Institute, Inc., the country-wide trade association of fishing industries.

As a market and potential customer North Carolina, a coastal State, would be expected to consume more fish per capita than the national average. Apparently the State does not consume per capita as much as the national average; certainly not of her own production which, even if it consumed all, would be equivalent only to about one-half to three-fourths of the national per capita average. The State itself and contiguous parts of neighboring States afford a potential market for at least two or three times the present production of the State. About five per cent of North Carolina's produce (half of it shrimp) is shipped to Fulton Market, New York; an unknown amount to Norfolk and other markets. On the other hand, fish products imported from Chesapeake States, New York, New England, and Florida are regularly found in restaurants, hotel and institutional dining rooms, and retail chain stores all over the State. The finfish product of North Carolina is shipped in crude form, round or whole, on ice, shrimp beheaded and oysters shucked; no filleting is done in the State, nor any freezing of standardized packaged products (which are growing in importance all over the country and are invading the State from elsewhere); the State's production is in highly discontinuous supply, the bulk of it in the fall.

Such, briefly stated, is the fishery industry of North Carolina. It is a small industry; it is in a part of the State which needs income; the menhaden industry is a valuable addition; but the food fish part of the industry shows no sign of sustained improvement; in the past seventy years it has not responded to changes for the better which might have caused it to improve, and there appears to be no reason to expect anything to happen spontaneously to make it improve now.

How can the fisheries of the State be so developed as to make a larger economic contribution to the welfare of the coastal communities?

Many of the handicaps and needs of the State's fisheries are common to the fisheries of the whole country, though some occur in aggravated form in North Carolina.

The one thing that will without fail benefit the entire fishing community is to increase demand for fishery products. Quantitative data concerning our markets are meagre and old, but it is well known that demand is greater in large cities than in small towns and in the country, and it is greater on the seaboard and around the Great Lakes than in the interior generally. It is greater in regions where populous religious denominations require fish on fast days. If the regions which are now light consumers of fish (such as up-State North Carolina and neighboring States) could be brought up to the per capita consumption of the heaviest consuming regions, the total demand for fish would be enormously increased, the aggregate (if not the individual) income of fishermen would be increased and the fishing communities would receive a transfushion of economic prosperity. The most dependable formula for improving demand is to produce a better product at lower cost, efficiently distributed, effectively and persuasively presented to more of the people more of the time.

The problem in North Carolina which appears to transcend all others in importance is that of the discontinuity of supply of fish over the four seasons and from day to day, complicated by the geographical separateness or disunity of the source of fish in the State. The occurrence of the principal fisheries in waves at different times in different parts of the State, and the subdivision of the producing region by sounds and rivers, taken together, make it difficult or impossible, with the present marketing organization, for the State to furnish a continuous and dependable supply of fish even to its own population. These complications multiply the number of dealers, hold down the size of business that each dealer does, prevent the practice of packaging and the manufacture of by-products, and generally increase the costs of handling and distribution. These two problems of time and place probably have more to do with the general backwardness of the fisheries of the State than any other determinants.

Our first recommendation therefore is that this particular problem, or pair of problems, be made the subject of a special and thorough study. It may be that the State or the University as such cannot solve it; but by analyzing it thoroughly and presenting the facts they might be instrumental in stimulating thought and interest in the subject on the part of business people who could do something about it.

The State fisheries may be actually losing ground in their home market by reason of their failure to produce packaged edible portions, whether or not frozen. Round fish are generally unsuitable as merchandising items for chain stores, and chain stores have proved to be exceedingly effective mechanisms for distribution of fish. In North Carolina they are not at all dependent on State fisheries. If the State cannot supply what they need, they can easily get it in Norfolk, Baltimore, or further north, as no doubt they do. If therefore appears that the State has little option but to modernize itself in this respect, or to see its markets continue to drift away to out-of-State sources.

The next subject of our observations and recommendations has to do with the business strategy of the fisheries of the State.

It appears to us that the sciences of biology and economics might effectively unite (as they rarely do) to lay down for the consideration of the industry a general strategy by means of which the State could make the most of its opportunities. Our case histories of 20-odd species in the United States (based on the long term) show clearly that different species of fish and shellfish behave in very diverse economic patterns. In some of them the market says clearly that it does not want any more, the price goes down on increased production, or on unchanged or even smaller production. In other cases, the market says clearly by rising prices even in the face of rising production that it wants more. It has said this for shrimp and it seems to say so for flounders, and, less emphatically, for mullet. Data were not available for similar case histories (for the long term comparison) of some other North Carolina species, but bay scallops (as distinguished from the large sea scallops) are in strong demand at all times, and just now at very high prices by reason of the great and perhaps temporary shortage; the white perch is highly esteemed as one of the most sought-after fresh water varieties in its class. It would seem to be the part of good judgment for economic studies to be made (over the shorter term of fifteen or twenty years) pointing the directions in which biological research or surveys would yield the greatest economic returns. If, as a result of such studies, favorable combinations of market demand and biological supply were brought to the attention of the fishermen, the State as a whole would be making the most of what it has. Possibly some changes in the regulations might also be indicated. Such study, for example, might indicate that the State is not taking full advantage of its favorable position in the soft crab fishery. The soft crab is available in North Carolina before it is available farther north. It is understood that Maryland dealers have come to North Carolina in the early spring and exploited the soft crab until such times as their own fisheries in Chesapeake Bay open, when they desert North Carolina and set up competition from their own headquarters, leaving the North Carolina business flat. However, our data suggest that the demand for soft crabs is exceedingly limited perhaps because of a certain psychological repugnance on the part of many people.

We understand also that there is a conservation law for soft crabs in New York which prohibits possession or sale of soft crabs of less than 5 inches. There are no soft crabs in New York during the spring when, of less than 5 inches, they are available in and could be supplied by North Carolina. The New York law therefore operates directly contrary to the interests of North Carolina and does no good in New York during that period.

The flounder appears to be an opportunity in North Carolina which is not adequately prosecuted. The attention of the fisherman is apparently so engrossed with shrimp that the flounder and perhaps other equally good fishes are being neglected.

For the country as a whole, there is the classical relationship among supply, demand, and price, so that increased production of any species evokes response in price. However, in those fisheries in which North Carolina produces a small percentage of the total, an increase of a large percentage of North Carolina production would be a very small increase on the national total; for example, North Carolina's production of shrimp (in 1945) was 5½ per cent of the national total, and the value 4 per cent. The effect of doubling North Carolina's production of shrimp, if all other States remained the same, would be to increase the total by 5½ per cent. This small increase could hardly have much if any effect on the price of shrimp, but could easily add nearly a million dollars to the fishing communities of the State. In like manner, other strategic opportunities could almost certainly be found by analytical study.

It is therefore recommended that economic and biological studies be prosecuted continuously, in parallel and in close cooperation with the regulating authorities, to establish a strategy of exploitation of the State's production as a whole to the best advantage of the fishing community.

The foregoing recommendation is based on our studies of price in relation to supply of fish in the United States as a whole, the presumption being that if information and recommendations of the kind relating to North Carolina fish were passed on to fishermen, their actions would be influenced favorably. Actually, we do not know to what extent fishermen are already aware of and responsive to the current economic forces of supply and demand, nor do we know how prices of North Carolina fish are established, or where. The small part of the product which goes to Fulton Market, New York, is priced competitively at New York; the field investigator's observations of the whole up-State mechanism indicate that sellers, retail, wholesale, and distributor, add a fixed amount of money per pound, box, or other unit, in making their selling prices, but who makes the prices to which they add their mark-ups? It can hardly be the fishermen. Judging from the field data available to us, we can draw only the conclusion that the prices are made by the coastal producer-dealers, i.e., those distributors who receive the fish first-hand from the fishermen. If this is so, then the ordinary forces of supply and demand (from consumers) do not operate at all in their classical manner so as to determine how much or what kind of fish the fishermen try to produce. All of our studies of the fisheries of the country as a whole indicate that the forces of supply and demand do in fact operate in the classical manner to determine and regulate the quantity, kind, and place of production. North Carolina may be an exception to that rule, in the sense that the interaction between supply and consumer demand is mediated in some complex manner by the price making of producer-dealers, distributors, wholesalers, and retailers.

With such a system it would be less simple than it otherwise might be to establish a general strategy so far as the State is concerned, for final price would bear little relation either to the cost of production or to the relative desirability of the different species.

Such a system also fails to take into consideration the risks involved in the valuations in the various species. Our data are too meagre and the subject is too important to reach conclusions with what information we now have.

It is therefore recommended that further field studies be made of the whole pricing arrangements for seafoods of all kinds on the coast of North Carolina and throughout the distribution mechanism in the various markets to the consumer, and particularly the prices of other competing foods, such as meats, poultry, eggs, etc., for comparison.

It would also probably be well worth while to conduct some systematic inquiry among the fishermen to ascertain the determinants of what they actually do, the extent of their awareness of market conditions, their responsiveness thereto, and their interpretations of what their best interests are.

While North Carolina does not appear to possess great resources in large-volume food finfish, it is fortunate that what it does possess appears to be rather in the invertebrates as delicacies than in finfish as competitive bulk items of food. The principal invertebrates are shrimp, crabs, clams, scallops, and oysters.

The oyster has long been an important resource of the State and is still among its most important potentials. Even with its long-continued decline and the rapid rise of the shrimp, the oyster still slightly exceeds the shrimp in value in the whole country. Although North Carolina's production of oysters is now a minor part of the national total, there is no doubt that the State is favored as a potential producer of oysters. Its waters are nearly free from starfish; there is no difficulty in obtaining a set of spat, and the rate of growth of oysters undoubtedly exceeds that of the more northern States.

The indications contained in this report suggest that the decline in the relative position of the oyster in this country is, at least in part and perhaps an important part, due to economic rather than biological factors. An organized program of biological research is already in progress. It is recommended that the oyster industry also be made the subject of a special economic study of both production and marketing. The study should include costs of production, employment and wages of labor, mechanization, and the competitive aspects of marketing.

In scallops, the whole Atlantic seaboard is passing through a crisis which everyone hopes is temporary. The scallop has been an important item in North Carolina; for a brief period (1928) the State led the country in its production. Although the abundance of the scallop may eventually be restored, there is a danger here that it may lose its market momentum and never be able to regain its place even if it returns in abundance. During the late war business houses continued to advertise products which they could not make, in order to prevent as far as possible loss of momentum. The diamond back terrapin lost its market momentum with the coming of prohibition in 1918, and on the repeal of prohibition in 1933 it had been forgotten, a new generation had come on and the terrapin did not regain a place in the market until after the Second World War. The effect of epidemic scares can have such an effect on oysters. Since the scallop is an article of undoubted delicacy of appeal and one of the State's important potential fishery assets, it should be kept before the public by every form of propaganda available lest it, too, lose all momentum and be forgotten by a new generation. Talk of the scarcity of scallops, the eel grass mystery, etc., can serve as well as anything else to keep it before the public.

In this study we are impressed by the apparent lack of relationship between the subjects chosen for biological interest and research on the one hand, and economic progress and welfare of the fisheries on the other. The literature of the fisheries everywhere for the last decade reflects a great interest and some excitement about the destruction of small fish, the usual dangers of depletion, the possibilities of maintaining a theoretical optimum yield of each species, and other subjects which from an economic point of view seem unrealistic. Insofar as the choice of subjects for biological attention can be slanted to economic purposes, we venture a few suggestions:

Perhaps the most important biological study that could be made in our case would be an appraisal of the total biological potential of the fisheries of North Carolina. The fisheries of the country as a whole continue to produce fish in accordance with the growth of population and with the pulse of the economic cycle. It has continued to do so as far back as we have any record. We do not know how much further expansion is possible, nor does it appear that biological science has afforded us any means of increasing the total production of all the fisheries of the country or even of a region, though a great deal of study has been devoted to particular species. If a study of the North Carolina potential shows that production could be increased 5-, 10-, or 20-fold and the increase would be worth so much in dollars, then an expenditure in substantial amounts of money could be justified in order to accomplish the increase. If, on the other hand, it is found that the potential increase is only slight, say, a factor of 1½ or 2 times, then obviously such large expenditures for development would not be justified. It would not be possible, of course, to measure the potential accurately, but some general idea or order of magnitude could be arrived at.

If it should be decided to conduct a study of this kind, then the entire food chain from diatoms to useful economic species should be studied as a whole and quantitatively so far as possible, including the measure of the percentage of vegetation that enters the animal chain, how much and what kinds of other species each species consumes, and by what other species it is itself consumed, and in what quantities; the relation between the amount of food consumed and the amount of resulting growth; the economic value of the consuming species in relation to the potential economic value of its prey; the effects of fishing for particular species on the production of the system as a whole; and also the effects of regulatory restriction of certain species on total production.

Increasing the efficiency of finding and catching fish has never been the subject of sustained and systematic research anywhere, so far as we know. Therefore, we commend to the attention of the University the possibilities for good that might come from an extensive and sustained study of the senses and sense organs, perceptions of and responses to stimuli by aquatic animals generally with a view to more effective means of finding and catching fish. Such studies should include the senses of hearing and the perception of under water vibrations, reactions to light of mixed and single wave lengths, the chemical senses of "taste," "smell," etc. The study should also include the emission by fishes of various stimuli and responses thereto by other animals, and the possible use by fishermen of these stimuli as means of finding and catching fish. Considered in their larger aspects, such studies should also include the teleological behavior of fishes generally, their methods of finding food, pursuing prey, finding mates, defending and protecting themselves, the knowledge of all of which should be conducive to the discovery of more and effective means of finding and catching fish.

The sea herring of the North Atlantic is well known to be positively phototropic, and for centuries has been caught by torching; possibly the menhaden, of the herring family, may be phototropic, too; the flounders have well developed color perception; scallops have eyes; many of the North Carolina species of fish make sounds which probably are functionally important. Advantage must be taken of any or all of these and similar facts to increase the efficiency of fishing methods, and to devise new fishing devices. It would be appropriate to carry on technical, experimental, and engineering studies in the design of fishing gear, whether along radically new lines as just suggested or the introduction and improvement of the more conventional types.

Aside from finding and catching fish, we do not recommend technological research generally, such as freezing, canning, packaging, mechanization, etc., as suitable for governmental or university research. This type of research is very expensive in both capital and operation and is best done by industry in close contact with or as part of actual operations. The fisheries of North Carolina can profit better, for the time being, by adopting technological advances already made elsewhere.

Finally, in closing this report, we point out that increased prosperity of the North Carolina fisheries will depend on increased demand for and sales of fish, and (except where culture is possible as with the oyster) a heavier draft of the natural fishery resources of the State and by more efficient methods all along the line from fisherman to retailer. The usual conflict of conservation and exploitation will be encountered and must be frankly faced and resolved. Where agriculture is now regarded as a source of wealth to be developed and utilized with the greatest possible efficiency, the fisheries are subject to confusion and contradiction on the part of the public and policy-making public officials; on the one hand, it is desired to expand and increase the economic importance of the fisheries, and on the other, the fisheries are commonly regarded as a perishable natural source in imminent danger of exhaustion unless protected by public regulation and restraint backed by police power; much of these regulations have the effect of imposing inefficiency upon the fisheries and increasing their costs. It appears that before important progress can be made in developing the fisheries, thinking on this subject must be clarified and possibly re-oriented or the emphasis shifted in a direction which will afford to the fisheries the same kind of encouragement to efficiency as is given to agriculture; unnecessary restraints should be removed and assurance given that the use of any improved techniques that may be developed will not be forbidden without scientific justification.

BIBLIOGRAPHY

Anglo-American Caribbean Commission.
1945. Guide to commercial shark fishing in the Caribbean area. U. S. Fish & Wildlife Service, Fishery Leaflet 135, 1945, 149 p.

Atwater, W. O.
1892. The chemical composition and nutritive values of food-fishes and aquatic invertebrates. Rept. U. S. Comm'r. Fish. for 1888 (1892), App. 10, p. 679-868. (9 charts).

Bigelow, Henry B., and William W. Welsh.
1925. Fishes of the Gulf of Maine. Bull. U. S. Bur. Fish., Vol. XL, Pt. I, 1924 (1925), 567 p., 278 figs., extensive bibliog. (Doc. 965, 1925).

Call, L. E.
1929. The increased efficiency of American agriculture. Science, Vol. LXIX, 1929, p. 54-60.

Cavin, J. P., and Marguerite C. Burk. (prepared under the supervision of).
1949. Consumption of food in the United States. U. S. Dept. Ag., Bur. Ag. Econ., Misc. Pub. No. 691, 196 p., 69 tables, 4 graphs.

Clark, Ernest D., and Lloyd H. Almy.
1918. Chemical study of food fishes [20 species]. Jour. Biol. Chem., Vol. XXXIII, 1918, p. 483-498, bibliog.

Conference Board, The.
1947. The Economic Almanac for 1948. New York: National Industrial Conference Board, 1947, 472 p. (Annual).

Conseil Permanent International pour l'Exploration de la Mer.
1938. Bulletin Statistique des Pêches Maritimes des Pays du Nord et de l'Ouest de l'Europe. Vol. XXVII, 1937; XXVIII, 1938 (and annually). Copenhagen.

Cooper, Martin R., Glen T. Barton and Albert P. Brodell.
1947. Progress of farm mechanization. U. S. Dept. of Ag. Misc. Pub. No. 630, 101 p.

Dill, D. B.
1921. Chemical study of certain Pacific Coast fishes. Jour Biol. Chem., Vol. XLVIII, 1921, p. 73-82.

Dominion of Canada, Dept. of Trade & Commerce, Dominion Bureau of Statistics.
1944-45. Fisheries and Animal Products Branch, Fisheries Statistics of Canada, 1944, 284 p.; 1945, 294 p. Ottawa. (Annual).

Food & Agriculture Organization, United Nations.
1945. Fisheries. Report of the Technical Committee on Fisheries submitted to the United Nations Interim Comm'n. on Food & Agriculture, April 13, 1945, 38 p.

Furnas, C. C., and S. M. Furnas.
1937. The Story of Man and His Food [*Earlier edition,* Man, Bread and Destiny]. New York: The Home Library, 1937, 364 p.

Ginsburg, Isaac.
1944. Fishes with fins and scales. Anatomy of fishes and its bearing on the requirements of certain religious dietary regulations, etc. (Jewish Dietary Laws). U. S. Fish & Wildlife Service, Fishery Leaflet No. 8, 1944, 8 p.

Goode, G. Brown (and a staff of associates).
1884-87. The Fisheries and Fishery Industries of the United States, V sections, 7 volumes. Sec. I, Text and plates, 1884; Secs. II, III, IV, and V (Vols. I and II, and Plates), 1887. U. S. Comm. of Fish and Fisheries.

Harper, F. A.
1945. Food differences around the world. *In:* Nutrition in Review, Report of the New York State Joint Legislative Committee on Nutrition, p. 77-81. Legislative Document (1945), No. 49, Albany.

Harvey, H. W.
1928. Biological Chemistry and Physics of Sea Water. New York: The Macmillan Co., 1928, 194 p.

Herrington, Wm. C.
1948. Imported fish: a major New England problem. Commercial Fisheries Review, Vol. 8, No. 2, Feb. 1946. Sep. No. 125, p. 1-16.

International Board of Inquiry for the Great Lakes.
1943. (Hubert R. Gallagher, Ch'm., A. G. Huntsman, Sec'y., D. J. Taylor and John Van Oosten.) Report and Supplement 213 p. Government Printing Office. Washington.

Johnson, Robert E., and Robert M. Kark.
1947. Environment and food intake in man. Science, Vol. 105, p. 378-379.

Jordan, David Starr, Barton Warren Evermann and Howard Walton Clark.
1930. Check list of the fishes and fishlike vertebrates of North and Middle America, etc. Rept. U. S. Comm'r. Fish. for 1928 (1930), Pt. II. App. X, 670 p. (Doc. 1055, 1930).

Larsen, Spencer A., William Reitz, and Katherine K. Burgum.
1948. Markets for Airborne Seafoods. Detroit: Wayne University Press, 1948, 148 p., 24 tables.

Lindeman, Raymond L.
1942. The trophic-dynamic aspect of ecology. Ecology, Vol. 23, 1942, p. 399-418, bibliog.

Manning, John Ruel.
1931. Fish meal in animal feeding, with bibliography. Rept. U. S. Comm'r. Fish. for 1930 (1931). App. XII, p. 371-407. (Doc. 1090, 1930).

McCance, R. A., and H. L. Shipp.
1933. The chemistry of flesh foods and their losses on cooking. Medical Research Council (Great Britain). Special Rept. Series No. 187, 146 p., extensive bibliog. London: H. M. Stat'y Off.

Maynard, L. A.
1946. Role and efficiency of animals in utilizing feed to produce human food. Jour. of Nutrition, Vol. 32, 1946, p. 345-360, selected bibliog.

North Carolina.
1942. The Department of Tax Research. Report, 371 p. Raleigh.
1946. State Planning Board. North Carolina Basic County Data, 2 vols. Raleigh.

Peck, James I.
1894. On the food of the menhaden. Bull. U. S. Fish Comm., Vol. XIII, 1893 (1894), p. 113-126, 8 plates.
1896. The sources of marine food. Bull. U. S. Fish Comm., Vol. XV, 1895 (1896), p. 351-368, 4 plates.

Ricker, William E.
1946. Production and utilization of fish populations. Ecological Monographs. Vol. 16, 1946, p. 373-391, bibliog.

Riley, Gordon A.
1941. Plankton studies III; Long Island Sound. Bull. Bing. Oceanog. Coll., Vol. VII, 1941, p. 1-93, bibliog. New Haven.
1944. The carbon metabolism and photosynthetic efficiency of the earth as whole (with introduction by G. Evelyn Hutchinson). American Scientist. Vol. 32, 1944, No. 2, p. 129-134.

Seiwell, H. R.
1935. The annual organic production and nutrient phosphorus requirement in the tropical western North Atlantic. Cons. Perm. Int. pour l'Expl. de la Mer, Jour. du Cons., Vol. X, 1935, p. 20-32, bibliog. Copenhagen.

Sherr, Harry, Edward A. Power, Richard A. Kahn, and others.
1948. Supply and distribution of fishery products in the continental United States, 1930-1947. U. S. Dept. Ag., Bur. Ag. Econ., The National Food Situation, NFS-45, July-Sept., 1948, p. 19-40.

Sherman, Henry C. (Chief), et al. (Staffs of Human Nutrition & Home Economics and U. S. Bureau of Labor Statistics).

1944. Family food consumption in the United States, spring, 1942. U. S. Dept. Ag. Misc. Pub. 550, 155 p.

Standard & Poor's. Trade and Securities Statistics.

1942. Basic statistics, Sections 1-9 through 1941, and Monthly Supplements (Historical and Current Series, Financial, Industrial, Commercial of United States, Canada, England, etc.). New York.

Statistical Abstract of the United States.

1944–45. U. S. Department of Commerce, Bur. Census, 1944-45, 1023 p. (and annually).

Supreme Commander for the Allied Powers, (General Headquarters).

1947. Japanese Fisheries Production, 1908-46 (A Statistical Report), Natural Resources Section, Rept. No. 95, 1947, 40 p. Tokyo.

Taylor, Harden F.

1932. Resources of the Ocean. Journal of the Franklin Institute. Vol. 214, 1932, p. 167-196. Philadelphia.

U. S. Bureau of Fisheries. (Papers by several authors: E. D. Clark, R. W. Clough, Donald K. Tressler, Arthur D. Holmes, Harden F. Taylor, and E. V. McCollum).

1926. Nutritive value of fish and shellfish. Rept. U. S. Comm'r. Fish. for 1925 (1926), App. X, p. 501-522, extensive bibliog.

U. S. Department of Agriculture. (numerous authors).

1939. Food and Life. Year Book of Agriculture, 76th Congress, 1st Session, House Document No. 28, 1165 p.

1940. Farmers in a Changing World. Year Book of Agriculture, 76th Congress, 3rd Session, House Document No. 695, 1215 p.

U. S. Bureau of Foreign and Domestic Commerce.

1947. National Income and Product Statistics of the United States, 1929-46. Prepared by National Income Division, Milton Gilbert, Chief. *Supplement to* Survey of Current Business, July, 1947, 54 p., 48 tables.

U. S. Senate.

1940. The Status of Wildlife in the United States. Report of the Special Subcommittee on the Conservation of Wildlife Resources pursuant to S. Res. 246. 76th Congress, 3rd Session, Senate Rept. No. 1203.

APPENDIX TO PART III

STATISTICAL TABLES

(*Table numbers consecutive with those in text.*)

Table number

1-A.

Table 37. Calendar of Regional Statistical Fisheries Canvasses of the United States, 1880-1940. [1/]

Year	1 New England	2 Middle Atlantic	3 Ches.	4 South Atlantic	5 Gulf	6 Lakes	7 Rivers	8 Pacific	Total 8 regions	9 Alaska	Total 9 regions
1880	x	x	x	x	x	x		x	7		7
1881											
1882											
1883											
1884											
1885						x			1		1
1886											
1887	x	x	x	(a)	(a)				3		3
1888	x	x	x	x	x			x	6		6
1889	x	x		x	x	(b)		(c)	4	(c)	4
1890		x	x	x	x	x		(c)	5	(c)	5
1891		x	x					(c)	2	(c)	2
1892								x	1	x	2
1893						x			1		1
1894							x		1		1
1895								x	1		1
1896											
1897		x	x	x	x				4		4
1898	x								1		1
1899						x	x	x	3		3
1900											
1901		x	x						2		2
1902	x			x	x				3		3
1903						x	x		2		2
1904		x	x					x	3		3
1905	x								1	x	2
1906										x	1
1907										x	1
1908	x	x	x	x	x	x	x	x	8	x	9
1909											
1910										x	1
Sub-total	8	10	9	7	7	7	4	7	59	6	65

Year	1 New England	2 Middle Atlantic	3 Ches.	4 South Atlantic	5 Gulf	6 Lakes	7 Rivers	8 Pacific	Total 8 regions	9 Alaska	Total 9 regions
1911											
1912											
1913											
1914											
1915								x	1		1
1916											
1917						x			1		1
1918				x	x				2		2
1919	x								1		1
1920			x						1		1
1921		x							1		1
1922						x	x	x	3		3
1923				x	x			x	3		3
1924	x							x	2		2
1925			x					x	2	x	3
1926		x						x	2		2
1927				x	x	x		x	4		4
1928	x			x	x	x		x	5		5
1929	x	x	x	x	x	x		x	7	x	8
1930	x	x	x	x	x	x		x	7	x	8
1931	x	x	x	x	x	x	x	x	8	x	9
1932	x	x	x	x	x	x		x	7	x	8
1933	x	x	x			x		x	5	x	6
1934			x	x	x	x		x	5	x	6
1935	x	x	x			x		x	5	x	6
1936		•	x	x	x	x		x	5		5
1937	x	x	x	x	x	x		x	7	x	8
1938	x	x	x	x	x	x		x	7	x	8
1939	x	x	x	x	x	x		x	7	x	8
1940	x	x	x	x	x	x		x	7	x	8
Sub-total	21	22	25	21	21	23	6	27	164	18	182

1/ Regions: 1. New England: Maine to Conn., incl.; 2. Middle Atlantic: N.Y., Penna. (both excl. of Great Lakes), N. J., Del.; 3. Chesapeake: Md., Va.; 4. South Atlantic: N.C., S.C., Ga., Fla. east coast (incl. Lake Okeechobee, 1927-40); 5. Gulf: West coast of Fla., Ala., Miss., La., Tex.; 6. Great Lakes System, U.S., excl. of Canadian, incl. of Lake Manakan, Lake of Woods & Rainy Lake, 1927-40; 7. Mississippi River drainage system; 8. Pacific: Wash., Ore., Calif.; 9. Alaska. (a) N.C., S.C. & Ga. canvassed; Fla. not canvassed. (b) Great Lakes canvassed by U. S. Bureau of Census. (c) Retrospectively canvassed in 1892-93.

Table 38. Recapitulation: United States Fisheries, All Fishery Products, Food and non-Food, Quantities, Values, Prices, Number of Fishermen, and Quantities and Values per Fisherman, 1887-1940. Partly interpolated.
(For definition of relative values and prices, see Table 20.)

A. Atlantic and Gulf of Mexico Regions.

	Quantity pounds '000	Actual value dollars '000	Actual price cents	1926 relative value dollars '000	Relative price cents	Fishermen number	Per Fisherman		
							Pounds	Actual dollars	Relative dollars
1887	1,090,334	27,105	2.49	48,400	4.44	91,733	11,900	295	528
1888	1,218,437	28,202	2.32	49,430	4.06	94,097	12,950	300	526
1889	1,307,346	29,672	2.27	52,000	3.98	110,459	11,830	268	471
1890	1,367,476	32,423	2.37	57,500	4.21	118,233	11,578	274	486
1891	1,301,396	32,991	2.54	59,150	4.55	118,862	10,980	280	502
1892	1,274,273	32,137	2.52	61,600	4.76	119,305	10,700	270	518
1893	1,247,152	31,283	2.51	58,550	4.69	119,748	10,450	262	490
1894	1,220,031	30,427	2.47	63,550	5.16	120,193	10,520	252	528
1895	1,192,310	29,575	2.48	60,600	5.08	120,636	9,850	248	501
1896	1,165,788	28,721	2.46	61,737	5.28	121,079	9,625	237	510
1897	1,138,657	27,867	2.45	59,780	5.24	121,523	9,350	229	492
1898	1,172,284	28,802	2.46	59,360	5.06	121,333	9,650	237	490
1899	1,267,440	30,356	2.40	58,160	4.59	122,122	10,430	248	476
1900	1,362,594	31,909	2.34	56,875	4.18	122,909	11,100	260	463
1901	1,457,747	33,463	2.29	60,500	4.15	123,697	11,800	271	490
1902	1,504,395	34,879	2.32	59,200	3.94	122,192	12,300	285	484
1903	1,494,703	35,984	2.40	60,400	4.04	119,723	12,500	301	508
1904	1,485,011	37,090	2.50	62,140	4.18	117,253	12,660	316	531
1905	1,430,591	37,041	2.59	61,620	4.31	115,354	12,400	322	535
1906	1,414,283	37,243	2.63	60,255	4.26	112,629	12,550	331	536
1907	1,397,974	37,446	2.68	57,399	4.10	109,908	12,560	341	522
1908	1,381,665	37,648	2.72	59,850	4.33	107,735	12,960	352	560
1915	1,614,980	47,977	2.97	69,000	4.27	85,537	18,950	561	809
1917	1,681,642	50,928	3.03	43,700	2.60	79,197	21,300	641	552

Table 38 (contd). Recapitulation: United States Fisheries, All Fishery Products, Food and non-Food, etc.

A. Atlantic and Gulf of Mexico Regions.

	Quantity pounds '000	Actual value dollars '000	Actual price cents	1926 relative value dollars '000	Relative price cents	Fishermen number	Per Fisherman Pounds	Per Fisherman Actual dollars	Per Fisherman Relative dollars
1918	1,714,974	52,402	3.07	39,900	2.33	76,026	22,600	695	526
1919	1,713,130	53,835	3.14	38,850	2.27	74,434	23,000	721	521
1920	1,704,058	54,574	3.20	35,340	2.07	72,801	23,400	750	485
1921	1,646,304	55,103	3.35	56,450	3.43	72,102	22,800	765	781
1922	1,544,976	55,362	3.58	57,210	3.70	71,718	21,600	775	800
1923	1,443,747	55,623	3.85	55,300	3.83	71,326	20,600	778	775
1924	1,374,478	56,288	4.10	57,400	4.18	72,173	19,000	780	785
1925	1,365,630	58,869	4.31	56,870	4.17	73,897	18,600	797	770
1926	1,383,058	60,652	4.10	60,652	4.10	74,161	18,610	818	818
1927	1,438,117	62,638	4.55	65,700	4.57	74,669	19,250	839	880
1928	1,469,578	64,161	4.36	66,350	4.51	75,259	19,500	852	880
1929	1,633,077	65,944	4.04	69,190	4.23	72,764	22,400	907	954
1930	1,601,279	58,754	3.67	63,000	4.25	70,663	22,700	803	962
1931	1,260,952	42,087	3.34	57,650	4.57	71,903	17,580	588	801
1932	1,280,666	30,988	2.42	47,800	3.73	67,348	19,100	460	723
1933	1,315,985	31,569	2.40	47,900	3.63	69,018	19,000	457	692
1934	1,539,068	37,277	2.42	49,800	3.24	72,347	21,300	515	689
1935	1,703,149	41,693	2.45	52,120	3.06	74,137	23,000	562	702
1936	1,806,280	46,146	2.54	57,150	3.15	74,995	24,100	615	760
1937	1,774,512	48,421	2.73	56,150	3.17	74,117	23,900	651	758
1938	1,764,830	46,241	2.62	58,840	3.33	72,632	24,300	638	811
1939	1,895,488	47,998	2.53	62,260	3.28	71,306	26,600	670	874
1940	1,877,876	50,249	2.68	64,250	3.42	68,403	27,400	735	940
1945	2,390,154	164,507	6.88	155,500	6.50	78,604	30,420	2,094	1,980

Table 39. Recapitulation: United States Fisheries, All Fishery Products, Food and non-Food, Quantities, Values and Prices, Number of Fishermen, and Quantities and Values per Fisherman, 1887-1940. Partly interpolated. (For definition of relative values and prices, Table 20.)

B. United States: Atlantic, Gulf, Great Lakes and Pacific; (not including Mississippi River System and Alaska.)

	Quantity pounds '000	Actual Value dollars '000	Actual Price cents	1926 Relative value dollars '000	Rel. price cents	Fishermen number	Per Fisherman Pounds	Per Fisherman Actual dollars	Per Fisherman Rel. dollars	Regions canvassed 1/
1887	1,281,798	33,508	2.62	59,640	4.67	110,399	11,610	304	542	1,2,3,4,5
1888	1,415,756	34,772	2.46	61,000	4.32	113,005	12,500	308	540	1,2,3,4,5,8
1889	1,510,734	36,402	2.41	63,880	4.23	129,268	11,680	281	494	1,2,4,5
1890	1,578,934	39,313	2.49	70,000	4.43	136,943	11,540	287	512	2,3,4,5,6
1891	1,512,353	40,018	2.65	71,760	4.74	137,877	10,970	290	520	2,3
1892	1,484,728	39,302	2.64	75,310	5.07	138,625	10,720	284	544	8
1893	1,461,121	38,263	2.62	71,650	4.90	140,045	10,440	273	512	6
1894	1,446,123	37,346	2.58	77,960	5.39	141,170	10,250	264	552	0
1895	1,431,126	36,432	2.55	74,650	5.22	142,292	10,060	256	524	8
1896	1,424,624	36,086	2.53	77,577	5.44	142,499	10,000	253	544	0
1897	1,418,094	35,740	2.52	76,700	5.41	142,708	9,940	250	537	2,3,4,5
1898	1,472,317	37,183	2.52	76,660	5.21	142,284	10,350	261	538	1
1899	1,588,078	39,245	2.47	75,200	4.73	142,838	11,130	276	525	6,8
1900	1,673,090	40,912	2.45	72,920	4.36	143,727	11,640	285	508	0
1901	1,758,101	42,581	2.42	77,000	4.38	144,618	12,150	294	532	2,3
1902	1,794,606	44,111	2.46	74,900	4.17	143,215	12,530	308	523	1,4,5
1903	1,774,772	45,330	2.55	76,050	4.29	140,849	12,600	322	540	6
1904	1,765,864	46,721	2.65	78,250	4.43	138,725	12,740	337	564	2,3,8
1905	1,716,097	46,917	2.73	78,100	4.55	136,938	12,550	343	570	1
1906	1,704,444	47,362	2.78	76,630	4.50	134,324	12,690	353	571	0
1907	1,692,788	47,809	2.82	73,400	4.34	131,713	12,710	363	557	0
1908	1,681,132	48,255	2.87	76,750	4.56	129,654	12,970	372	592	All
1915	2,024,521	63,016	3.11	90,700	4.48	111,338	18,200	567	813	8
1917	2,085,681	67,580	3.24	57,500	2.76	103,203	20,200	654	557	6

Table 39 (contd). Recapitulation: United States Fisheries, All Fishery Products, Food and non-Food, etc.

B. United States: Atlantic, Gulf, Great Lakes and Pacific; (not including Mississippi River System and Alaska).

	Quantity pounds '000	Actual value dollars '000	Actual price cents	1926 relative value dollars '000	Rel. price cents	Fishermen number	Per Fisherman Pounds	Per Fisherman Actual dollars	Per Fisherman Rel. dollars	Regions Canvassed 1/
1918	2,117,393	69,658	3.29	53,050	2.46	98,681	21,450	706	528	4,5
1919	2,113,929	71,695	3.39	51,700	2.44	96,668	21,860	742	534	1
1920	2,103,237	73,039	3.46	47,310	2.24	94,164	22,330	762	502	3
1921	2,043,862	74,173	3.63	76,000	3.72	92,583	22,100	801	822	2
1922	1,940,914	75,036	3.87	77,600	4.00	91,258	21,250	822	850	6,8
1923	1,962,739	81,376	4.14	80,900	4.12	91,639	21,400	855	852	4,5,8
1924	1,959,936	83,072	4.24	84,720	4.32	93,542	19,950	888	906	1,8
1925	2,084,944	90,202	4.32	87,580	4.19	96,701	21,570	933	904	3,8
1926	2,007,490	86,341	4.30	86,341	4.30	98,645	20,350	875	875	2,8
1927	2,181,957	91,740	4.20	96,100	4.40	101,008	21,610	908	952	4,5,6,8
1928	2,238,059	90,635	4.05	93,750	4.18	100,430	22,300	903	934	1,4,5,6,8
1929	2,752,900	97,770	3.55	102,550	3.72	99,915	27,550	978	1,027	All
1930	2,529,616	87,868	3.47	101,700	4.02	97,217	26,000	916	1,046	All
1931	1,949,985	61,628	3.16	84.450	4.33	97,977	19,900	630	863	All
1932	1,924,888	44,761	2.33	69,100	3.59	92,164	20,800	486	750	All
1933	2,250,750	49,607	2.20	75,300	3.34	94,947	23,700	523	793	1,2,3,6,8
1934	3,181,579	62,351	1.96	83,210	2.62	99,158	32,100	629	840	3,4,5,6,8
1935	3,469,572	70,726	2.04	88,400	2.55	101,321	34,330	694	872	1,2,3,6,8
1936	3,825,899	77,417	2.02	95,840	2.51	101,238	37,800	766	947	3,4,5,6,8
1937	3,435,347	83,231	2.43	96,450	2.81	102,086	33,650	816	944	All
1938	3,372,240	78,410	2.32	99,800	2.96	103,293	32,670	759	966	All
1939	3,694,549	82,177	2.22	106,500	2.88	103,698	35,610	788	1,026	All
1940	3,413,453	85,471	2.50	108,700	3.19	98,728	34,600	866	1,102	All
1945	3,897,074	241,001	6.18	227,900	5.84	117,774	33,080	2,047	1,934	All

1/ See Table 37.

Table 40. Recapitulation: United States Fisheries: Food Fish Only, Quantities, Values and Prices, Actual and Relative, 1887-1940. Partly interpolated.

Year	A. Atlantic and Gulf of Mexico Regions					B. United States: Atlantic, Gulf of Mexico, Great Lakes and Pacific (Mississippi River System and Alaska excluded)				
	Quantity pounds '000	Actual Value dollars '000	Actual price cents	1926 Relative Value dollars '000	Relative price cents	Quantity pounds '000	Actual Value dollars '000	Actual Price cents	1926 Relative Value dollars '000	Relative price cents
1887	682,396	25,044	3.68	44,800	6.58	865,236	31,199	3.61	55,700	6.46
1888	700,058	26,221	3.76	46,100	6.59	892,653	32,638	3.67	57,200	6.44
1889	703,247	27,243	3.88	47,800	6.80	904,126	33,514	3.71	58,800	6.50
1890	745,525	29,965	4.02	53,300	7.15	954,687	36,091	3.78	64,200	6.73
1891	743,002	30,732	4.14	55,050	7.41	951,878	36,689	3.85	65,760	6.91
1892	749,644	30,031	4.01	57,600	7.69	958,233	35,819	3.74	68,600	7.16
1893	756,284	29,338	3.88	54,950	7.27	968,748	35,223	3.64	65,980	6.82
1894	763,007	28,648	3.75	59,800	7.84	987,955	34,753	3.52	72,560	7.34
1895	769,566	27,967	3.63	57,200	7.44	1,006,999	34,292	3.40	70,250	6.98
1896	776,207	27,263	3.51	58,619	7.56	1,034,182	34,110	3.30	73,339	7.09
1897	782,848	26,571	3.39	57,000	7.28	1,061,366	33,941	3.20	72,850	6.87
1898	792,340	27,422	3.46	56,550	7.14	1,091,400	35,380	3.24	72,950	6.68
1899	833,199	28,817	3.46	55,220	6.63	1,152,801	37,275	3.23	71,400	6.20
1900	874,059	30,232	3.46	53,874	6.16	1,183,628	38,765	3.28	69,089	5.84
1901	914,919	31,606	3.46	57,200	6.26	1,214,455	40,258	3.32	72,150	5.94
1902	955,304	32,849	3.44	55,760	5.84	1,244,804	41,620	3.34	70,680	5.68
1903	927,295	33,735	3.64	56,610	6.10	1,206,765	42,625	3.53	71,600	5.85
1904	899,289	34,619	3.85	58,000	6.45	1,179,694	43,796	3.71	73,360	6.22
1905	892,144	34,620	3.88	57,610	6.46	1,177,074	44,116	3.75	73,400	6.24
1906	926,387	34,930	3.77	56,501	6.10	1,214,844	44,745	3.77	72,381	5.96
1907	960,636	35,239	3.67	54,030	5.63	1,253,619	45,373	3.62	69,575	5.55
1908	994,874	35,548	3.58	56,540	5.68	1,293,383	46,000	3.56	73,190	5.66
1915	912,094	43,151	4.73	62,100	6.82	1,312,236	58,042	4.42	83,600	6.37
1917	887,749	45,321	5.11	38,900	4.38	1,279,502	61,677	4.82	52,450	4.10

Table 40 (contd). Recapitulation: United States Fisheries, Food Fish Only, etc.

Year	A. Atlantic and Gulf of Mexico Regions.					B. United States: Atlantic, Gulf of Mexico, Great Lakes and Pacific (Mississippi River System and Alaska excluded)				
	Quantity pounds '000	Actual value dollars '000	Actual price cents	1926 relative value dollars '000	Relative price cents	Quantity pounds '000	Actual value dollars '000	Actual price cents	1926 relative value dollars '000	Relative price cents
1918	875,846	46,408	5.30	35,350	4.04	1,263,285	63,247	5.00	48,170	3.82
1919	870,988	47,751	5.48	34,450	3.95	1,254,114	65,074	5.19	46,950	3.75
1920	861,924	48,511	5.63	31,420	3.65	1,240,736	66,318	5.34	42,950	3.46
1921	859,891	49,339	5.74	50,580	5.88	1,234,398	67,629	5.48	69,320	5.62
1922	864,076	50,208	5.81	51,950	6.01	1,234,261	68,982	5.59	71,300	5.78
1923	868,259	51,077	5.88	50,800	5.85	1,345,559	75,995	5.64	75,550	5.61
1924	882,572	52,223	5.92	53,250	6.03	1,378,750	77,820	5.64	79,400	5.76
1925	955,839	55,188	5.77	53,300	5.59	1,560,237	85,544	5.48	82,600	5.29
1926	1,025,066	57,366	5.59	57,366	5.59	1,609,607	82,683	5.14	82,683	5.14
1927	1,093,707	59,476	5.44	62,400	5.70	1,797,906	88,066	4.90	92,360	5.14
1928	1,154,475	61,363	5.32	63,440	5.50	1,830,804	86,872	4.74	89,800	4.90
1929	1,238,727	62,764	5.06	65,800	5.31	2,153,496	92,814	4.31	97,400	4.52
1930	1,231,346	55,735	4.53	64,500	5.24	2,013,603	83,851	4.16	97,080	4.82
1931	1,029,743	40,493	3.93	55,450	5.38	1,622,689	59,626	3.68	81,720	5.04
1932	951,845	29,409	3.09	45,400	4.77	1,395,564	42,619	3.05	65,790	4.71
1933	990,550	29,705	3.00	45,080	4.55	1,594,005	46,677	2.93	70,810	4.44
1934	1,096,913	34,816	3.18	46,500	4.24	1,832,533	56,426	3.08	75,380	4.11
1935	1,197,767	38,970	3.25	48,700	4.06	2,080,066	64,591	3.10	80,700	3.88
1936	1,237,481	42,482	3.43	52,580	4.25	2,064,663	68,020	3.29	84,200	4.08
1937	1,290,766	45,271	3.51	52,450	4.07	2,147,812	75,217	3.50	87,200	4.06
1938	1,278,103	43,600	3.41	55,500	4.34	2,046,313	70,994	3.47	90,300	4.41
1939	1,318,742	44,528	3.39	57,920	4.39	2,247,628	73,865	3.61	95,750	4.68
1940	1,237,618	46,928	3.79	59,740	4.82	2,211,742	79,409	3.59	101,100	4.57
1945	1,576,459	155,692	9.88	147,200	9.34	2,680,786	223,184	8.31	210,300	7.84

Table 41. United States Fisheries, All Fishery Products, Food and non-Food: Quantities and Values, by Regions, as canvassed, 1887-1940: Relative Values and Actual and Relative Prices Calculated. (Relative values and prices in money of constant purchasing power in terms of All-Commodity Wholesale Price Index, 1926 = 100, U. S. Bureau of Labor Statistics.)

1. New England.

	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents	Fishermen number	Per Fisherman: Pounds	Per Fisherman: Actual dollars	Per Fisherman: 1926 relative dollars
1887	575,918	11,138	1.93	19,900	3.46	27,051	20,300	412	700
1888	625,303	11,089	1.77	19,450	3.12	26,639	23,500	414	729
1889	653,607	10,551	1.62	18,500	2.83	27,417	23,900	385	678
1898	394,090	9,682	2.46	19,960	5.06	22,367	17,630	434	896
1902	524,896	11,767	2.24	19,980	3.81	24,031	21,800	488	830
1905	461,483	12,510	2.71	20,800	4.51	24,204	19,050	518	860
1908	512,407	14,004	2.71	22,250	4.34	21,910	23,400	640	1,030
1919	460,291	19,237	4.18	13,880	3.01	17,314	26,550	1,118	804
1924	402,998	18,161	4.51	18,520	4.60	15,007	26,830	1,208	1,232
1928	598,842	24,962	4.18	25,800	4.32	16,659	36,000	1,496	1,545
1929	688,893	28,293	4.11	29,680	4.31	17,160	40,000	1,648	1,732
1930	695,304	26,644	3.84	30,850	4.44	17,077	41,700	1,560	1,800
1931	534,680	19,490	3.65	26,700	5.00	17,888	29,900	1,092	1,497
1932	480,521	14,001	2.92	21,600	4.50	16,472	29,180	850	1,315
1933	499,936	13,486	2.70	20,470	4.10	17,073	29,250	780	1,196
1935	655,430	17,984	2.74	22,480	3.43	18,449	35,500	970	1,218
1937	670,864	19,937	2.97	23,100	3.44	19,624	34,200	1,015	1,179
1938	631,520	18,275	2.90	23,270	3.69	20,248	31,200	902	1,145
1939	663,866	19,509	2.94	25,300	3.81	18,712	35,500	1,041	1,350
1940	626,054	20,496	3.28	26,090	4.17	18,546	33,700	1,100	1,410
1945	845,471	56,590	6.70	53,500	6.34	20,386	41,500	2,775	2,625

Table 42. United States Fisheries, All Fishery Products, etc., continued.

2. Middle Atlantic.

	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents	Fishermen number	Per Fisherman: Pounds	Per Fisherman: Actual dollars	Per Fisherman: 1926 relative dollars
1887	216,062	7,986	3.69	14,260	6.60	18,355	11,770	435	777
1888	278,915	8,100	2.90	14,210	5.10	18,949	14,710	427	750
1889	269,295	7,577	2.81	13,280	4.93	22,819	11,800	332	582
1890	293,869	8,300	2.83	14,760	5.03	23,392	12,570	355	632
1891	259,008	8,503	3.28	15,240	5.88	23,749	10,900	358	638
1897	217,786	7,186	3.30	15,420	7.08	22,290	9,770	322	692
1901	336,772	8,249	2.46	14,910	4.43	23,159	14,540	356	640
1904	367,919	9,223	2.51	15,450	4.20	19,104	19,250	483	809
1908	204,921	7,316	3.57	11,650	5.69	14,998	13,660	481	777
1921	322,538	10,885	3.37	11,160	3.46	10,276	31,350	1,059	1,095
1926	153,428	10,919	7.12	10,919	7.12	9,953	15,420	1,098	1,098
1929	164,858	11,553	7.00	12,110	7.34	10,491	15,720	1,102	1,155
1930	180,058	9,990	5.55	11,560	6.42	10,605	17,000	942	1,090
1931	151,341	7,320	4.84	10,030	6.63	9,604	15,750	762	1,045
1932	141,221	4,654	3.30	7,185	5.08	8,370	16,860	556	859
1933	169,755	4,811	2.83	7,305	4.30	8,574	19,800	562	852
1935	279,438	6,416	2.30	8,020	2.87	9,620	29,050	667	834
1937	264,652	7,896	2.98	9,145	3.46	7,720	34,300	1,023	1,185
1938	216,858	8,249	3.81	10,520	4.86	7,549	28,700	1,093	1,393
1939	280,052	7,387	2.64	9,580	3.42	7,740	36,200	955	1,238
1940	355,553	7,651	2.15	9,730	2.73	7,737	45,900	989	1,258
1945	494,193	23,224	4.70	21,950	4.44	10,848	45,500	2,140	2,022

Table 43. United States Fisheries, All Fishery Products, etc., continued.

3. <u>Chesapeake</u>

	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents	Fishermen number	Per Fisherman: Pounds	Per Fisherman: Actual dollars	Per Fisherman: 1926 relative dollars
1887	202,838	5,121	2.53	9,130	4.50	30,683	6,620	167	298
1888	219,054	5,996	2.73	10,520	4.80	32,116	6,830	187	328
1890	324,824	9,656	2.97	17,170	5.29	46,056	7,070	210	373
1891	320,819	10,104	3.16	18,100	5.64	46,389	6,920	218	390
1897	362,593	6,797	1.88	14,580	4.02	50,878	7,120	133	286
1901	445,120	8,079	1.81	14,600	3.28	47,764	9,320	169	306
1904	419,583	8,453	2.01	14,150	3.37	43,257	9,690	195	327
1908	411,145	7,540	1.83	11,990	2.92	38,221	10,750	197	314
1920	523,489	12,559	2.40	8,140	1.56	25,413	20,600	494	320
1925	321,323	13,586	4.23	13,130	4.08	24,793	12,960	549	530
1929	264,698	11,214	4.23	11,760	4.44	18,470	14,330	607	637
1930	308,158	11,055	3.59	12,800	4.15	19,391	15,900	570	660
1931	285,622	7,195	2.52	9,860	3.45	20,689	13,800	348	477
1932	359,007	5,905	1.64	9,120	2.54	20,946	17,130	282	435
1933	272,380	5,061	1.86	7,681	2.78	20,142	13,530	251	381
1934	289,011	5,943	2.06	7,940	2.75	20,591	14,040	289	386
1935	265,827	5,525	2.08	6,910	2.60	19,116	13,900	289	361
1936	314,095	6,488	2.06	8,033	2.55	18,283	17,180	355	439
1937	292,245	6,361	2.18	7,378	2.52	16,529	17,700	385	446
1938	294,594	6,663	2.26	8,480	2.88	15,297	19,250	436	554
1939	323,653	7,197	2.22	9,330	2.88	14,718	21,980	489	634
1940	320,756	7,457	2.32	9,482	2.96	14,269	22,460	523	665
1945	304,463	30,363	9.98	28,700	9.42	17,673	17,250	1,718	1,625

Table 44. United States Fisheries, All Fishery Products, etc., continued.

4. South Atlantic 1/

	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel price cents	Fishermen number	Per Fisherman Pounds	Per Fisherman Actual dollars	Per Fisherman 1926 relative dollars
1887 2/	56,447	1,183	2.09	2,111	3.74	8,655	6,520	137	244
1888	54,347	1,197	2.20	2,100	3.86	9,060	6,000	132	232
1889	57,023	1,455	2.55	2,552	4.48	12,054	4,730	121	212
1890	65,208	1,574	2.41	2,800	4.29	12,454	5,240	126	225
1897	77,782	1,833	2.36	3,932	5.06	14,247	5,460	129	276
1902	100,597	2,840	2.82	4,820	4.79	17,278	5,820	164	279
1908	157,814	4,021	2.55	6,396	4.05	17,663	8,940	228	362
1918	330,950	5,349	1.62	4,075	1.23	10,568	31,300	506	385
1923	225,714	5,087	2.25	5,059	2.24	10,094	22,350	504	502
1927	261,678	5,880	2.25	6,165	2.36	11,527	22,700	510	533
1928	258,934	6,190	2.39	6,404	2.47	11,882	21,780	521	539
1929	337,733	5,933	1.76	6,225	1.84	11,978	28,170	495	520
1930	275,807	4,270	1.55	4,942	1.76	10,416	26,480	410	475
1931	150,393	3,067	2.04	4,200	2.79	11,319	13,290	271	371
1932	154,304	2;384	1.55	3,680	2.38	10,799	14,280	221	341
1934	261,080	3,624	1.41	4,840	1.89	10,585	24,680	343	457
1936	369,984	5,507	1.48	6,820	1.84	13,272	27,900	415	514
1937	315,774	4,051	1.28	4,697	1.49	12,463	25,300	325	377
1938	414,307	4,317	1.04	5,492	1.32	12,522	33,100	345	439
1939	388,102	4,035	1.04	5,235	1.36	12,585	30,750	321	416
1940	325,515	4,064	1.25	5,096	1.57	12,439	26,680	327	410
1945	395,531	13,210	3.34	12,930	3.27	12,803	30,900	1,032	1,010

1/ Includes Lake Okeechobee, 1927-1940 inclusive.

2/ Florida east coast extrapolated from 1888, other South Atlantic States canvassed.

Table 45. United States Fisheries, All Fishery Products, etc., continued.

5. Gulf of Mexico

	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents	Fisherman number	Per Fisherman: Pounds	Per Fisherman: Actual dollars	Per Fisherman: 1926 relative dollars
1887 1/	39,069	1,677	4.30	2,993	7.67	6,989	5,590	240	428
1888	40,818	1,820	4.46	3,191	7.82	7,335	5,570	248	435
1889	55,482	2,263	4.08	3,972	7.16	9,083	6,110	249	437
1890	58,803	2,439	4.15	4,340	7.38	9,475	6,210	267	458
1897	57,576	2,272	3.95	4,875	8.47	11,180	5,150	203	436
1902	95,140	3,494	3.67	5,930	6.24	12,814	7,420	273	463
1908	95,378	4,767	5.00	7,580	7.95	14,943	6,385	319	504
1918	118,834	6,509	5.48	4,958	4.17	8,812	13,480	739	563
1923	146,493	8,086	5.52	8,040	5.48	10,576	13,840	764	760
1927	176,310	9,966	5.66	10,450	5.93	15,133	11,650	659	691
1928	171,900	9,860	5.74	10,200	5.94	16,356	10,510	603	624
1929	176,895	8,951	5.06	9,390	5.31	14,665	12,060	611	641
1930	141,952	6,795	4.78	7,865	5.54	13,174	10,790	516	598
1931	138,916	5,015	3.61	6,868	4.95	12,403	11,200	405	554
1932	145,613	4,044	2.78	6,243	4.29	10,761	13,540	376	580
1934	186,834	6,370	3.41	8,503	4.55	14,313	13,050	445	594
1936	187,009	8,035	4.30	9,942	5.32	15,734	11,900	511	632
1937	230,997	10,176	4.40	11,800	5.11	17,781	12,990	572	664
1938	207,551	8,737	4.21	11,110	5.36	17,066	12,160	512	651
1939	239,815	9,870	4.12	12,800	5.34	17,551	13,660	562	730
1940	250,018	10,581	4.23	13,460	5.38	15,502	16,130	682	869
1945	350,496	41,120	11.72	38,850	11.08	16,894	20,750	2,435	2,300

1/ Florida west coast and Alabama extrapolated from 1888, other Gulf States canvassed.

Table 46. United States Fisheries, All Fishery Products, etc.. continued.

6. Great Lakes

	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents	Fishermen number	Per Fisherman Pounds	Per Fisherman Actual dollars	Per Fisherman 1926 relative dollars
1885	99,842	2,692	2.70	4,725	4.73	9,116	10,960	295	518
1889 1/	117,086	2,616	2.23	4,588	3.92	6,598	17,750	397	696
1890	113,899	2,472	2.17	4,400	3.86	7,991	14,250	309	551
1893	96,620	2,271	2.35	4,450	4.61	8,528	11,330	266	522
1899	113,727	2,611	2.30	5,002	4.40	7,813	14,550	334	641
1903	86,195	2,746	3.18	4,606	5.34	7,595	11,350	361	606
1908	106,632	3,767	3.54	5,990	5.62	8,539	12,500	441	702
1917	104,269	6,295	6.04	5,355	5.14	7,006	14,880	898	764
1922	108,732	6,690	6.16	6,920	6.37	6,134	17,720	1,091	1,130
1927	87,326	6,795	8.36	7,120	8.64	5,825	13,950	1,166	1,222
1928	63,368	5,961	9.39	6,960	11.00	5,438	11,650	1,097	1,280
1929	85,389	6,788	7.96	7,120	8.34	7,159	11,930	948	995
1930	94,948	6,050	6.37	7,000	7.38	6,980	13,600	867	1,003
1931	91,727	6,029	6.58	8,260	9.01	6,839	13,410	882	1,210
1932	83,744	4,389	5.24	6,775	8.09	6,932	12,070	634	978
1933	74,604	4,050	5.43	6,150	8.24	7,256	10,290	558	848
1934	96,411	5,124	5.32	6,845	7.10	7,579	12,700	676	904
1935	90,223	5,945	6.59	7,440	8.25	6,601	13,660	901	1,127
1936	94,276	6,389	6.78	7,910	8.39	5,623	16,760	1,136	1,407
1937	83,958	6,033	7.18	7,000	8.34	6,414	13,090	940	1,091
1938	81,[illegible]	6,083	7.47	7,740	9.50	6,976	11,680	873	1,110
1939	85,2[illegible]	6,762	7.94	8,770	10.29	7,390	11,540	916	1,186
1940	79,296	5,623	7.10	7,160	9.03	5,142	15,420	1,094	1,392
1945	78,642	13,800	17.56	13,040	16.60	5,142	15,280	2,682	2,535

1/ U. S. Census Canvass; not used in this study.

Table 47. United States Fisheries, All Fishery Products, etc., continued.

8. Pacific

	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents	Fishermen number	Per Fisherman Pounds	Per Fisherman Actual dollars	Per Fisherman 1926 relative dollars
1888	87,043	4,010	4.55	7,038	8.08	10,467	8,320	383	672
1892	108,076	4,827	4.46	9,248	8.46	10,971	9,860	440	844
1895	135,894	4,473	3.29	9,170	6.75	13,366	10,160	335	686
1899	206,911	6,278	3.03	12,020	5.81	12,903	16,040	487	932
1904	190,615	6,681	3.51	11,190	5.87	13,688	13,930	488	818
1908	193,056	6,839	3.54	10,870	5.63	13,380	14,310	511	812
1915	304,796	9,306	3.05	13,390	4.49	18,464	16,510	504	726
1922	287,206	12,984	4.53	13,440	4.68	13,406	21,400	968	1,002
1923	415,741	19,042	4.58	18,920	4.55	14,241	29,200	1,337	1,330
1924	487,688	20,052	4.11	20,440	4.19	15,359	31,750	1,305	1,332
1925	627,025	24,580	3.92	23,740	3.79	16,856	37,180	1,458	1,408
1926	537,624	18,915	3.53	18,915	3.53	18,597	28,900	1,018	1,018
1927	662,513	22,307	3.37	23,390	3.53	20,514	32,300	1,088	1,140
1928	705,112	20,513	2.91	21,210	3.01	19,733	35,700	1,040	1,075
1929	1,034,434	25,038	2.42	26,280	2.54	19,992	51,750	1,254	1,315
1930	833,389	23,064	2.77	26,680	3.20	19,574	42,570	1,177	1,363
1931	597,307	13,512	2.26	18,500	3.10	19,235	31,040	703	962
1932	560,478	9,384	1.67	14,490	2.57	17,882	31,350	525	810
1933	860,161	13,988	1.63	21,220	2.47	18,673	46,100	749	1,137
1934	1,546,100	19,950	1.29	26,620	1.72	19,232	80,410	1,037	1,385
1935	1,676,200	23,088	1.68	28,840	1.72	20,583	81,500	1,122	1,400
1936	1,925,342	24,882	1.28	30,780	1.60	20,620	93,400	1,206	1,492
1937	1,576,877	28,777	1.51	33,350	2.11	21,555	73,200	1,335	1,547
1938	1,525,885	26,086	1.71	33,190	2.50	23,635	64,600	1,103	1,404
1939	1,713,826	27,417	1.76	35,580	2.28	25,002	68,600	1,097	1,423
1940	1,456,281	29,598	2.03	37,660	2.59	25,183	57,800	1,466	1,866
1945	1,428,278	62,694	4.38	59,300	4.15	34,028	42,000	1,842	1,742

Table 48. United States Fisheries, Food Fish only, Quantities and Values, by Regions, as Canvassed, 1887-1940; Relative Values, and Actual and Relative Prices Calculated.

1. New England.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1887	356,274	9,732	2.75	17,380	4.92
1888	357,292	9,899	2.79	17,880	4.89
1889	321,195	9,109	2.80	15,980	4.98
1898	358,356	9,364	2.61	19,310	5.39
1902	500,345	11,287	2.25	19,150	3.82
1905	424,255	11,911	2.81	19,820	4.67
1908	472,333	13,460	2.85	21,400	4.53
1919	430,081	18,628	4.33	13,440	3.12
1924	389,844	18,084	4.66	18,410	4.72
1928	593,486	24,884	4.19	25,710	4.34
1929	688,215	28,271	4.11	29,650	4.31
1930	695,519	26,621	3.84	30,820	4.45
1931	534,478	19,399	3.63	26,580	4.97
1932	480,289	13,929	2.90	21,490	4.47
1933	497,538	13,366	2.69	20,290	4.08
1935	650,285	17,899	2.75	22,380	3.44
1937	669,665	19,820	2.96	22,970	3.43
1938	630,496	18,164	2.88	23,110	3.67
1939	662,991	19,321	2.91	25,070	3.78
1940	624,674	20,288	3.24	25,800	4.13
1945	814,151	56,420	6.93	53,350	6.56

2. Middle Atlantic.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1887	127,934	7,776	6.08	13,880	10.85
1888	127,171	7,750	6.10	13,600	10.70
1889	116,597	7,200	6.17	12,640	10.84
1890	119,453	7,881	6.60	14,020	11.75
1891	116,645	8,134	6.97	14,390	12.33
1897	121,318	6,964	5.74	14,950	12.32
1901	119,892	7,701	6.42	13,920	11.60
1904	105,774	8,406	7.95	14,080	13.21
1908	119,901	7,073	5.90	11,250	9.38
1921	92,843	9,577	10.31	9,808	10.56
1926	113,524	10,743	9.46	10,743	9.46
1929	124,178	11,241	9.05	11,790	9.49
1930	127,468	9,498	7.45	10,990	8.62
1931	110,722	7,084	6.40	9,710	8.77
1932	98,078	4,630	4.72	7,144	7.29
1933	90,157	4,558	5.06	6,920	7.68
1935	99,787	5,895	5.91	7,370	7.38
1937	116,074	7,184	6.19	8,325	7.17
1938	129,966	7,955	6.12	10,120	7.99
1939	131,438	6,678	5.08	8,660	6.59
1940	110,172	6,797	6.12	8,641	7.78
1945	124,747	19,910	15.95	18,810	15.08

Table 49. **United States Fisheries, Food Fish Only, etc., continued.**

3. Chesapeake.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1887	117,683	4,948	4.20	8,840	7.51
1888	134,528	5,826	4.33	10,220	7.60
1890	189,513	9,389	4.95	16,700	8.81
1891	183,887	9,841	5.35	17,640	9.60
1897	183,588	6,541	3.56	14,050	7.65
1901	164,504	7,635	4.64	13,800	8.39
1904	161,815	7,918	4.89	13,260	8.20
1908	208,725	7,031	3.37	11,180	5.36
1920	157,091	10,399	6.62	6,740	4.29
1925	170,731	12,142	7.11	11,730	6.88
1929	165,469	10,391	6.28	10,900	6.59
1930	192,316	10,288	5.40	11,910	6.20
1931	172,702	6,827	3.95	9,350	5.42
1932	163,521	5,252	3.21	8,103	4.96
1933	156,390	4,675	2.99	7,040	4.50
1934	145,132	5,343	3.68	7,140	4.92
1935	144,739	5,114	3.54	6,398	4.42
1936	146,536	5,572	3.80	6,900	4.71
1937	170,265	5,876	3.45	6,808	4.00
1938	199,511	6,302	3.16	8,021	4.02
1939	195,972	6,651	3.39	8,624	4.40
1940	177,509	6,909	3.89	8,794	4.95
1945	214,953	29,760	13.84	28,100	13.07

4. South Atlantic.[1]

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1887	41,690[2]	1,164	2.79	2,078	4.98
1888	40,503	1,180	2.91	2,070	5.11
1889	48,270	1,444	2.99	2,531	5.24
1890	52,798	1,558	2.95	2,770	5.25
1897	66,472	1,813	2.73	3,890	5.86
1902	81,634	2,795	3.42	4,742	5.80
1908	99,475	3,909	3.93	6,215	6.22
1918	73,172	3,740	5.11	2,849	3.89
1923	77,533	4,335	5.59	4,310	5.56
1927	103,712	5,191	5.00	5,442	5.25
1928	108,090	5,606	5.19	5,800	5.36
1929	103,313	4,957	4.80	5,200	5.03
1930	82,812	3,494	4.22	4,042	4.88
1931	77,936	2,961	3.80	4,060	5.21
1932	77,128	2,279	2.95	3,515	4.56
1934	106,273	3,105	2.92	4,146	3.90
1936	139,914	4,587	3.28	5,680	4.06
1937	110,666	3,451	3.12	4,000	3.61
1938	111,538	3,495	3.13	4,450	3.99
1939	100,859	3,201	3.18	4,151	4.12
1940	100,683	3,311	3.29	4,215	4.18
1945	136,961	11,926	8.71	11,265	8.23

1/ Includes Lake Okeechobee, Florida, 1927-1940.

2/ Florida east coast extrapolated from 1888; other States canvassed.

Table 50. United States Fisheries, Food Fish Only, etc., continued.

5. Gulf of Mexico.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1887 1/	38,815	1,424	3.67	2,542	6.55
1888	40,564	1,566	3.86	2,748	6.78
1889	55,165	1,882	3.42	3,300	5.98
1890	58,437	2,000	3.43	3,560	6.10
1897	57,243	1,917	3.35	4,112	7.18
1902	94,531	3,102	3.28	5,265	5.57
1908	94,440	4,075	4.31	6,480	6.86
1918	103,968	5,673	5.46	4,320	4.15
1923	126,445	7,077	5.60	7,030	5.56
1927	162,244	8,931	5.50	9,360	5.77
1928	165,488	8,969	5.42	9,280	5.60
1929	157,552	7,904	5.02	8,297	5.27
1930	135,231	5,834	4.32	6,755	5.00
1931	133,905	4,222	3.15	5,785	4.32
1932	132,829	3,319	2.50	5,120	3.85
1934	176,600	5,510	3.12	7,360	4.17
1936	183,126	6,923	3.78	8,576	4.68
1937	224,096	8,940	3.99	10,360	4.62
1938	206,592	7,684	3.72	9,780	4.73
1939	227,482	8,677	3.81	11,250	4.95
1940	224,580	9,623	4.29	12,240	5.45
1945	285,647	37,656	13.18	35,580	12.46

1/ Florida west coast and Alabama extrapolated from 1888; other Gulf States canvassed.

6. Great Lakes 1/

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1885	99,842	2,692	2.70	4,720	4.73
1889 2/	117,086	2,616	2.23	4,590	3.93
1890	113,898	2,472	2.17	4,400	3.86
1893	96,620	2,271	2.35	4,256	4.40
1899	113,727	2,611	2.29	5,002	4.40
1903	86,195	2,746	3.19	4,606	5.34
1908	106,618	3,752	3.52	5,970	5.80
1917	104,269	6,295	6.03	5,354	5.13
1922	102,484	6,456	6.30	6,675	6.51
1927 2/	81,327	6,795	8.35	7,125	8.76
1928	63,568	5,961	9.41	6,170	9.74
1929	77,675	6,438	8.28	6,760	8,70
1930	89,663	5,878	6.56	6,825	7.62
1931	90,143	5,994	6.65	8,215	9.11
1932	81,849	4,362	5.32	6,730	8.22
1933	72,730	4,027	5.54	6,300	8.66
1934	93,277	5,071	5.44	6,760	7.25
1935	89,536	5,932	6.63	7,420	8.29
1936	92,929	6,353	6,83	7,860	8.46
1937	83,112	6,007	7.23	6,960	8.38
1938	81,226	6,077	7.48	7,730	9.52
1939	84,639	6,754	7.98	8,760	10.35
1940	79,087	5,621	7.11	7,160	9.05
1945	78,628	13,799	17.55	13,040	16.60

1/ Includes, from 1927 onward, Lake Namakan, Lake of the Woods and Rainy Lakes, Minnesota.

2/ Canvassed by U.S.Bureau of Census; not used in this study.

Table 51. United States Fisheries, Food Fish Only, etc., continued.

7. Mississippi River System.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1894	44,349	1,384	3.12	2,892	6.50
1899	49,149	1,365	3.18	2,998	6.10
1903	41,518	1,582	3.81	2,654	6.40
1908	72,018	2,439	3.38	3,878	5.33
1922	53,966	3,454	6.40	3,572	6.62
1931	45,129	2,475	5.48	3,390	7.50

Lake Namakan, Lake of the Woods and Rainy Lakes, Minnesota[1] separately.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1927	2,139	180	8.42	189	8.84
1928	1,797	150	8.34	155	8.62
1929	2,555	182	7.12	191	7.47
1930	2,681	155	5.78	180	6.71
1931	2,446	164	6.70	224	9.16
1932	2,840	97	3.42	149	5.24
1933	2,204	98	4.44	149	6.76
1934	2,396	121	5.05	161	6.72
1935	2,457	140	5.70	173	7.05
1936	2,317	130	5.62	161	6.95
1937	2,103	112	5.32	130	6.18
1938	1,942	119	6.12	151	7.78
1939	1,953	81	4.15	105	5.38
1940	2,409	125	5.19	159	6.60

[1] Included in Great Lakes, 1927-1940.

8. Pacific.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1888	84,319	3,857	4.58	6,763	8.03
1892	106,210	3,450	3.25	6,610	6.22
1895	135,111	3,941	2.92	8,079	5.98
1899	205,875	5,802	2.82	11,120	5.38
1904	190,125	6,230	3.28	10,430	5.48
1908	191,891	6,700	3.49	10,650	5.55
1915	295,397	9,158	3.10	13,170	4.46
1922	267,701	12,318	4.60	12,740	4.76
1923	379,047	18,394	4.85	18,270	4.82
1924	402,157	19,005	4.72	19,390	4.82
1925	514,608	23,697	4.60	22,900	4.45
1926	498,983	18,590	3.72	18,590	3.72
1927	622,872	21,795	3.50	22,850	3.67
1928	612,961	19,548	3.19	20,200	3.30
1929	837,094	23,612	2.82	24,780	2.96
1930	692,594	22,238	3.21	25,750	3.72
1931	502,803	13,139	2.61	18,000	3.58
1932	361,870	8,848	2.45	13,650	3.77
1933	530,725	12,945	2.34	19,650	3.55
1934	642,343	16,539	2.57	22,080	3.44
1935	792,763	19,689	2.48	24,610	3.11
1936	734,253	19,185	2.61	23,740	3.23
1937	773,934	23,939	3.10	27,750	3.59
1938	686,984	21,317	3.10	27,150	3.95
1939	844,247	22,583	2.67	29,280	3.47
1940	895,037	26,860	3.00	34,180	3.82
1945	1,025,699	53,713	5.24	50,750	4.95

Table 52. Alaska Fisheries: All Fishery Products and All Food Fish, Quantities, Values and Prices, Actual and Relative.
(For definition of relative values and prices, see Table 20.)

9. Alaska. All Fishery Products.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1889	65,914	2,631	3.99	4,620	7.01
1890	72,216	1,967	2.72	3,500	4.85
1891	86,145	2,317	2.69	4,150	4.82
1892	63,151	1,418	2.25	2,718	4.30
1905	117,247	7,712	6.58	12,820	10.94
1906	167,408	9,071	5.42	14,670	8.77
1907	170,358	10,160	5.96	15,590	9.16
1908	217,813	11,847	5.44	18,820	8.65
1910	214,536	13,260	6.18	18,840	8.78
1925	594,901	10,232	1.72	9,880	1.66
1929	651,425	17,084	2.62	17,920	2.75
1930	620,702	12,756	2.05	14,770	2.38
1931 1/					
1932	606,519	7,062	1.16	10,900	1.80
1933	630,773	9,158	1.45	13,900	2.20
1934	819,269	11,957	1.46	15,960	1.95
1935	648,710	9,093	1.40	11,360	1.75
1936	932,341	14,226	1.52	17,610	1.89
1937	834,819	14,717	1.76	17,060	2.04
1938	798,825	12,220	1.53	15,550	1.95
1939	666,477	11,458	1.72	14,960	2.24
1940 1/					
1945 1/					

1/ No non-food items reported.

Food Fish.

Year	Quantity pounds '000	Actual value dollars '000	Price cents	1926 Relative value dollars '000	Rel. price cents
1889	65,914	1,553	2.35	2,724	4.13
1890	72,216	1,699	2.35	3,022	4.24
1891	86,145	2,100	2.44	3,765	4.37
1892	63,151	1,308	2.07	2,508	3.97
1905	113,395	7,022	6.20	11,680	10.30
1906	165,230	8,466	5.12	13,700	7.69
1907	168,156	9,976	5.92	15,300	9.10
1908	212,420	11,018	5.18	17,530	8.25
1910	205,134	12,421	6.05	17,650	8.60
1925 2/					
1929	642,498	16,582	2.58	17,300	2.69
1930	611,285	12,285	2.01	14,220	2.32
1931	598,125	10,043	1.68	13,750	2.30
1932	598,856	6,971	1.16	10,750	1.80
1933	627,395	9,089	1.06	13,800	1.60
1934	809,915	11,706	1.44	15,640	1.93
1935	638,336	8,703	1.36	10,880	1.70
1936	923,529	13,891	1.51	17,200	1.86
1937	825,783	14,328	1.78	16,600	2.01
1938	793,948	12,040	1.52	15,320	1.93
1939	662,542	11,321	1.71	14,670	2.21
1940	563,688	10,612	1.88	13,500	2.40
1945	593,498	22,217	3.75	21,000	3.54

2/ Non-food items not separable from totals in 1925

Table 55. Ranking of Principal Species of Fish in Representative Years or Periods, United States and Alaska, 1890-1940; Quantities, Values, Percentages of Totals, and Prices.

1889-1892 1/

Species 2/	Quantity pounds '000	Per cent of all fish	Cumulative	Per cent of all food fish	Cumulative	Species 2/	Value $'000	Per cent of all fish	Cumulative	Per cent of all food fish	Cumulative	Price cents per lb.
Menhaden	219,968	13.0	13.0	--	--	Oysters 3/	14,833	34.8	34.8	38.0	38.0	8.52
Oysters, meats 3/	172,885	10.2	23.2	16.1	16.1	(Salmon, Pac.)	3,710	8.7	43.5	9.4	47.4	3.96
Cod, Atl.& Pac 4/	105,298	6.2	29.4	9.8	25.9	Cod, Atl.& Pac. 4/	2,789	6.5	50.0	7.1	54.5	2.65
(Salmon, Pac.)	93,688	5.5	34.9	9.4	35.3	Shad	1,764	4.1	54.1	4.5	59.0	4.24
(Alewives) 5/	62,258	3.7	38.6	5.8	41.1	(Clams)	1,691	4.0	58.1	4.3	63.3	7.78
Herring, sea 6/	52,190	3.1	41.7	4.9	46.0	Lobster	1,051	2.5	60.6	2.7	66.0	4.58
Lake herring	48,753	2.9	44.6	4.5	50.5	Haddock	1,046	2.5	63.1	2.7	68.7	2.23
Haddock	46,913	2.8	47.4	4.4	54.9	Halibut	874	2.0	65.1	2.2	70.9	7.68
Shad	41.645	2.5	49.9	3.9	58.8	Mackerel (Atl.)	732	1.7	66.8	1.9	72.8	7.16
Lobster	22,984	1.4	51.3	2.1	60.9	"Sea trout" 7/	709	1.7	68.5	1.8	74.6	3.39
(Clams, meats)	21,767	1.3	52.6	2.0	62.9	Menhaden	694	1.6	70.1	-	--	0.32
"Sea trout") 7/	20,925	1.2	53.8	2.0	64.9	Bluefish	637	1.5	71.6	1.6	76.2	4.15
Mullet 8/	20,759	1.2	55.0	1.9	66.8	Crab	572	1.3	72.9	1.5	77.7	3.22
Crabs	17,735	1.0	56.0	1.7	68.5	(Alewives) 5/	571	1.3	74.2	1.4	79.1	0.90
(Pike & pike perch)	16,835	1.0	57.0	1.6	70.1	Lake herring	562	1.3	75.5	1.4	80.5	1.15
Bluefish	15,348	0.9	57.9	1.4	71.5	Lake whitefish	519	1.2	76.7	1.3	81.8	4.18
Lake trout	12,890	0.8	58.7	1.2	72.7	Lake trout	508	1.2	77.9	1.3	83.1	3.94
Lake whitefish	12,401	0.7	59.4	1.2	73.9	(Pike & pike perch)	417	1.0	78.9	1.1	84.2	2.48
Halibut	11,391	0.7	60.1	1.1	75.0	Mullet 8/	388	0.9	79.8	1.0	85.2	1.87
Mackerel, (Atl.)	10,229	0.6	60.7	1.0	76.0	Herring, sea 6/	329	0.8	80.6	0.9	86.1	0.63
20 "Species", 19 food fish.												
Total food fish	1,071,253	63.4	63.4	100.0	100.0		39,440	92.2	92.2	100.0	100.0	
Total all fish	1,695,695	100.0	100.0	--	--		42,668	100.0	100.0	--	--	

1/ Composite figures, averages of nearby years for the regions within the period; Mississippi River, 1894.
2/ The term Species as here used, is commercial rather than biological. The more inclusive "species" (alewives, clams, pike and pike perch and salmon) are in parentheses; certain other "species", such as crabs, "sea trout" 7/ and perhaps shad and oysters, include, in addition to the main ones, minor quantities of closely allied true species. 3/ Figures may include some seed oysters. 4/ Cod, of which 69,791 (000) pounds was salt weight; if salt converted to fresh gutted, total would be 173,727 (000) pounds. 5/ (Alewives) of which 14,030 (000) was salt weight. 6/ (Herring, sea) of which 9,233 (000) was salt weight. 7/ Squeteague or weakfish, Cynoscion sp., principally regalis. 8/ (Mullet) of which 5,954 (000) was salt weight.

Table 54. Ranking of the Principal Species of Fish in Representative Years or Periods, United States and Alaska, 1890-1940: Quantities, Values, Percentages of Totals and Prices.

1908

Species 1/	Quantity pounds '000	Per cent of all fish	Cumulative	Per cent of all food fish	Cumulative	Species 1/	Value $'000	Per cent of all fish	Cumulative	Per cent of all food fish	Cumulative	Price Cts./lb.
Menhaden	394,776	19.3	19.3	-	-	Oysters 2/	12,722	20.1	20.1	21.4	21.4	8.47
Oysters, meats 2/	152,046	7.4	26.7	9.6	9.6	Sockeye salmon	7,791	12.3	32.4	13.1	34.5	6.28
Herring, sea	127,150	6.2	32.9	8.0	17.6	Cod	2,914	4.6	37.0	4.9	39.4	2.65
Sockeye salmon	124,006	6.1	39.0	7.9	25.5	Shad	2,113	3.3	40.3	3.5	42.9	7.64
Cod	110,053	5.5	44.5	7.0	32.5	Lobsters	1,931	3.1	43.4	3.2	46.1	12.63
(Alewives)	89,978	4.4	48.9	5.7	38.2	(Clams)	1,916	3.1	46.5	3.2	49.3	11.30
Haddock	59,987	2.9	51.8	3.8	42.0	"Sea trout" 3/	1,776	2.8	49.3	3.0	52.3	3.57
Crabs	52,913	2.6	54.4	3.4	45.4	Pink salmon	1,751	2.8	52.1	2.9	55.2	3.33
"Sea trout" 3/	49,869	2.4	56.8	3.2	48.6	Halibut	1,738	2.7	54.8	2.9	58.1	4.33
Pink salmon	45,731	2.2	59.0	2.9	51.5	Haddock	1,308	2.1	56.9	2.2	60.3	2.18
Carp	42,763	2.1	61.1	2.7	54.2	Carp	1,135	1.8	58.7	1.9	62.2	2.65
Lake herring	41,118	2.0	63.1	2.6	56.8	Lake herring	989	1.6	60.3	1.7	63.9	2.40
Halibut	40,133	2.0	65.1	2.5	59.3	Crabs	912	1.4	61.7	1.5	65.4	1.72
Hake	34,340	1.7	66.8	2.2	61.5	Mullet	908	1.4	63.1	1.5	66.9	2.70
Mullet	33,703	1.6	68.4	2.1	63.6	Menhaden	893	1.4	64.5	-	-	.23
Shad	27,641	1.3	69.7	1.7	65.3	Mackerel, Atl.	848	1.3	65.6	1.4	68.3	7.00
(Flounders)	23,346	1.1	70.8	1.5	66.8	Herring, sea	820	1.3	67.1	1.4	69.7	.65
Shrimp	19,080	.9	71.7	1.2	68.0	Lake trout	800	1.3	68.4	1.3	71.0	6.65
(Catfish)	17,817	.9	72.6	1.1	69.1	(Catfish)	785	1.2	69.6	1.3	72.3	4.41
(Clams, meats)	16,983	.8	73.4	1.1	70.2	Red snapper	636	1.0	70.6	1.1	73.4	4.71
Lobsters	15,279	.7	74.1	1.0	71.2	(Alewives)	589	.9	71.5	1.0	74.4	.64
Red snapper	13,498	.6	74.7	.8	72.0	(Flounders)	588	.9	72.4	1.0	75.4	2.52
Mackerel, Atl.	12,103	.6	75.3	.8	72.8	Shrimp	494	.8	73.2	.8	76.2	2.59
Lake trout	12,024	.6	75.9	.7	73.5	Hake	464	.7	73.9	.8	77.0	1.34
24 "Species", 23 food fish.												
(All Salmon)	284,914	13.9		18.1			13,959	22.1		23.5		4.90
Total												
Food fish	1,577,821	77.0	77.0	100.0	100.0		59,487	94.2	94.2	100.0	100.0	
All fish	2,047,229	100.0	100.0	-	-		63,227	100.0	100.0	-	-	

1/ The term species as here used, is commercial rather than biological. The more inclusive "species" (Alewives, Catfish, Clams and Flounders) are in parentheses; certain other "species", such as crabs, shrimp, "sea trout", and perhaps shad, include, in addition to the main ones, minor quantities of closely allied true species.
2/ Market oysters only; seed oysters excluded.
3/ Squeteague or weakfish, *Cynoscion* sp., principally *regalis*.

Table 55. Ranking of the Principal Species of Fish in Representative Years or Periods, United States and Alaska, 1890-1940: Quantities, Values, Percentages of Totals and Prices.

1929-30-31 Species 1/	Quantity Pounds '000	Per Cent of All Fish	Cumulative	Per Cent of All Food Fish	Cumulative	Species 1/	Value $'000	Per Cent of All Fish	Cumulative	Per Cent of All Food Fish	Cumulative	Price Cts./lb.
Pilchard, all	482,159	15.5	15.5	-	-	Oysters (meats) 3/	10,938	11.1	11.1	11.6	11.6	13.06
Pilchard, food	341,067	-	-	13.2	13.2	Haddock	7,727	7.8	18.9	8.2	19.8	3.25
Menhaden	330,999	11.0	26.5	-	-	Sockeye salmon	5,286	5.4	24.3	5.6	25.4	3.63
Pink salmon	245,024	7.9	34.4	9.4	22.6	Halibut	4,810	4.9	29.2	5.1	30.5	9.70
Haddock	237,112	7.6	42.0	9.1	31.7	Chinook salmon	4,193	4.2	33.4	4.4	34.9	7.92
Sea herring	220,825	7.1	49.1	8.5	40.2	Pink salmon	4,079	4.1	37.5	4.3	39.2	1.67
Sockeye salmon	145,509	4.7	53.8	5.6	45.8	Shrimp	3,516	3.6	41.1	3.7	42.9	3.45
Cod	120,489	3.9	57.7	4.6	50.4	Lobsters	3,367	3.4	44.5	3.6	46.5	26.48
Shrimp 3/	101,674	3.3	61.0	3.9	54.3	Cod	3,314	3.4	47.9	3.5	50.0	2.75
Oysters, meats	83,716	2.7	63.7	3.2	57.5	(Flounders)	3,066	3.2	51.1	3.3	53.3	4.27
Chum salmon	83,418	2.7	66.4	3.2	60.7	Yellowfin tuna	2,525	2.6	53.7	2.7	56.0	5.80
Crabs	79,025	2.5	68.9	3.0	63.7	Pilchard, all	2,383	2.4	56.1	-	-	.49
(Flounders)	71,968	2.3	71.2	2.8	66.5	Hard clams	2,261	2.3	58.4	2.4	58.4	24.90
Mackerel, (Atl.)	54,460	1.7	72.9	2.1	68.6	Crabs	2,184	2.2	60.6	2.3	60.7	2.89
Chinook salmon	52,924	1.7	74.6	2.0	70.6	Mackerel, (Atl.)	2,027	2.0	62.6	2.2	62.9	3.72
Halibut	49,593	1.6	76.2	1.9	72.5	Shad	1,887	1.9	64.5	2.0	64.9	12.72
Silver salmon	43,616	1.4	77.6	1.7	74.2	Silver salmon	1,706	1.7	66.2	1.8	66.7	3.92
Yellowfin tuna	43,544	1.4	79.0	1.7	75.9	Pilchard, food	1,687	-	-	1.8	68.5	.49
"Sea trout" 2/	33,179	1.1	80.1	1.3	77.2	White fish	1,657	1.7	67.9	1.8	70.3	15.70
Mackerel, (Pac.)	29,586	.9	81.0	1.1	78.3	Menhaden	1,591	1.6	69.5	-	-	.48
(Catfish)	16,248	.5	81.5	.6	78.9	Herring, sea	1,543	1.6	71.1	1.7	72.0	.70
Shad	14,830	.5	82.0	.6	79.5	Lake trout	1,428	1.4	72.5	1.5	73.5	13.37
Lobsters	12,708	.4	82.4	.5	80.0	"Sea trout" 2/	1,403	1.4	73.9	1.5	75.0	4.23
Lake trout	10,685	.4	82.8	.4	80.4	(Catfish)	1,165	1.2	75.1	1.2	76.2	7.17
Whitefish	10,537	.4	83.2	.4	80.8	Chum salmon	1,022	1.0	76.1	1.1	77.3	1.23
Hard clams	9,075	.3	83.5	.3	81.1	Mackerel, (Pac.)	426	.4	76.5	.5	77.8	1.44
25 "Species", 24 food fish.												
All Salmon	570,526	18.3		22.0			16,283	15.9		17.4		2.85
" Tuna	80,172	2.6		3.1			4,100	4.0		4.4		5.12
" Clams	23,959	.8		.9			3,345	3.3		3.5		13.97
Total 4/												
Food fish	2,592,361	83.2	83.2	100.0	100.0		94,209	95.5	95.5	100.0	100.0	
All fish	3,116,633	100.0	100.0				98,613	100.0	100.0			

1/ The term species as here used, is commercial rather than biological. The more inclusive "Species" (Catfish and flounders) are in parentheses; certain other "species", such as shrimp, crabs, "sea trout" 2/, and perhaps shad, include, in addition to the main ones, minor quantities of closely allied true species.
2/ Squeteague or weakfish, *Cynoscion* sp., principally *regalis*.
3/ Market oysters only; seed oysters excluded.
4/ Average of Atlantic, Gulf, Great Lakes, Pacific and Alaska regions; Mississippi River figures for 1931.

Table 56. Ranking of the Principal Species of Fish in Representative Years or Periods, United States and Alaska, 1890-1940: Quantities, Values, Percentages of Totals and Prices.

1938-39-40 (Average)

Species 1/	Quantity Pounds '000	Per Cent of All Fish	Cumulative	Per Cent of All Food Fish	Cumulative	Species 1/	Value $'000	Per Cent of All Fish	Cumulative	Per Cent of All Food Fish	Cumulative	Price Cts./lb.
Pilchard, all	1,085,458	25.6	25.6	-	-	Oysters (meats) 2/	8,371	8.7	8.7	9.5	9.5	9.30
Menhaden	566,651	13.4	39.0	-	-	Pilchard, all	6,001	6.2	14.9	-	-	0.55
Pilchard, food	332,660	-	-	11.5	11.5	Yellowfin tuna	5,774	6.0	20.9	6.5	16.0	5.75
Pink salmon	229,958	5.4	44.4	8.0	19.5	Shrimp	5,173	5.4	26.3	5.8	21.8	3.48
Sea herring	202,213	4.8	49.2	7.0	26.5	Sockeye salmon	4,678	4.9	31.2	5.3	27.1	2.75
Sockeye salmon	170,226	4.0	53.2	5.9	32.4	Haddock	4,371	4.5	35.7	4.9	32.0	2.68
Haddock	163,006	3.8	57.0	5.6	38.0	Pink salmon	3,672	3.8	39.5	4.1	36.1	1.60
Shrimp	148,784	3.5	60.5	5.1	43.1	Halibut	3,404	3.5	43.0	3.8	39.9	7.38
Cod	120,964	2.8	63.3	4.2	47.3	(Flounders)	3,188	3.3	46.3	3.6	43.5	5.73
Yellowfin tuna	100,579	2.4	65.7	3.5	50.8	Cod	2,811	2.9	49.2	3.2	46.7	2.32
Crabs	100,426	2.4	68.1	3.5	54.3	Crabs	2,739	2.8	52.0	3.1	49.8	2.73
Mackerel, Pacific	93,754	2.2	70.3	3.2	57.5	Chinook salmon	2,577	2.7	54.7	2.9	52.7	6.22
Oysters (meats) 2/	89,740	2.1	72.4	3.1	60.6	Lobsters	2,152	2.2	56.9	2.4	55.1	17.96
(Flounders)	85,506	2.0	74.4	3.0	63.6	Menhaden	1,948	2.0	58.9	-	-	.34
Chum salmon	80,430	1.9	76.3	2.8	66.4	Pilchard, food	1,820	-	-	2.0	57.1	.55
Rosefish	76,404	1.8	78.1	2.6	69.0	Skipjack tuna	1,728	1.8	60.7	1.9	59.0	4.70
Croaker	56,048	1.3	79.4	1.9	70.9	Lake trout	1,664	1.8	62.5	1.9	60.9	17.10
Halibut	46,181	1.0	80.4	1.6	72.5	Silver salmon	1,430	1.5	64.0	1.6	62.5	3.78
Chinook salmon	41,480	1.0	81.4	1.4	73.9	Mullet	1,258	1.3	65.3	1.4	63.9	3.43
Mackerel, (Atl.)	38,838	.9	82.3	1.3	75.2	(Catfish)	1,227	1.3	66.6	1.4	65.3	6.86
Silver salmon	37,877	.9	83.2	1.3	76.5	Herring, sea	1,202	1.2	67.8	1.4	66.7	.59
Mullet	36,690	.9	84.1	1.3	77.8	Clams, soft	1,158	1.2	69.0	1.3	68.0	7.49
Skipjack tuna	36,591	.9	85.0	1.3	79.1	Scallops, sea	1,143	1.2	70.2	1.3	69.3	13.35
(Catfish)	17,906	.4	85.4	.6	79.7	Chum salmon	1,095	1.1	71.3	1.2	70.5	1.36
Albacore	17,050	.4	85.8	.6	80.3	Rosefish	1,060	1.1	72.4	1.2	71.7	1.39
Soft clams	15,485	.4	86.2	.5	80.8	Mackerel (Atl.)	1,057	1.1	73.5	1.2	72.9	2.72
Shad	12,192	.3	86.5	.4	81.2	Mackerel (Pac.)	999	1.0	74.5	1.1	74.0	1.07
Lobsters	11,989	.3	86.8	.4	81.6	Albacore	990	1.0	75.5	1.1	75.1	5.80
Lake trout	9,717	.2	87.0	.3	81.9	Shad	979	1.0	76.5	1.1	76.2	8.04
Sea scallops	8,566	.2	87.2	.3	82.2	Croaker	828	.9	77.4	.9	77.1	1.48
29 "species", 28 food fish.												
All salmon	559,971	13.2	-	19.4	-		13,452	14.0	-	15.2	-	2.40
" tuna	179,832	4.2		6.2			9,706	10.1	-	11.0	-	5.40
" clams	33,267	.8		1.2			3,303	3.4	-	3.7		9.93
Total												
Food fish	2,887,083	67.8	67.8	100.0	100.0		88,555	93.2	93.2	100.0	100.0	
All fish	4,252,126	100.0	100.0	-	-		96,346	100.0	100.0	-	-	

1/ The term species as here used, is commercial rather than biological. The more inclusive "species" (catfish and flounders) are in parentheses: certain other "species", such as shrimp, crabs, and perhaps shad and oysters, include, in addition to the main ones, minor quantities of closely allied true species.
2/ Market oysters only; seed oysters excluded.
3/ Averages of the Atlantic, Gulf, Great Lakes, Pacific and Alaska; Mississippi River figures for 1931.

Table 57 Market Oysters, exclusive of seed, Atlantic and Gulf of Mexico (Pacific excluded) Production, Values Actual and Relative, and Prices Actual and Relative, for 1880, and continuously by years, 1887-1940. Partly interpolated. 1/

Year	Quantity 2/ Pounds '000	Value Dollars '000	Price Cents	Relative 3/ Value Dollars '000	Relative 3/ Price Cents
1880	155,405	12,206	7.96	18,800	12.25
1887	135,425	10,049	7.42	17,950	13.26
1888	142,300	10,547	7.41	18,500	13.00
1889	155,348	11,535	7.43	20,230	13.03
1890	170,695	13,786	8.08	24,520	14.38
1891	170,294	14,693	8.63	26,330	15.33
1892	169,132	14,275	8.45	27,360	16.17
1893	167,433	13,756	8.22	25,760	15.38
1894	165,732	13,235	8.00	27,650	16.68
1895	164,031	12,716	7.76	26,080	15.90
1896	162,330	12,196	7.52	26,330	16.23
1897	160,629	11,676	7.28	25,050	15.60
1898	160,808	11,974	7.45	24,670	15.33
1899	158,226	12,159	7.69	23,300	14.73
1900	155,644	12,343	7.93	22,000	14.14
1901	153,061	12,526	8.18	22,660	14.80
1902	150,435	12,969	8.63	22,010	14.63
1903	149,918	13,656	9.12	22,920	15.30
1904	149,400	14,342	9.60	24,000	16.06
1905	148,961	13,938	9.36	23,200	15.55
1906	148,951	13,304	8.94	21,500	14.44
1907	148,902	12,670	8.52	19,940	13.39
1908	148,874	12,035	8.09	19,150	12.86
1909	149,107	12,030	8.07	17,800	11.93
1910	149,342	12,024	8.05	17,070	11.43
1911	151,166	12,236	8.10	18,850	12.47
1912	148,058	12,156	8.22	17,600	11.90
1913	142,504	12,130	8.52	17,370	12.19
1914	136,951	12,103	8.84	17,770	12.97
1915	131,396	12,076	9.20	17,380	13.23
1916	125,841	12,051	9.58	14,100	11.21
1917	120,289	12,025	10.00	10,230	8.50
1918	114,734	11,998	10.47	9,140	7.97
1919	111,042	12,132	10.93	8,750	7.88
1920	108,380	12,194	11.25	7,900	7.29
1921	106,519	12,448	11.19	12,740	11.96
1922	105,248	12,783	12.15	13,200	12.55
1923	103,978	13,118	12.62	13,050	12.55
1924	102,919	13,469	13.10	13,720	13.33
1925	102,103	13,892	13.60	13,420	13.15
1926	98,265	13,792	14.02	13,792	14.02
1927	96,154	13,899	14.45	14,560	15.14
1928	92,590	13,607	14.70	14,080	15.20
1929	89,318	12,905	14.45	13,530	15.15
1930	86,255	11,592	13.43	13,420	15.56
1931	72,799	7,163	9.84	9,810	13.47
1932	66,052	5,692	8.61	8,780	13.28
1933	61,531	4,846	7.88	7,360	12.03
1934	76,565	6,010	7.85	8,025	10.48
1935	74,444	6,249	8.40	7,820	10.50
1936	74,368	7,330	9.86	9,075	12.20
1937	87,386	7,917	9.06	9,170	10.50
1938	77,874	7,690	9.88	9,790	12.57
1939	84,020	7,509	8.94	9,530	11.35
1940	78,381	7,713	9.84	9,815	12.53
1945	65,421	23,283	35.58	22,000	33.62

1/ Totals of the quantities and values of the five Atlantic Coast statistical regions; in each region the years not canvassed were supplied by straight line interpolation. (See calendar of canvasses, Table 37).

2/ Quantities of net edible meats were originally assumed to be 7 pounds per bushel and so reported up to 1931; the figures here used are as revised by the Fish and Wildlife Service (U. S. Senate, 1940) in accordance with approximate actual yields of the several regions.

3/ In money of constant purchasing power, All Commodity Wholesale Price Index, 1926 = 100, U. S. Bur.Lab. Stat.

Table 58.

Production and Value of Menhaden for Atlantic and Gulf States, 1880-1945.
(In thousands of pounds and thousands of dollars.)

	New England		Mid-Atlantic		Chesapeake		So.Atlantic		Gulf		North Carolina	
	Lbs.	$	Lbs.	$	Lbs.	$	Lbs.	$	Lbs.	$	Lbs.	$
1880	154,800	540	318,600	1,261	92,117	316	---	---	---	---	---	---
1887	77,169	173	88,108	206	62,684	129	14,756	18	---	---	14,756	18
1888	128,930	311	151,722	347	60,035	117	13,844	17	---	---	13,844	17
1889	173,461	425	137,754	362	---	---	8,753	12	---	---	8,753	12
1890	---	---	159,185	407	135,312	267	12,410	16	--	---	12,410	16
1891	---	---	125,598	353	136,932	263	---	---	---	---	---	---
1897	---	---	91,159	218	179,009	256	11,310	20	---	---	11,310	20
1898	22,600	62	---	---	---	---	---	---	---	---	---	---
1901	---	---	213,320	543	280,616	445	---	---	---	---	---	---
1902	18,469	56	---	---	---	---	18,862	31	13	1	18,867	31
1904	---	---	254,009	803	257,768	536	---	---	---	---	---	---
1905	31,775	82	---	---	---	---	---	---	---	---	---	---
1908	46,856	142	84,994	65	202,382	459	57,412	70	3,153	4	57,912	70
1918	---	---	---	---	---	---	257,757	1,605	14,414	111	179,911	1,307
1919	28,434	364	---	---	---	---	---	---	---	---	---	---
1920	---	---	---	---	366,387	2159	---	---	---	---	---	---
1921	---	---	227,935	1,307	---	---	---	---	---	---	---	---
1923	---	---	---	---	---	---	148,181	752	19,473	135	63,290	326
1924	7,536	79	---	---	---	---	---	---	---	---	---	---
1925	---	---	---	---	150,493	1455	---	---	---	---	---	---
1926	---	---	39,891	162	---	---	---	---	---	---	---	---
1927	---	---	---	---	---	---	157,965	689	13,466	60	98,987	490
1928	5,175	74	---	---	---	---	150,844	585	5,857	39	99,302	431
1929	395	12	40,546	169	99,229	823	234,420	977	18,815	167	173,490	719
1930	1,708	17	52,478	368	115,842	767	192,994	776	6,175	30	134,051	536
1931	5	1	40,467	182	112,920	369	72,456	106	4,450	10	67,877	94
1932	54	1	43,194	73	195,488	653	77,176	104	12,170	28	54,476	75
1933	1,029	3	79,575	236	115,991	386	---	---	---	---	---	---
1934	---	---	---	---	143,879	600	154,807	519	9,579	22	106,651	356
1935	4,284	14	179,603	474	121,088	411	---	---	---	---	---	---
1936	---	---	---	---	167,559	916	230,070	919	3,393	8	150,088	599
1937	294	2	148,505	657	121,980	485	204,928	600	6,450	16	61,706	220
1938	328	2	86,941	340	95,083	361	302,769	822	353	2	146,819	427
1939	122	1	148,584	689	127,681	546	287,243	834	11,849	31	186,968	557
1940	88	1	245,369	842	145,227	549	224,882	753	25,195	70	129,592	485
1941	---	---	---	---	182,223	955	---	---	---	---	---	---
1942	75	1	204,517	1,606	64,115	451	---	---	---	---	---	---
1943	132	1	196,259	1,889	---	---	---	---	---	---	---	---
1944	70	1	304,314	2,478	77,970	460	---	---	---	---	---	---
1945	200	2	139,230	1,129	89,357	591	256,279	1,714	64,506	456	141,533	975

Table 59. Value of the Pack of Canned Fishery Products in the United States, 1940. 1/

Kind	Value dollars	Per cent of total value	Cumulative per cent
Salmon	38,049,668	40.40	40.40
Tuna	23,727,560	25.20	65.60
Sardines	12,711,651	13.50	79.10
Shrimp & Soup	4,334,184	4,60	83.70
Mackerel	4,101,369	4.36	88.06
Clam Products	3,778,363	4.01	92.07
Oysters & Soup	2,622,313	2.78	94.85
Dog & Cat Food	1,861,838	1.98	96.83
Fish Cakes	776,684	.83	97.66
Caviar	355,759	.38	98.04
Fish Flakes	345,938	.37	98.41
Crabs	313,938	.33	98.74
Alewife & Roe	237,939	.25	98.99
Misc. Fish & Roe	208,519	.22	99.21
Shad Roe	204,960	.22	99.43
Misc. Hors d'oeuvre	136,698	.15	99.58
Salmon eggs (for bait)	128,101	.14	99.72
Turtle Products	124,056	.13	99.85
Squid	78,364	.08	99.93
Fish Chowder	23,249	.02	99.95
Terrapin Products	4,126	.004	99.954
Finnan Haddie	2,590	.003	99.957
	94,181,941	99.957	

1/ Arranged and calculated from Fish & Wildlife Service data.

Table 60. Quantity of Whole Fish and Fillets Frozen in the United States, 1940. 1/

	Pounds of Product	Percent of Total Quantity	Cumulative Percent of Total
Whiting	21,610,128	11.02	11.02
Rosefish fillets	19,156,236	9.77	20.79
Halibut	18,273,717	9.31	30.10
Haddock fillets	16,712,351	8.52	38.62
Shrimp	15,986,052	8.15	46.77
Salmon	14,513,889	7.40	54.17
Mackerel (except Sp.)	12,864,970	6.56	60.73
Pollock fillets	9,659,519	4.93	65.66
Cod "	4,989,493	2.55	68.21
Ciscoes	4,226,950	2.16	70.37
Sablefish	3,954,473	2.02	72.39
Herring	3,773,029	1.92	74.31
Scallops	3,160,425	1.61	75.92
Cod (except fillets)	2,449,688	1.25	77.17
Other shellfish	2,368,391	1.21	78.38
Croaker	2,349,145	1.20	79.58
Squid	2,036,861	1.04	80.62
Smelts	1,994,479	1.02	81.64
Flounders	1,849,959	.94	82.58
Pike	1,785,915	.91	83.49
Swordfish	1,781,094	.91	84.40
Lake Trout	1,587,248	.81	85.21
Whitefish	1,275,456	.65	85.86
Butterfish	1,158,963	.59	86.45
Spiny Lobster	1,086,982	.55	87.00
Perch	834,957	.43	87.43
Weakfish	663,704	.34	87.77
Shad & Roe	578,951	.30	88.07
Catfish	442,046	.23	88.30
Suckers	309,534	.16	88.46
Scup	302,177	.15	88.61
Sturgeon	275,948	.14	88.75
Bluefish	256,902	.13	88.88
Other, misc.	21,885,151	11.15	100.03
	196,154,783	100.03	

1/ Arranged and calculated from Fish & Wildlife data.

Table 61. **Monthly Catch and Utilization of Fish and Shellfish, 1945.** 1/

(Round weight basis.)

Month	Form Marketed				Total Catch	
	Fresh and Frozen	Canned	Cured	Byproducts and bait 2/		
	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds	1,000 Pounds	Percent
January	74,000	66,000	2,000	62,000	204,000	4.4
February	88,000	34,000	2,000	11,000	135,000	3.0
March	126,000	12,000	3,000	2,000	143,000	3.1
April	129,000	16,000	8,000	19,000	172,000	3.7
May	207,000	37,000	17,000	48,000	309,000	6.8
June	232,000	66,000	13,000	167,000	478,000	10.5
July	210,000	239,000	13,000	209,000	671,000	14.7
August	207,000	220,000	14,000	280,000	721,000	15.8
September	167,000	128,000	9,000	263,000	567,000	12.4
October	174,000	202,000	7,000	175,000	558,000	12.2
November	156,000	131,000	12,000	86,000	365,000	8.0
December	91,000	79,000	10,000	67,000	247,000	5.4
Total	1,841,000	1,230,000	110,000	1,389,000	4,570,000	100.0

1/ U. S. Fish & Wildlife Service, Bulletin 27264, Oct. 1947.

2/ An additional 600 million pounds of waste from canning, dressing, and filleting operations was also used in the manufacture of byproducts.

Note:--Data partly estimated.

Table 62. Production Fish Meal, Fertilizer and Oil in the United States, 1940. (In order of money value.)

Kind		Quantity	Value	Average price	Value percent of total value	Cumulative percent
			Fish Meal.			
Pilchard	tons	69,975	$3,007,705	$43.00	55.0	55.0
Tuna & mackerel	"	14,955	610,007	40.80	11.1	66.1
Ground fish (cod, haddock, etc.)	"	8,250	424,889	51.50	7.8	73.9
Menhaden	"	8,895	414,548	46.70	7.6	81.5
Herring	"	9,216	380,134	41.30	7.0	88.5
Shrimp	"	1,716	49,810	29.00	0.9	89.4
Salmon	"	969	47,914	49.50	0.9	90.3
Blue crab	"	1,685	31,480	18.68	0.6	90.9
Shark	"	527	24,775	47.00	0.5	91.4
King crab	"	286	11,439	40.00	0.2	91.6
Miscellaneous	"	10,262	468,856	45.70	8.6	100.2
Total	"	126,736	$5,471,557	43.20	100.2	
			Fertilizer.			
Menhaden (dry and acid)	"	62,874	$2,280,214	$36.30	96.5	96.5
Alewife	"	618	29,575	47.80	1.3	97.8
Blue crab	"	646	10,418	16.10	0.4	98.2
Miscellaneous	"	2,370	42,057	17.75	1.8	100.0
Total	"	66,508	$2,362,264	$35.50	100.0	
			Oils.			
Pilchard	gallons	12,626,849	$3,761,160	$ 0.30	31.3	31.3
Tuna liver	"	226,553	2,831,791	12.50	23.6	54.9
Menhaden	"	5,774,671	1,304,720	0.22	10.8	65.7
Shark liver	"	241,102	1,132,570	4.69	9.4	75.1
Whale	"	2,561,518	952,164	0.37	7.9	83.0
Liver, misc.	"	41,709	870,624	20.88	7.2	90.2
Herring	"	2,241,169	606,722	0.27	5.1	95.3
Cod liver	"	281,257	253,168	0.90	2.1	97.4
Tuna & mackerel	"	447,326	123,801	0.28	1.0	98.4
Salmon	"	97,746	81,910	0.84	0.7	99.1
Miscellaneous	"	275,638	106,548	0.39	0.9	100.0
Total	"	24,815,538	$12,025,178		100.0	

Table 63. Economic Conditions in Seaboard Counties of North Carolina.

County	Population						Fisheries 1/			
	1920	1930	1940	Percent change '20-'40	Density of population per sq.mi. 1940	Rural farm population 1940	Prod'n fish, avge '36-'40 incl. pounds (000)	Value of prod'n annual avge '36-'40 incl. dollars	Number fishermen avge '36-'40 incl.	Number dealers 1945
Beaufort	31,024	35,026	36,431	17.4	44.8	19,295	2,716	93,442	393	9
Bertie	23,993	25,844	26,201	9.2	37.8	19.491	3,402	39,180	69	1
Brunswick	14,876	15,818	17,125	15.1	19.7	9,526	20,050	172,461	660	6
Camden	5,382	5,461	5,440	1.1	22.7	3,397	31	1,362	15	0
Carteret	15,384	16,900	18,284	18.9	34.4	4,060	132,690	912,632	2605	50
Chowan	10,649	11,282	11,572	8.7	64.3	7,507	4,225	48,671	156	5
Craven	24,048	30,665	31,298	30.1	43.4	12,230	266	7,270	80	2
Currituck	7,268	6,710	6,709	-7.7	24.6	4,027	582	25,222	156	0
Dare	5,115	5,202	6,041	18.1	15.6	230	6,759	296,520	771	10
Gates	10,537	10,551	10,060	-4.5	29.3	7,808	112	1,699	16	0
Hertford	16,294	17,542	19,352	18.8	54.4	12,580	559	6,712	39	0
Hyde	8,386	8,550	7,860	-6.3	12.4	5,013	2,268	65,801	187	10
Martin	20,828	23,400	26,111	25.7	54.3	17,380	320	5,718	101	1
New Hanover	40,620	43,010	47,935	18.0	221.0	2,652	1,478	47,335	415	3
Onslow	14,703	15,289	17,939	22.0	23.7	13,603	1,367	45,856	325	5
Pamlico	9,060	9,299	9,706	7.1	28.5	3,992	5,352	144,584	391	15
Pasquotank	17,670	19,143	20,568	16.4	90.0	5,642	669	31,664	57	2
Pender	14,788	15,686	17,710	19.8	20.7	11,504	1,081	31,113	165	5
Perquimans	11,137	10,668	9,773	-12.2	37.5	6,614	350	18,364	77	0
Tyrrell	4,849	5,164	5,556	14.6	13.9	3,646	395	13,477	97	1
Washington	11,429	11,603	12,323	7.8	36.7	6,180	435	9,992	93	2
Total or avge	318,040	342,813	363,994	14.5	36.4	176,377	185,285	2,019,632	6,909	
No.Ca.	2,559,123	3,170,276	3,571,623	39.6	72.	1,656,501	185,285	2,019,632	6,909	
% of N.C.	12.4	10.8	10.2			10.6	100	100	100	
U.S.A.	105,710,620	122775,046	131669275	24.5	44.2	30,216,188	4059,524	98,957,000		

1/ U. S. Fish & Wildlife Service

Bladen County, 1936 only, 100 pounds.

Table 64. Economic Conditions in Seaboard Counties of North Carolina.

Agriculture, 1940 1/

	Number of farms	Avge size, acres	Avge value land & bldgs per farm $(000)	Farms mortgaged percent	Farm tenancy percent	Number farmers & farm managers	Gross farm income $(000)	Autos per 100 farms	Tractors & trucks per 100 farms
Beaufort	3,256	70.2	2,914	39.2	38.2	3,220	4,463	40	18
Bertie	3,095	78.9	2,446	34.2	63.0	3,430	3,470	46	9
Brunswick	1,721	95.2	1,507	24.7	20.2	1,590	1,229	25	13
Camden	561	106.7	4,122	35.6	43.5	583	781	66	28
Carteret	714		2,313	22.4	24.5	538	785	32	29
Chowan	1,006	70.0	3,996	47.9	47.6	862	1,456	54	25
Craven	2,226	72.8	2,654	27.6	47.7	2,210	2,738	35	12
Currituck	788	102.8	3,251	25.9	33.9	691	843	51	18
Dare	55	45.4	3,409	12.5	9.1	15	32	40	29
Gates	1,308	84.4	2,395	39.1	42.4	1,228	1,255	48	11
Hertford	2,023	72.6	2,849	42.9	70.4	1,956	2,410	44	10
Hyde	996	62.2	2,363	34.0	44.3	883	634	28	12
Martin	2,406	76.7	3,498	41.2	62.1	2,360	4,261	50	13
New Hanover	324	66.6	5,620	40.2	12.3	268	758	71	74
Onslow	2,188	71.4	1,910	28.7	46.3	2,440	1,969	36	7
Pamlico	843	87.7	2,695	33.3	21.2	736	1,163	33	21
Pasquotank	844	96.1	5,028	46.0	39.9	757	1,271	65	29
Pender	1,965	66.0	2,010	25.3	29.7	1,826	1,545	37	16
Perquimans	1,056	84.7	3,231	39.5	46.7	1,028	1,139	56	19
Tyrrell	599	66.6	2,481	45.5	31.2	466	623	34	8
Washington	969	64.0	2,614	34.2	43.1	904	1,077	29	11
Total or average	28,943	75.1	2,760	34.8	44.7	27,991	33,900	43	15
North Carolina	278,276	67.7	2,647	29.1	44.4	247,769	262,438	46	11
Pct. of N.C.	10.3					11.3	12.9		
United States	6,096,799	174.0	5,518	38.8	38.7	5,140,000	7,813,645	68	43

1/ U. S. Bureau of Census.

Table 65. Economic Conditions in Seaboard Counties of North Carolina.

County	Manufacturing 1939[1]							Forestry[2]		
	Number establishments	Number wage earners	Total wages paid $(000)	Per wage earner $	Value product $(000)	Value added by manufacture $(000)	Value added per wage earner $	Volume stand. timber 1938 bd.ft. (000,000)	Production bd.ft. 1942 (000)	Value (est. $28 per M) $(000)
Beaufort	22	650	342	527	2,067	966	1,486	984	58,612	1,641
Bertie	12	507	212	418	697	378	746	1,703	49,244	1,380
Brunswick	19	531	304	573	2,564	949	1,786	653	10,468	298
Camden	1							446	447	13
Carteret	20	463	244	528	1,172	645	1,392	517	7,581	207
Chowan	12	368	179	486	894	381	1,036	191	9,324	261
Craven	32	1,121	674	601	3,357	1,554	1,386	680	32,139	900
Currituck	2							300	3,105	87
Dare	3	26	15	571	40	27	1,054	216		
Gates	5	42	20	484	88	29	685	1,115	4,115	115
Hertford	13	601	307	510	1,130	669	1,112	827	13,906	389
Hyde	1							404	2,250	63
Martin	15	559	474	848	3,066	1,346	2,407	1,049	26,262	736
New Hanover	61	2,606	1,775	681	17,610	9,121	3,500	131	2,356	66
Onslow	9	148	84	569	277	153	1,033	768	7,287	204
Pamlico	5	17	7	389	74	37	2,173	283	6,723	188
Pasquotank	28	1,639	1,001	611	4,190	2,407	1,469	253	28,365	794
Pender	14	228	94	415	325	186	821	596	16,353	458
Perquimans	8	230	132	575	743	364	1,582	375	15,547	435
Tyrrell	6	80	27	332	92	57	709	551	13,100	367
Washington	6	277	161	582	532	285	1,030	415	10,694	299
Total or avge	294	10,091	6,052	597	30,429	19,553	1,930	12,457	317,678	8,901
North Carolina	3,225	270,207	199,289	737	1,421,329	545,952	2,020	42,790	1,700,833	
Pct. of N.C.	9.1	3.8	3.0		2.1	3.6		29.1	18.6	
United States	184,230	7,886,567	9,089,941	1,153	56,843,025	24,682,918	3,129			

1/ U. S. Bureau of Census.

2/ U. S. Dept. Ag. (Forestry Serv.)

Table 66. Economic Conditions in Seaboard Counties of North Carolina.

County	Housing, 1940: Dwelling units 1/ Number	Electric lights pct.	Running water pct.	Private inside toilet pct.	Need major repairs pct.	Built since 1929 pct.	Occupied units 1/ Number	By owner percent	Population per unit	With radio percent	Effective Buying income $(000) 1939 2/	Effective Buying income $(000) 1944 1/	Retail trade per cap.dol. 3/ 1940	Number hosp. beds 1/	Per M. population 1940
Beaufort	8740	34.4	27.1	20.5	49.4	17.0	8150	49.8	4.47	47.8	10388	22955	158	85	2.70
Bertie	5400	23.9	11.2	8.9	43.8	15.3	5350	37.8	4.89	43.8	5790	10758	100	15	.57
Brunswick	3820	22.0	13.1	11.0	38.2	27.3	3670	68.7	4.66	39.7	3523	4532	75	50	2.92
Camden	1310	19.3	6.0	4.2	69.3	14.0	1270	42.8	4.28	52.9	1191	991	38	--	--
Carteret	4600	49.5	34.0	28.3	26.0	22.7	4260	71.5	4.29	55.5	4758	9878	134	36	1.97
Chowan	2690	35.8	28.4	22.8	30.3	11.6	2540	41.5	4.55	48.4	3086	6833	149	--	--
Craven	7700	22.7	28.8	22.7	22.5	15.0	7370	44.3	4.81	45.8	9327	24836	190	105	3.36
Currituck	1740	20.4	9.6	6.7	46.3	13.9	1660	47.6	4.03	43.5	1456	1879	71	--	--
Dare	1810	48.0	28.5	23.4	36.9	33.2	1450	83.0	4.15	64.5	1419	2699	130	--	--
Gates	2170	18.0	4.6	3.7	37.2	11.1	2120	53.4	4.74	41.0	2121	1872	64	--	--
Hertford	4110	28.1	19.7	14.6	31.4	14.5	4020	36.5	4.81	48.0	4346	8584	130	--	--
Hyde	1930	22.5	3.5	2.7	54.4	10.4	1720	57.2	4.57	39.7	1651	1342	54	--	--
Martin	5300	30.7	15.3	12.3	37.3	14.6	5140	35.8	5.09	43.8	6629	15094	151	35	1.34
New Hanover	13680	76.2	78.6	70.7	21.6	22.5	12050	38.3	3.98	68.3	23710	75985	333	458	9.50
Onslow	3950	13.3	9.0	7.3	40.6	24.6	3780	52.2	4.75	41.7	3705	5614	85	55	3.06
Pamlico	2270	24.2	8.3	5.9	27.4	20.6	2170	65.9	4.47	39.4	1971	2206	47	--	--
Pasquotank	5020	50.6	52.1	41.9	46.9	10.3	4870	41.3	4.23	65.8	7189	19961	240	30	1.46
Pender	4130	23.8	11.9	10.6	49.6	27.0	3750	62.2	4.72	39.6	3575	5188	75	--	--
Perquimans	2440	21.0	16.5	14.7	57.9	8.6	2270	44.0	4.31	45.5	2267	4653	122	--	--
Tyrrell	1260	15.8	9.7	6.6	52.1	16.5	1210	58.0	4.59	48.6	1140	1373	76	20	3.60
Washington	2700	29.6	16.1	11.8	54.1	12.1	2600	45.5	4.73	47.2	2878	4963	102	--	--
Total or avge	86770	36.6	29.9	25.0	37.5	19.1	81420	48.1	4.53	50.0	102070	232196	155	889	2.65
No. Carolina	821000	54.4	39.1	30.3	30.6	22.1	790000	42.4	4.50	61.8	1088305	2424420	177	9058	2.58
Pct.of N.C.	10.6						10.2				9.4	9.6		9.8	
U.S.A.	37325000	78.8	69.9	59.7	18.3	15.9		43.6	3.80	82.8			319		2.84
							34855,000				67783307	148415967		373115	

1/ State Planning Board, Basic County Data, 1946. 2/ Calculated by Prof.Dudley J.Cowden and Warren W.Webb.
3/ State Planning Board, Basic County Data, 1946, from Sales Management Magazine.

Table 67. Economic Conditions in Seaboard Counties of North Carolina.

State Income Taxes of 21 Coastal Counties, 1940.[1]

County	Individual Income Tax			Domestic Corporation T	
	Number of returns	Tax paid	Tax per 100 of population[2]	Number of returns	Tax pa
Beaufort	662	$ 13,066.77	$ 35.90	37	$ 10,282.27
Bertie	174	3,064.26	11.62	10	2,512.50
Brunswick	122	1,575.82	9.18	4	404.79
Camden	52	450.39	8.28	--	--------
Carteret	291	5,093.09	27.75	26	4,425.43
Chowan	192	3,714.32	32.10	10	2,832.52
Craven	524	11,762.04	37.50	48	8,257.07
Currituck	92	484.66	7.22	--	--------
Dare	70	527.87	8.74	4	--------
Gates	71	1,846.65	18.48	5	87.50
Hertford	247	5,912.01	30.25	22	2,471.11
Hyde	56	158.32	2.02	1	--------
Martin	349	6,369.95	24.45	23	3,241.60
New Hanover	3065	127,181.56	274.00	110	39,342.68
Onslow	89	950.45	5.34	1	--------
Pamlico	48	393.26	4.10	2	--------
Pasquotank	654	23,560.81	119.50	44	19,400.06
Pender	132	2,155.52	12.26	3	90.62
Perquimans	106	1,239.90	12.74	4	2,647.65
Tyrrell	48	365.41	6.55	3	573.73
Washington	212	2,900.31	23.52	2	--------
Total or average	7236	212,773.37	58.50	357	96,648.53
" North Carolina	100076	3,675,167.00	102.80	5,139	3,535,798.00
Percent of "	7.24	5.29	56.90	6.95	2.77

1/ N. C. Report of Department of Tax Research, 1942. 2/ Per capita tax calculated on U. S. Census of 1940.

Table 68. North Carolina Fisheries: Principal Species of Fish in All Years of Field Canvasses, 1880 to 1945; Quantities, Values, Percentages of Totals, and Prices.

1880

Food Fish

Species 1/	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewive	15,520	47.2	47.2
Mulle'	3,368	10.1	57.3
Shad	3,221	9.8	67.1
Oysters	1,190	3.6	70.7
Spotted sea trout	950	2.9	73.6
Bluefish	600	1.8	75.4
Sturgeon	437	1.3	76.7
Clams (hard)	310	.9	77.6
Terrapin	125	.4	78.0
All other food fish	7,183	21.8	100.0
Total food fish (No Menhaden in 1880)	32,902		

Species 1/	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	329,569	39.0	39.0	10.22
Alewives	142,784	16.9	55.9	.92
Mullet	80,500	9.5	65.4	2.39
Oysters	60,000	7.1	72.5	5.04
Spotted sea trout	23,000	2.7	75.2	2.42
Sturgeon	18,094	2.1	77.3	4.14
Clams (hard)	15,575	1.8	79.1	5.03
Bluefish	12,000	1.4	80.5	2.00
Terrapin	10,850	1.3	81.8	8.82
All other food fish	153,323	18.2	100.0	
Total food fish	845,695			

1/ The classifications and names of "species" in these tables are those which appear in the original reports of the U. S. Fish Commission, Bureau of Fisheries and Fish and Wildlife Service. Squeteague means the "sea trouts", gray, spotted, et cetera; black bass means the fresh water game fish, large-mouth black bass; the perch is _Morone americana_, the white perch found in both fresh and salt water.

Table 69. 1/

North Carolina--1887

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	17,818	59.4	59.4
Shad	4,746	15.8	75.2
Mullet	1,894	6.3	81.5
Oysters	1,176	3.9	85.4
Squeteague	766	2.5	87.9
Bluefish	640	2.1	90.0
Striped bass	500	1.7	91.7
Perch	410	1.4	93.1
Black bass	392	1.3	94.4
Porpoises	---	---	
All other food fish	1,711	5.6	100.0
Total food fish	30,053	67.0	
Menhaden, etc.	14,756	33.0	
Total all fish	44,809	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	298,069	39.5	39.5	5.23
Alewives	173,088	23.0	62.5	.97
Mullet	67,330	8.9	71.4	3.55
Oysters	48,353	6.4	77.8	4.11
Striped bass	24,944	3.3	81.1	4.99
Squeteague	22,473	3.0	84.1	2.93
Bluefish	21,313	2.8	86.9	3.33
Black bass	18,327	2.4	89.3	4.67
Perch	14,991	2.0	91.3	3.65
Porpoises	9,255	1.2	92.5	--
All other food fish	56,368	7.5	100.0	
Total food fish	754,511	97.6		
Menhaden, etc.	18,446	2.4		0.13
Total all fish	772,957	100.0		

--- Quantity not available.

1/ See footnotes on first table of this series.

Table 70. 1/ North Carolina - 1888.

Food Fish.

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu- lative
Alewives	15,346	53.2	53.2
Shad	5,693	19.7	72.9
Mullet	1,760	6.1	79.0
Oysters	1,130	3.9	82.9
Squeteague	811	2.8	85.7
Bluefish	737	2.6	88.3
Striped bass	560	1.9	90.2
Perch	437	1.5	91.7
Black bass	419	1.5	93.2
Porpoises	-----	---	
All other food fish	1,982	6.8	100.0
Total food fish	28,875	67.6	
Menhaden, etc.	13,844	32.4	
Total all fish	42,719	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu- lative	Price Cts./lb.
Shad	295,029	38.9	38.9	5.19
Alewives	161,553	21.3	60.2	1.05
Mullet	61,051	8.0	68.2	3.47
Oysters	46,129	6.1	74.3	4.08
Striped bass	27,981	3.7	78.0	5.00
Bluefish	25,032	3.3	81.3	3.40
Squeteague	24,284	3.2	84.5	2.99
Black bass	21,032	2.8	87.3	5.02
Porpoises	16,125	2.1	89.4	--
Perch	15,975	2.1	91.5	3.67
All other food fish	65,001	8.5	100.0	
Total food fish	759,192	97.8		
Menhaden, etc.	17,247	2.2		0.13
Total all fish	776,439	100.0		

1/ See footnotes on first table of this series.

Table 71. 1/

North Carolina - 1889

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	14,389	39.7	39.7
Oysters	5,530	15.2	54.9
Shad	5,356	14.7	69.6
Mullet	3,052	8.4	78.0
Squeteague	1,707	4.7	82.7
Bluefish	895	2.5	85.2
Perch	583	1.6	86.8
Striped bass	531	1.5	88.3
Black bass	420	1.2	89.5
All other food fish	3,847	10.5	100.0
Total food fish	36,310	79.8	
Menhaden, etc.	8,753	20.2	
Total all fish	45,546	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	280,198	29.8	29.8	5.24
Oysters	194,272	20.7	50.5	3.51
Alewives	145,383	15.5	66.0	1.01
Mullet	84,945	9.0	75.0	2.80
Squeteague	44,129	4.7	79.7	2.58
Striped bass	30,611	3.3	83.0	5.77
Perch	21,998	2.3	85.3	3.77
Black bass	21,152	2.3	87.6	5.04
Blue fish	20,877	2.2	89.8	2.36
All other food fish	95,344	10.2	100.0	
Total food fish	938,909	87.9		
Menhaden, etc.	11,518	12.1		0.13
Total all fish	950,427	100.0		

1/ See footnotes on first table of this series.

Table 72. 1/

North Carolina - 1890

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	16,481	43.2	43.2
Shad	5,768	15.2	58.4
Oysters	4,456	11.7	70.1
Mullet	3,585	9.4	79.5
Squeteague	1,886	4.9	84.4
Bluefish	1,345	3.5	87.9
Perch	609	1.6	89.5
Striped bass	568	1.5	91.0
Black bass	408	1.0	92.0
Quahogs	226	.6	92.6
All other food fish	2,862	7.4	100.0
Total food fish	38,194	75.5	
Menhaden, etc.	12,410	24.5	
Total all fish	50,604	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	306,015	30.3	30.3	5.31
Oysters	175,567	17.4	47.7	3.94
Alewives	164,636	16.3	64.0	1.00
Mullet	97,243	9.6	73.6	2.71
Squeteague	48,856	4.8	78.4	2.59
Bluefish	33,603	3.3	81.7	2.50
Striped bass	32,138	3.2	84.9	5.66
Perch	22,769	2.2	87.1	3.74
Black bass	20,492	2.0	89.1	5.02
Quahogs	12,090	1.2	90.3	5.35
All other food fish	98,089	9.7	100.0	
Total food fish	1,011,498	98.4		
Menhaden, etc.	16,171	1.6		0.13
Total all fish	1,027,669	100.0		

1/ See footnotes on first table of this series.

Table 73. 1/

North Carolina - 1897

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	15,790	30.6	30.6
Shad	8,963	17.4	48.0
Oysters	4,741	9.2	57.2
Mullet	3,410	6.6	63.8
Squeteague	3,090	6.0	69.8
Bluefish	1,696	3.3	73.1
Croakers	1,279	2.5	75.6
Crabs, hard)	40	.0	
" soft)	987	1.9	77.5
Clams	938	1.8	79.3
Spot	850	1.6	80.9
Striped bass	845	1.6	82.5
Perch	806	1.6	84.1
Black bass	535	1.1	85.2
Sturgeon	372	.7	85.9
Spanish mackerel	331	.6	86.5
All other food fish	6,980	13.5	100.0
Total food fish	51,653	80.7	
Menhaden, etc.	11,310	19.3	
Total all fish	62,963	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	362,811	28.0	28.0	4.05
Oysters	241,099	18.6	46.6	5.08
Alewives	127,055	9.8	56.4	0.81
Squeteague	95,219	7.3	63.7	3.08
Mullet	90,338	7.0	70.7	2.64
Striped bass	58,035	4.5	75.2	6.86
Clams	53,703	4.1	79.3	5.72
Bluefish	46,752	3.6	82.9	2.75
Perch	24,044	1.9	84.8	2.98
Black bass	23,611	1.8	86.6	4.41
Croakers	18,936	1.5	88.1	1.48
Spanish mackerel	18,017	1.4	89.5	5.44
Spot	14,197	1.1	90.6	1.67
Sturgeon	13,525	1.0	91.6	3.64
Crabs, hard)	1,000	.1)		2.50
" soft)	3,992	.3)	92.0	.40
All other food fish	103,983	8.0	100.0	
Total food fish	1,296,317	98.5		
Menhaden, etc.	19,700	1.5		0.17
Total all fish	1,316,017	100.0		

1/ See footnotes on first table of this series.

Table 74. 1/

North Carolina - 1902

Food Fish.

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative	Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Alewives	11,173	23.7	23.7	Shad	384,808	22.5	22.5	5.56
Mullet	6,705	14.2	37.9	Oysters	268,363	15.7	38.2	4.76
Shad	6,567	13.9	51.8	Mullet	187,643	11.0	49.2	2.80
Oysters	5,646	12.0	63.8	Squeteague	156,247	9.1	58.3	4.13
Squeteague	3,781	8.0	71.6	Alewives	116,212	6.8	65.1	1.04
Croaker	1,929	4.1	75.9	Striped bass	113,631	6.6	71.7	9.66
Clams	1,175	2.5	78.4	Clams	86,662	5.1	76.8	7.38
Striped bass	1,175	2.5	80.9	Perch	62,666	3.7	80.5	6.66
Bluefish	977	2.1	83.0	Black bass	58,013	3.4	83.9	9.17
Perch	941	2.0	85.0	Croaker	38,320	2.2	86.1	1.98
Spot	873	1.8	86.8	Bluefish	34,268	2.0	88.1	3.51
Hickory shad	685	1.5	88.3	Hickory shad	33,552	2.0	90.1	4.90
Black bass	633	1.3	89.6	Spot	20,116	1.2	91.3	2.31
Eels	507	1.0	90.6	Eels	19,962	1.2	92.5	3.99
Spanish mackerel	354	.7	91.3	Spanish mackerel	19,948	1.2	93.7	5.64
All other food fish	4,088	8.7	100.0	All other food fish	107,830	6.3	100.0	
Total food fish	47,209	71.5		Total food fish	1,708,241	98.2		
Menhaden, etc.	18,862	28.5		Menhaden, etc.	31,420	1.8		0.17
Total all fish	66,071	100.0		Total all fish	1,739,661	100.0		

1/ See footnotes on first table of this series.

Table 75. 1/

North Carolina - 1908

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative	Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Alewives	10,928	25.8	25.8	Shad	373,000	22.1	22.1	9.47
Mullet	5,070	11.9	37.7	Oysters	227,300	13.4	35.5	5.47
Squeteague	4,635	10.9	48.6	Squeteague	206,000	12.2	47.7	4.45
Oysters	4,159	9.8	58.4	Mullet	175,000	10.3	58.0	3.45
Shad	3,942	9.3	67.7	Alewives	140,000	8.3	66.3	1.28
Butterfish	1,302	3.1	70.8	Clams	82,000	4.8	71.1	11.30
Bluefish	1,256	3.0	73.8	Bluefish	45,000	2.7	73.8	3.58
Croaker	1,177	2.8	76.6	Perch, white	44,000	2.6	76.4	4.43
Perch, white	993	2.3	78.9	Black bass	40,000	2.4	78.8	7.83
Spot	852	2.0	80.9	Striped bass	36,000	2.1	80.9	7.06
Kingfish	817	1.9	82.8	Crabs, hard)	1,100	.1		.97
Clams	726	1.7	84.5	" soft)	33,000	1.9	82.9	11.91
Black bass	511	1.2	85.7	Spanish mackerel	34,000	2.0	84.9	7.44
Striped bass	510	1.2	86.9	Croaker	31,000	1.8	86.7	2.63
Catfish	504	1.2	88.1	Butterfish	29,000	1.7	88.4	2.30
Pigfish	476	1.1	89.2	Kingfish	28,000	1.7	90.1	3.43
Spanish mackerel	457	1.1	90.3	Hickory shad	20,000	1.2	91.3	5.31
Crabs, hard)	113	.3		Spot	16,000	.9	92.2	1.88
" soft)	277	.7	91.3	Pigfish	14,000	.8	93.0	2.94
Hickory shad	377	.9	92.2	Catfish	11,000	.7	93.7	2.18
All other food fish	3,319	7.8	100.0	All other food fish	107,500	6.3	100.0	
Total food fish	42,401	42.5		Total food fish	1,692,900	95.8		
Menhaden, etc.	57,490	57.5		Menhaden, etc.	74,300	4.2		0.13
Total all fish	99,891	100.0		Total all fish	1,767,200	100.0		

1/ See footnotes on first table of this series.

Table 76. 1/

North Carolina - 1918.

Food Fish.

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu- lative
Alewives	14,484	48.0	48.0
Squeteague	3,361	11.2	59.2
Shad	1,657	5.5	64.7
Spot	1,236	4.1	68.7
Oysters	1,198	4.0	72.4
Mullet	1,128	3.7	76.5
Shrimp	940	3.1	79.6
Butterfish	731	2.4	82.0
Perch, white	617	2.0	84.0
Black bass	551	1.8	85.8
Scallops	423	1.4	87.2
Croaker	387	1.3	88.5
Crabs, hard)	146	.5	
" soft)	234	.8	89.8
Bluefish	323	1.1	90.9
Striped bass	286	.9	91.8
Clams	197	.7	92.5
All other food fish	2,251	7.5	100.0
Total food fish	30,150	14.4	
Menhaden, etc.	179,931	85.6	
Total all fish	210,081	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu- lative	Price Cts./lb.
Alewives	401,219	24.0	24.0	2.77
Shad	376,696	22.6	46.6	22.70
Squeteague	209,493	12.6	59.2	6.24
Mullet	91,075	5.5	64.7	8.08
Oysters	70,280	4.2	68.9	5.86
Black bass	63,137	3.8	72.7	11.46
Spot	56,299	3.4	76.1	4.56
Clams	46,598	2.8	78.9	23.64
Striped bass	46,030	2.8	81.7	16.10
Scallops	31,618	1.9	83.6	7.48
Perch, white	31,150	1.9	85.5	5.05
Bluefish	29,677	1.8	87.3	9.19
Crabs, hard)	1,983	.1		1.36
" soft)	23,821	1.4	88.8	10.17
Butterfish	24,785	1.5	90.3	3.39
Shrimp	23,485	1.4	91.7	2.50
Croaker	11,912	.7	92.4	3.08
All other food fish	120,936	7.5	100.0	
Total food fish	1,669,194	56.0		
Menhaden, etc.	1,309,514	44.0		0.73
Total all fish	2,978,708	100.0		

1/ See footnotes on first table of this series.

Table 77. 1/

North Carolina - 1923

Food Fish.

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	6,522	21.0	21.0
Oysters	3,089	9.9	30.9
Gray trout	3,070	9.9	40.8
Shad	2,370	7.6	48.4
Croaker	2,262	7.3	55.7
Spot	1,751	5.7	61.4
Mullet	1,749	5.6	67.0
Shrimp	1,658	5.3	72.3
Spotted trout	914	3.0	75.3
Bluefish	897	2.9	78.2
King whiting	560	1.6	80.0
Scallops	554	1.8	81.8
Harvestfish	521	1.7	83.5
Crabs, hard)	331	1.1	
" soft)	182	.6	85.2
Striped bass	477	1.5	86.7
White perch	438	1.4	88.1
Pigfish	385	1.2	89.3
Hickory shad	381	1.2	90.5
Flounders	333	1.1	91.6
Black bass	321	1.0	92.6
Clams	263	..8	93.4
All other food fish	2,046	6.6	100.0
Total food fish	31,074	32.9	
Menhaden, etc.	63,290	67.1	
Total all fish	94,364	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	582,591	27.9	27.9	24.60
Oysters	229,576	11.0	38.9	7.43
Mullet	148,769	7.1	46.0	8.51
Gray trout	134,531	6.4	52.4	4.38
Alewives	119,404	5.7	58.1	1.83
Spotted trout	116,316	5.6	63.7	12.72
Striped bass	75,953	3.6	67.3	15.92
Bluefish	66,805	3.2	70.5	7.46
Clams	64,064	3.1	73.6	24.40
Spot	60,397	2.9	76.5	3.45
Croaker	53,993	2.6	79.1	2.39
Shrimp	50,772	2.4	81.5	3.06
Black bass	47,227	2.3	83.8	14.71
Scallops	46,214	2.2	86.0	8.35
White perch	33,749	1.6	87.6	7.71
Crabs, hard)	5,395	.3		1.63
" soft)	27,692	1.3	89.2	15.21
Hickory shad	29,598	1.4	90.6	7.77
Harvestfish	22,217	1.1	91.7	4.27
Flounders	22,039	1.1	92.8	6.62
King whiting	21,326	1.0	93.8	3.61
Pigfish	8,823	0.4	94.2	2.29
All other food fish	121,081	5.8	100.0	
Total food fish	2,088,532	86.5		
Menhaden, etc.	325,967	13.5		0.52
	2,414,499	100.0		

1/ See footnotes on first table of this series.

Table 78. 1/

North Carolina - 1927

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	13,911	31.3	31.3
Mullet	4,325	9.7	41.0
Croaker	3,932	8.9	49.9
Gray trout	3,581	8.1	58.0
Oysters	2,398	5.4	63.4
Shad	2,387	5.4	68.8
Spot	1,959	4.4	73.2
Shrimp	1,276	2.8	76.0
Crabs, hard)	956	2.2	
" soft)	269	.6	78.8
Spotted trout	953	2.2	81.0
Harvestfish	938	2.1	83.1
Bluefish	852	1.9	85.0
Scallops	835	1.9	86.9
Striped bass	738	1.7	88.6
Carp	632	1.4	90.0
Hickory shad	530	1.2	91.2
White perch	505	1.1	92.3
King whiting	487	1.1	93.4
Flounders	349	.8	94.2
Sea bass	316	.7	94.9
Clams	315	.7	95.6
All other food fish	1,965	4.4	100.0
Total food fish	44,409	31.0	
Menhaden, etc.	98,987	69.0	
Total all fish	143,396	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	475,292	20.7	20.7	19.93
Mullet	262,192	10.4	31.1	6.07
Oysters	200,742	8.7	39.8	8.37
Gray trout	162,215	7.0	46.8	4.53
Alewives	147,032	6.4	53.2	1.06
Scallops	119,767	5.2	58.4	14.35
Striped bass	119,481	5.2	63.6	16.20
Spotted trout	101,018	4.4	68.0	10.60
Croaker	77,385	3.4	71.4	1.97
Clams	70,940	3.1	74.5	22.50
Crabs, hard)	19,512	.8		2.04
" soft)	44,257	1.9	77.2	16.45
Bluefish	54,281	2.4	79.6	6.38
Shrimp	45,706	2.0	81.6	3.58
Spot	45,531	2.0	83.6	2.32
White perch	40,574	1.8	85.4	8.03
Carp	35,898	1.6	87.0	5.68
Hickory shad	35,328	1.5	88.5	6.66
Harvestfish	29,227	1.3	89.8	3.12
King whiting	27,733	1.2	91.0	5.70
Sea bass	25,248	1.1	92.1	8.00
Flounders	23,009	1.0	93.1	6.60
All other food fish	138,137	6.9	100.0	
Total food fish	2,300,505	83.4		
Menhaden, etc.	459,850	16.6		0.39
Total all fish	2,760,355	100.0		

1/ See footnotes on first table of this series.

Table 79. 1/

North Carolina - 1928

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumulative
Alewives	7,808	18.7	18.7
Croaker	6,775	16.2	34.9
Squeteague	5,127	12.3	47.2
Shad	3,118	7.5	54.7
Spot	2,954	7.1	61.8
Mullet	2,502	6.0	67.8
Oysters	2,287	5.5	73.3
Crabs, hard)	847	2.0	
" soft)	629	1.5	76.8
Scallops	1,394	3.3	80.1
Shrimp	845	2.0	82.1
Harvestfish	781	1.9	84.0
King whiting	780	1.9	85.9
Carp	755	1.8	87.7
Bluefish	754	1.8	89.5
Striped bass	507	1.2	90.7
Catfishes	483	1.1	91.8
White perch	458	1.1	92.9
Flounders	455	1.1	94.0
Sea bass	424	1.0	95.0
Clams	324	.7	95.7
All other food fish	1,813	4.3	100.0
Total food fish	41,820	29.6	
Menhaden, etc.	99,302	70.4	
Total all fish	141,122	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumulative	Price Cts./lb.
Shad	573,007	26.1	26.1	18.39
Squeteague	297,308	13.6	39.7	5.80
Oysters	167,490	7.6	47.3	7.33
Mullet	143,683	6.6	53.9	5.74
Scallops	125,845	5.7	59.6	9.03
Crabs, hard)	16,821	.8		1.99
" soft)	96,365	4.4	64.8	15.32
Alewives	110,727	5.0	69.8	1.42
Croaker	101,362	4.6	74.4	1.50
Striped bass	71,935	3.3	77.7	14.18
Spot	66,182	3.0	80.7	2.24
Clams	61,168	2.8	83.5	18.86
Bluefish	45,830	2.1	85.6	6.08
Carp	40,477	1.8	87.4	5.36
King whiting	34,053	1.6	89.0	4.37
Shrimp	30,447	1.4	90.4	3.60
White perch	30,367	1.4	91.8	6.63
Sea bass	27,674	1.3	93.1	6.58
Flounders	25,550	1.2	94.3	5.62
Harvestfish	19,537	.9	95.2	2.50
Catfishes	16,072	.7	95.9	3.33
All other food fish	91,266	4.1	100.0	
Total food fish	2,193,366	83.7		
Menhaden, etc.	430,998	16.3		0.43
Total all fish	2,624,364	100.0		

1/ See footnotes on first table of this series.

Table 80. 1/

North Carolina - 1929

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative	Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Alewives	10,767	24.6	24.6	Shad	350,424	19.3	19.3	18.30
Croaker	7,679	17.5	42.1	Squeteague	254,593	14.0	33.3	8.69
Squeteague	5,090	11.6	53.7	Oysters	245,633	13.5	46.8	5.00
Spot	3,310	7.5	61.2	Mullet	123,727	6.8	53.6	4.82
Oysters	2,828	6.4	67.6	Croaker	116,567	6.4	60.0	1.52
Mullet	2,568	5.9	73.5	Alewives	102,223	5.6	65.6	0.95
Shad	1,913	4.4	77.9	Spot	80,528	4.4	70.0	2.41
Crabs, hard)	855	1.9		Crabs hard)	15,170	.8		1.77
" soft)	351	.8	80.6	" soft)	52,620	2.9	73.7	14.99
Shrimp	897	2.1	82.7	Clams	59,843	3.3	77.0	15.74
Flounders	725	1.6	84.3	Bluefish	48,328	2.7	79.7	7.66
Scallops, bay	686	1.6	85.9	Flounders	47,511	2.6	82.3	6.56
Bluefish	631	1.4	87.3	Striped bass	41,224	2.3	84.6	16.76
Harvestfish	616	1.4	88.7	Scallops	37,960	2.1	86.7	5.54
Carp	527	1.2	89.9	Carp	36,804	2.0	88.7	6.98
Clams	380	.9	90.8	Shrimp	30,560	1.7	90.4	3.41
Sea bass	261	.6	91.4	Sea bass	20,354	1.1	91.5	7.80
Striped bass	246	.6	92.0	Harvestfish	14,029	.8	92.3	2.28
All other food fish	3,494	8.0	100.0	All other food fish	139,277	7.7	100.0	
Total food fish	43,824	20.3		Total food fish	1,817,375	71.7		
Menhaden, etc.	172,490	79.7		Menhaden, etc.	718,515	28.3		0.42
Total all fish	216,314	100.0		Total all fish	2,535,890	100.0		

1/ See footnotes on first table of this series.

Table 81. 1/

North Carolina - 1930

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	9,839	28.2	28.2
Croakers	5,708	16.4	44.6
Mullet	2,836	8.1	52.7
Gray trout	2,333	6.7	59.4
Spot	2,237	6.4	65.8
Oysters	2,206	6.3	72.1
Crabs, hard)	1,160	3.3	
" soft)	379	1.1	76.5
Shrimp	1,299	3.7	80.2
Shad	1,172	3.4	83.6
Bluefish	843	2.4	86.0
Spotted trout	694	2.0	88.0
Carp	470	1.3	89.3
Catfishes	460	1.3	90.6
Striped bass	457	1.3	91.9
White perch	442	1.3	93.2
Scallops	432	1.2	94.4
Flounders	350	1.0	95.4
Hickory shad	324	0.9	96.3
Clams	317	0.9	97.2
All other food fish	929	2.8	100.0
Total food fish	34,887	20.6	
Menhaden, etc.	134,051	79.4	
Total all fish	168,939	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	209,989	16.2	16.2	17.91
Oysters	155,148	11.9	28.1	7.04
Mullet	91,434	7.0	35.1	3.22
Gray trout	82,613	6.4	41.5	3.54
Crabs, hard)	18,995	1.5		1.64
" soft)	57,068	4.4	47.4	15.05
Croakers	75,419	5.8	53.2	1.48
Alewives	68,308	5.2	58.4	0.69
Striped bass	60,550	4.7	63.1	13.23
Spotted trout	58,271	4.5	67.6	8.40
Scallops	53,923	4.1	71.7	12.48
Bluefish	41,781	3.2	74.9	4.96
Shrimp	40,752	3.1	78.0	3.14
Clams	40,680	3.1	81.1	12.84
Spot	38,034	2.9	84.0	1.70
White perch	32,992	2.5	86.5	7.46
Carp	32,409	2.5	89.0	6.90
Catfishes	20,307	1.6	90.6	4.42
Flounders	17,458	1.3	91.9	4.99
Hickory shad	13,857	1.1	93.0	4.28
All other food fish	90,862	7.0	100.0	
Total food fish	1,300,850	70.1		
Menhaden, etc.	555,631	29.9		0.42
Total all fish	1,856,481	100.0		

1/ See footnotes on first table of this series.

Table 82. 1/

North Carolina - 1931

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative	Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Alewives	7,993	26.4	26.4	Shad	139,409	14.0	14.0	15.79
Croaker	4,310	14.2	40.6	Gray trout	103,926	10.5	24.5	3.47
Gray trout	2,994	9.9	50.5	Oysters	92,061	9.3	33.8	6.14
Crabs, hard)	1,852	6.1)		Alewives	80,723	8.1	41.9	1.01
" soft)	311	1.0)	57.6	Flounder	76,182	7.7	49.6	7.52
Mullet	2,124	7.0	64.6	Crabs, hard)	25,211	2.5)		1.36
				" soft)	46,586	4.7)	56.8	15.00
				Spotted trout	65,537	6.6	63.4	5.91
Spot	1,715	5.7	70.3	Croaker	56,796	5.7	69.1	1.32
Oysters	1,501	5.0	75.3	Scallops	50,250	5.1	74.3	10.15
Spotted trout	1,108	3.7	79.0					
Flounder	1,014	3.3	82.3	Mullet	43,952	4.4	78.7	2.07
Shad	883	2.9	85.2	Striped bass	34,526	3.5	82.3	10.59
Bluefish	676	2.2	87.4	Clams	30,775	3.1	85.4	9.27
Scallops	495	1.6	89.0	Spot	25,754	2.6	88.0	1.52
Shrimp	338	1.1	90.1	Bluefish	17,501	1.8	89.8	2.59
Clams	332	1.1	91.2	Carp	15,351	1.6	91.4	5.90
White perch	328	1.1	92.3	Shrimp	13,975	1.1	92.5	4.14
Striped bass	326	1.1	93.4	White perch	13,025	1.3	93.8	3.97
Butterfish	304	1.0	94.4	Catfishes	11,196	1.1	94.9	3.84
Catfishes	290	1.0	95.4	Butterfish	5,173	0.5	95.4	1.70
Carp	260	0.9	96.3					
All other food fish	1,130	3.7	100.0	All other food fish	45,453	4.6	100.0	
Total food fish	30,284	30.8		Total food fish	993,362	91.3		
Menhaden	67,877	69.2		Menhaden	94,196	8.7		0.14
Total all fish	98,161	100.0		Totel all fish	1,087,558	100.0		

1/ See footnotes on first table of this series.

Table 83. 1/

North Carolina - 1932

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative	Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lbs.
Alewives	6,584	20.7	20.7	Shad	125,926	16.8	16.8	13.60
Croaker	4,540	14.3	35.0	Spotted trout	78,363	10.4	27.2	4.13
Gray trout	3,636	11.5	46.5	Gray trout	64,097	8.5	35.7	1.76
Mullet	2,472	7.8	54.3	Striped bass	54,516	7.3	43.0	10.85
Spotted trout	1,896	6.0	60.3	Crabs, hard)	18,448	2.4)		.99
Crabs, hard)	1,848	5.8)		" soft)	33,921	4.5)	49.9	10.98
" soft)	309	1.0)	67.1	Mullet	51,685	6.9	56.8	2.09
Spot	1,587	5.0	72.1	Oysters	51,339	6.8	63.6	4.27
Oysters	1,201	3.8	75.9	Croaker	46,642	6.2	69.8	1.03
Harvestfish	1,077	3.4	79.3	Alewives	41,899	5.6	75.4	0.64
Shad	925	2.9	82.2	Flounder	32,797	4.3	79.7	4.15
White perch	832	2.6	84.8	White perch	21,302	2.8	82.5	2.56
Flounder	790	2.5	87.3	Spot	17,821	2.4	84.9	1.12
Bluefish	687	2.2	89.5	Clams	17,278	2.3	87.2	6.62
Catfishes	525	1.6	91.1	Bluefish	16,409	2.3	89.5	2.39
Striped bass	507	1.6	92.7	Harvestfish	11,858	1.5	91.0	1.10
Shrimp	292	0.9	93.6	Catfishes	9,600	1.3	92.3	1.83
Clams	261	0.8	94.4	Shrimp	9,393	1.3	93.6	3.22
All other food fish	1,769	5.6	100.0	All other food fish	48,314	6.4	100.0	
Total food fish	31,738	36.8		Total food fish	751,608	90.9		
Manhaden	54,476	63.2		Menhaden	75,135	9.1		0.14
Total all fish	86,214	100.0		Total all fish	826,743	100.0		

1/ See footnotes on first table of this series.

Table 84. 1/

North Carolina - 1934

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative
Alewives	14,897	26.2	26.2
Gray trout	7,729	13.6	39.8
Croaker	7,683	13.5	53.3
Crabs, hard)	4,544	8.0)	
" soft)	251	.4)	61.7
Spot	4,788	8.4	70.1
Mullet	3,889	6.8	76.9
Shrimp	2,564	4.5	81.4
Spotted trout	1,849	3.3	84.7
Bluefish	1,766	3.1	87.8
Shad	1,274	2.2	90.0
Oysters	1,161	2.0	92.0
Flounder	987	1.7	93.7
Harvestfish	820	1.4	95.1
White perch	522	0.9	96.0
Striped bass	362	0.6	96.6
Clams	338	0.6	97.2
All other food fish	1,387	2.4	100.0
Total food fish	56,811	34.8	
Menhaden	106,651	65.2	
Total all fish	163,462	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Shad	193,187	14.7	14.7	15.17
Gray trout	180,588	13.7	28.4	2.34
Mullet	105,289	8.0	36.4	2.71
Crabs, hard)	67,238	5.1)		1.48
" soft)	36,210	2.8)	44.3	14.42
Spotted trout	96,165	7.3	51.6	5.20
Croaker	91,058	6.9	58.5	1.17
Alewives	90,901	6.9	65.4	0.61
Shrimp	80,367	6.1	71.5	3.13
Spot	73,035	5.5	77.0	1.53
Bluefish	63,515	4.8	81.8	3.60
Oysters	53,092	4.0	85.8	4.57
Flounder	42,150	3.2	89.0	4.27
Striped bass	35,675	2.7	91.7	9.86
Clams	33,647	2.6	94.3	9.96
White perch	22,343	1.7	96.0	4.28
Harvestfish	12,325	1.0	97.0	1.50
All other food fish	39,967	3.0	100.0	
Total food fish	1,316,752	78.7		
Menhaden	355,503	21.3		0.33
Total all fish	1,672,225	100.0		

1/ See footnotes on first table of this series.

Table 85, 1/

North Carolina - 1936

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative	Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Alewives	11,928	17.1	17.1	Gray trout	314,192	14.7	14.7	3.50
				Mullet	222,291	10.4	25.1	3.44
Croaker	9,743	14.0	31.1	Crabs, hard)	132,316	6.2)		2.76
Gray trout	8,969	12.9	44.0	" soft)	60,486	2.8)	34.1	28.00
				Shad	176,627	8.3	42.4	16.00
Spot	7,443	10.7	54.7	Spot	166,683	7.8	50.2	2.24
Crabs, hard)	6,375	9.1)						
" soft)	216	.3)	64.1	Oysters	160,631	7.5	57.7	6.48
Mullet	6,471	9.3	73.4	Alewives	129,675	6.1	63.8	1.09
Shrimp	3,815	5.5	78.9	Shrimp	119,541	5.6	69.4	3.13
Oysters	2,480	3.6	82.5	Bluefish	109,618	5.1	74.5	5.41
Bluefish	2,028	2.9	85.4	Croaker	104,726	4.9	79.4	1.09
Spotted trout	1,399	2.0	87.4	Spotted trout	88,408	4.1	83.5	6.32
King whiting	1,216	1.7	89.1	Clams	75,326	3.5	87.0	8.98
Flounder	1,175	1.7	90.8	Flounder	66,920	3.1	90.1	5.69
Shad	1,095	1.6	92.4	Striped bass	61,257	2.9	93.0	7.98
Harvestfish	893	1.3	93.7	King whiting	31,493	1.5	94.5	2.59
Clams	839	1.2	94.9	Spanish mackerel	21,614	1.0	95.5	5.00
Striped bass	768	1.1	96.0	Harvestfish	11,300	0.5	96.0	1.27
Spanish mackerel	435	0.6	96.6					
All other food fish	2,504	3.4	100.0	All other food fish	82,519	4.0	100.0	
Total food fish	69,790	31.7		Total food fish	2,135,624	78.1		
Menhaden	150,088	68.3		Menhaden	599,145	21.9		0.40
Total all fish	219,878	100.0		Total all fish	2,734,769	100.0		

1/ See footnotes on first table of this series.

Table 86. 1/

North Carolina - 1937

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu- lative	Species	Value	Per Cent of Total Value Food Fish	Cumu- lative	Price Cts./lb.
Croaker	9,988	19.6	19.6	Gray trout	214,029	14.9	14.9	2.85
Gray trout	7,525	14.7	34.3	Mullet	134,043	9.3	24.2	3.37
Alewives	5,818	11.4	45.7	Shrimp	125,502	8.7	32.9	3.00
Spot	5,270	10.3	56.0	Croaker	118,349	8.2	41.1	1.18
Shrimp	4,184	8.2	64.2	Oysters	112,051	7.8	48.9	5.78
Mullet	3,974	7.8	72.0	Shad	106,151	7.4	56.3	15.21
Crabs, hard)	3,246	6.4)		Spot	91,195	6.3	62.6	1.71
" soft)	142	.3)	78.7					
Oysters	1,941	3.8	82.5	Bluefish	82,011	5.7	68.3	4.95
				Spotted trout	73,701	5.1	73.4	8.18
Bluefish	1,657	3.2	85.7	Crabs, hard)	51,538	3.6)		1.59
				" soft)	22,600	1.6)	78.6	15.92
Spotted trout	901	1.8	87.5					
King whiting	722	1.4	88.9	Striped bass	69,424	4.8	83.4	9.74
Striped bass	713	1.4	90.3	Alewives	58,461	4.1	87.5	1.01
Shad	698	1.4	91.7	Clams	34,343	2.4	89.9	7.99
Catfishes	653	1.3	93.0	King whiting	21,596	1.5	91.4	2.99
Harvestfish	641	1.2	94.2	Flounder	20,190	1.4	92.8	5.00
Drum, red	441	0.9	95.1	Catfishes	18,478	1.3	94.1	2.83
Clams	430	0.8	95.9	Drum, red	14,777	1.0	95.1	3.35
Flounder	404	0.8	96.7	Harvestfish	10,368	0.7	95.8	1.62
All other food fish	1,701	3.3	100.0	All other food fish	59,953	4.2	100.0	
Total food fish	51,049	45.2		Total food fish	1,438,760	86.8		
Menhaden	61,706	54.8		Menhaden	219,531	13.2		0.36
Total all fish	112,755	100.0		Total all fish	1,658,291	100.0		

1/ See footnotes on first table of this series.

Table 87. 1/

North Carolina - 1938

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu- lative	Species	Value	Per Cent of Total Value Food Fish	Cumu- lative	Price Cts./lb.
Alewives	11,219	21.6	21.6	Gray trout	195,849	12.8	12.8	3.85
Croaker	6,475	12.5	34.1	Shad	164,571	10.8	23.6	15.95
				Shrimp	137,469	9.0	32.6	3.01
Spot	5,738	11.0	45.1	Mullet	127,959	8.4	41.0	3.91
Gray trout	5,095	9.8	54.9					
Shrimp	4,569	8.8	63.7	Alewives	112,211	7.4	48.4	1.26
Crabs, hard)	3,830	7.4)						
" soft)	124	.2)	71.3	Oysters	98,468	6.5	54.9	6.90
Mullet	3,276	6.3	77.6	Bluefish	96,508	6.3	61.2	5.22
Bluefish	1,849	3.6	81.2	Croaker	91,373	6.0	67.2	1.41
King whiting	1,573	3.0	84.2	Crabs, hard)	72,455	4.8)		1.89
				" soft)	18,652	1.2)	73.2	15.04
Oysters	1,427	2.8	87.0	Spot	88,677	5.8	79.0	1.55
				Spotted trout	67,131	4.4	83.4	7.91
Shad	1,032	2.0	89.0	Striped bass	48,628	3.2	86.6	9.30
Spotted trout	848	1.6	90.6					
Catfishes	718	1.4	92.0	King whiting	47,464	3.1	89.7	3.02
Shark	581	1.1	93.1	Clams	27,756	1.8	91.5	7.76
Drum, red	530	1.0	94.1	Flounder	25,000	1.6	93.1	5.00
Striped bass	523	1.0	95.1	Catfishes	21,392	1.4	94.5	2.98
Flounder	501	1.0	96.1	Drum, red	18,000	1.2	95.7	3.40
Clams	358	0.7	96.8	Shark	1,744	1.1	96.8	3.00
All other food fish	1,680	3.2	100.0	All other food fish	62,266	4.1	100.9	
Total food fish	51,946	26.1		Total food fish	1,523,573	78.1		
Menhaden	146,819	73.9		Menhaden	426,503	21.9		0.29
Total all fish	198,765	100.0		Total all fish	1,950,076	100.0		

1/ See footnotes on first table of this series.

Table 88. 1/

North Carolina - 1939

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu-lative	Species	Value	Per Cent of Total Value Food Fish	Cumu-lative	Price Cts./lb.
Alewives	7,714	18.2	18.2	Shrimp	161,122	12.1	12.1	3.35
Croaker	5,058	11.9	30.1	Shad	137,310	10.3	22.4	15.98
Shrimp	4,811	11.3	41.4	Mullet	102,660	7.7	30.1	3.60
Spot	4,469	10.5	51.9	Gray trout	87,283	6.5	36.6	3.07
				Croaker	85,095	6.4	43.0	1.68
				Spotted trout	84,694	6.4	49.4	6.34
Crabs, hard)	2,854	6.7)		Crabs, hard)	53,574	4.0)		1.88
" soft)	173	.4)	59.0	" soft)	26,030	2.0)	55.4	15.05
Gray trout	2,840	6.7	65.7					
Mullet	2,854	6.7	72.4	Spot	78,378	5.9	61.3	1.75
King whiting	1,464	3.4	75.8	Alewives	77,183	5.8	67.1	1.00
Spotted trout	1,334	3.1	78.9					
Catfishes	1,215	2.9	81.8	Oysters	72,964	5.4	72.5	6.90
Oysters	1,056	2.5	84.3	Flounder	51,247	3.8	76.3	5.24
Bluefish	1,009	2.4	86.7	Clams	50,360	3.8	80.1	8.02
Flounder	978	2.3	89.0	Bluefish	50,297	3.8	83.9	4.99
Harvestfish	891	2.1	91.1	King whiting	45,401	3.4	87.3	3.10
Shad	859	2.0	93.1	Catfishes	37,250	2.8	90.1	3.06
Clams	628	1.5	94.6	Striped bass	33,755	2.5	92.6	9.96
Striped bass	339	0.8	95.4	Harvestfish	21,040	1.6	94.2	2.36
Carp	294	0.7	96.1	Carp	20,018	1.5	95.7	6.82
All other food fish	1,649	3.9	100.0	All other food fish	57,908	4.3	100.0	
Total food fish	42,489	19.0		Total food fish	1,333,569	70.5		
Menhaden	181,968	81.0		Menhaden	556,844	29.5		0.31
Total all fish	224,457	100.0		Total all fish	1,890,413	100.0		

1/ See footnotes on first table of this series.

Table 89. 1/

North Carolina - 1940

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumu- lative
Alewives	8,707	21.2	21.2
Croaker	4,310	10.5	31.7
Crabs, hard)	4,008	9.8	
" soft)	286	0.7	42.2
Shrimp	4,156	10.1	52.3
Spot	4,081	10.0	62.3
Gray trout	3,629	8.8	71.1
Mullet	2,096	5.1	76.2
Catfishes	1,317	3.2	79.4
Spotted trout	1,158	2.8	82.2
Shad	801	2.0	84.2
Oysters	690	1.7	85.9
King whiting	683	1.7	87.6
Striped bass	540	1.3	88.9
Clams	530	1.3	90.2
Flounder	498	1.2	91.4
Bluefish	448	1.1	92.5
Carp	438	1.1	93.6
Harvestfish	434	1.1	94.7
Sea bass	306	0.8	95.5
All other food fish	1,873	4.5	100.0
Total food fish	40,989	24.0	
Menhaden, etc.	129,592	76.0	
Total all fish	170,581	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumu- lative	Price Cts./lb.
Gray trout	181,645	13.2	13.2	5.00
Shrimp	124,695	9.0	22.2	3.00
Shad	119,505	8.6	30.8	14.93
Crabs, hard)	75,957	5.5		1.90
" soft)	42,900	3.1	39.4	15.00
Alewives	108,856	7.9	47.3	1.25
Spotted trout	92,672	6.7	54.0	8.00
Croaker	86,208	6.2	60.2	2.00
Mullet	83,836	6.1	66.3	4.00
Spot	72,032	5.2	71.5	1.77
Striped bass	59,389	4.3	75.8	11.00
Oysters	52,560	3.8	79.6	7.62
Catfishes	46,116	3.4	83.0	3.50
Clams	45,067	3.3	86.3	8.50
Bluefish	35,844	2.6	88.9	8.00
Flounder	34,814	2.5	91.4	7.75
King whiting	20,502	1.5	92.9	3.00
Carp	19,662	1.4	94.3	4.50
Sea bass	13,784	1.0	95.3	4.58
Harvestfish	12,735	0.9	96.2	2.94
All other food fish	50,671	3.8	100.0	
Total food fish	1,379,450	74.0		
Menhaden, etc.	485,164	26.0		0.38
Total all fish	1,864,614	100.0		

1/ See footnotes on first table of this series.

Table 90. 1/

North Carolina - 1945

Food Fish

Species	Quantity Pounds '000	Per Cent of All Food Fish	Cumulative
Shrimp	10,614	18.7	18.7
Alewives	8,022	14.2	32.9
Spot	6,265	11.1	44.0
Crabs, hard)	5,696	10.1)	
" soft)	184	.3)	54.4
Gray trout	4,737	8.4	62.8
Croaker	4,215	7.4	70.2
Mullet	3,241	5.7	75.9
Oysters	1,707	3.0	78.9
Flounders	1,204	2.1	81.0
Catfishes	1,172	2.1	83.1
King whiting	1,158	2.0	85.1
Shad	912	1.6	86.7
Carp	882	1.6	88.3
Shad, hickory	854	1.5	89.8
Harvestfish	812	1.4	91.2
Bluefish	627	1.1	92.3
Striped bass	608	1.1	93.4
Spanish mackerel	507	.9	94.3
Clams, hard	502	.9	95.2
White perch	501	.9	96.1
Spotted trout	500	.9	97.0
All other food fish	1,716	3.0	100.0
Total food fish	56,636	28.6	
Menhaden	141,533	71.4	
Total all fish	198,169	100.0	

Species	Value	Per Cent of Total Value Food Fish	Cumulative	Price Cts./lb.
Shrimp	849,160	18.8	18.8	8.00
Gray trout	525,422	11.6	30.4	11.08
Oysters	400,210	8.8	39.2	23.47
Croakers	337,208	7.5	46.7	8.00
Crabs, hard)	284,820	6.3)		5.00
" soft)	55,290	1.2)	54.2	30.00
Spot	314,235	7.0	61.2	5.00
Mullet	259,296	5.7	66.9	8.00
Shad	198,613	4.4	71.3	21.78
Alewives	176,783	3.9	75.2	2.20
Clams, hard	151,447	3.3	78.5	30.17
Flounders	141,232	3.1	81.6	11.73
Striped bass	121,156	2.7	84.3	19.90
Spotted trout	99,651	2.2	86.5	20.00
Catfishes	75,786	1.7	88.2	6.47
Bluefish	75,600	1.7	89.9	12.05
Hickory shad	68,224	1.5	91.4	8.00
Spanish mackerel	60,804	1.4	92.8	12.00
White perch	60,240	1.3	94.1	12.00
King whiting	57,925	1.3	95.4	5.00
Harvestfish	48,902	1.1	96.5	6.02
Carp	26,463	.6	97.1	3.00
All other food fish	132,154	2.9	100.0	
Total food fish	4,520,621	82.2		
Menhaden	974,631	17.8		0.70
Total all fish	5,495,252	100.0		

1/ See footnotes on first table of this series.

Table 91. Production and Value of Principal Commercial Fishes in North Carolina. 1887-1945.

	Alewives		Black bass		Bluefish		Butterfish	
	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value
1887	17,818	173,088	392	18,327	640	21,313	-	-
1888	15,346	161,553	419	21,032	737	25,032	-	-
1889	14,389	145,383	420	21,152	895	20,877	-	-
1890	16,481	164,636	408	20,492	1,345	33,603	-	-
1897	15,790	127,055	535	23,611	1,696	46,752	95	1,758
1902	11,173	116,212	633	58,013	977	34,268	83	1,357
1908	10,928	140,000	511	40,000	1,256	45,000	1,302	29,000
1918	14,484	401,219	551	63,137	323	29,677	731	24,785
1923	6,522	119,404	321	47,227	897	66,805	299	14,625
1927	13,911	147,032			852	54,281	342	11,095
1928	7,808	110,727			754	45,830	112	2,576
1929	10,767	102,223			631	48,328	76	1,853
1930	9,839	68,308			843	41,781	183	4,301
1931	7,993	80,723			676	17,501	304	5,173
1932	6,584	41,899			687	16,409	55	786
1934	14,897	90,901			1,766	63,515	44	745
1936	11,928	129,675			2,028	109,618	358	5,528
1937	5,818	58,461			1,657	82,011	13	370
1938	11,219	112,211			1,849	96,508	15	453
1939	7,714	77,183			1,009	50,297	47	1,251
1940	8,707	108,856			448	35,844	44	2,639
1945	8,022	176,783			627	75,600	30	1,800

Table 31 (contd).

	Carp		Catfishes		Clams		Crabs, hard		Crabs, soft	
	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value
1887	-	-	19	564	78	3,233	47 1/	1,105 1/		
1888	-	-	19	581	148	6,150	47 1/	1,110 1/		
1889	-	-	55	1,248	155	8,265	50 1/	1,250 1/		
1890	-	-	54	1,246	226	12,090	47 1/	1,185 1/		
1897	-	-	192	4,646	938	55,703	40	1,000	987	3,992
1902	47	2,116	405	11,971	1,175	86,662	3	100	200	14,553
1908	228	7,000	504	11,000	726	82,000	113	1,100	277	33,000
1918	155	5,619	305	9,783	197	46,598	146	1,983	234	23,821
1923	209	10,438	255	6,877	263	64,064	331	5,395	182	27,692
1927	632	35,898	453	14,771	315	70,940	956	19,512	269	44,257
1928	755	40,477	483	16,072	324	61,168	847	16,821	629	96,365
1929	527	36,804	399	16,699	380	59,843	855	15,170	351	52,620
1930	470	32,409	460	20,307	317	40,680	1,160	18,995	379	57,068
1931	260	15,351	290	11,196	332	30,775	1,852	25,211	311	46,586
1932	128	6,640	525	9,600	261	17,278	1,848	18,448	309	33,921
1934	109	4,316	163	3,173	338	35,647	4,544	67,238	251	36,210
1936	511	14,108	471	9,446	839	75,326	6,375	132,316	216	60,486
1937	324	6,923	653	18,478	430	34,343	3,246	51,538	142	22,600
1938	224	2,934	718	21,392	358	27,756	3,830	72,455	124	18,652
1939	294	20,018	1,215	37,250	628	50,360	2,854	53,574	173	26,030
1940	438	19,662	1,317	46,116	530	45,067	4,008	75,957	286	42,900
1945	882	26,463	1,172	75,786	502	151,447	5,696	284,820	184	55,290

1/ Not separated - hard and soft.

Table 91(contd).

	Croaker		Eels		Flounder		Harvestfish		Hickory shad	
	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value
1887	- 2/	- 2/	6	297			-	-	197	6,062
1888	- 2/	- 2/	7	486			-	-	192	6,253
1889	286	7,172	55	3,476	48	872	-	-	-	-
1890	311	7,867	161	9,726	49	894	-	-	-	-
1897	1,279	18,936	97	4,051	174	3,199	-	-	231	7,583
1902	1,929	38,320	507	19,962	262	5,256	-	-	685	33,552
1908	1,177	31,000	258	5,600	403	16,000	-	-	377	20,000
1918	387	11,912	175	13,333	91	7,022	-	-	158	13,388
1923	2,262	53,993	180	17,036	333	22,039	521	22,217	381	29,598
1927	3,932	77,385	160	12,340	349	23,009	938	29,227	530	35,328
1928	6,775	101,362	77	5,753	455	25,550	781	19,537	397	19,269
1929	7,679	116,567	107	6,644	725	47,511	616	14,029	319	17,557
1930	5,708	75,419	142	10,787	350	17,458	343	10,111	324	13,857
1931	4,310	56,796	114	6,672	1,014	76,182	48	968	192	5,877
1932	4,540	46,642	57	1,877	790	32,797	1,077	11,858	117	4,055
1934	7,683	91,058	44	2,043	987	42,150	820	12,325	100	4,634
1936	9,743	104,726	64	3,426	1,175	66,920	893	11,300	221	6,604
1937	9,988	118,349	91	2,539	404	20,190	641	10,368	160	4,320
1938	6,475	91,373	112	3,806	501	25,000	429	12,941	111	2,479
1939	5,058	85,095	75	4,352	978	51,247	891	21,040	253	7,062
1940	4,310	86,208	78	3,905	498	34,814	434	12,735	336	11,768
1945	4,215	337,208	116	5,581	1,204	141,232	812	48,902	854	68,224

2/ Spot and Croaker combined in 1887 and 1888.

Table 91 (contd.).

	King whiting		Menhaden		Mullet		Oysters			Pigfish	
	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Bushels 1/	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value
1887	19	790	14,756	18,446	1,894	67,330	212,980	1,176	48,353		
1888	20	800	13,644	17,247	1,760	61,051	204,703	1,130	46,129		
1889	31	1,062	8,753	11,518	3,052	84,945	1,001.620	5,530	194,272		
1890	35	1,231	12,410	16,171	3,585	97,243	807,260	4,456	175,567		
1897	45	1,133	11,310	19,700	3,410	90,338	858,818	4,741	241,099		
1902	120	3,395	18,862	31,420	6,705	187,643	1,022,813	5,646	268,363		
1908	817	28,000	57,412	70,000	5,070	175,000	753,500	4,159	227,300	476	14,000
1918	—	—	179,910	1,306,489	1,128	91,075	216,962	1,198	70,280		
1923	560	21,326	63,290	325,967	1,749	148,769	559,628	3,089	229,576	385	8,823
1927	487	27,733	98,987	489,250	4,325	262,192	434,375	2,398	200,742		
1928	780	34,053	99,302	430,998	2,502	143,683	414,241	2,287	167,490		
1929	387	15,191	173,490	718,515	2,568	123,727	512,395	2,828	245,633		
1930	272	11,165	134,051	535,631	2,836	91,434	411,354	2,206	155,148		
1931	181	5,396	67,877	94,196	2,124	43,952	251,352	1,501	92,061		
1932	300	4,033	54,476	75,135	2,472	51,685	210,395	1,201	51,339		
1934	302	7,240	106,651	355,503	3,889	105,289	208,012	1,161	53,092		
1936	1,216	31,493	150,088	599,145	6,471	222,291	500,101	2,480	160,631		
1937	722	21,596	61,706	219,531	3,974	134,043	351,612	1,941	112,051		
1938	1,573	47,464	146,619	426,503	3,276	127,959	334,170	1,427	98,468		
1939	1,464	45,401	181,968	556,844	2,854	102,660	313,234	1,056	72,964		
1940	683	20,502	129,592	485,164	2,096	83,836	204,260	690	52,560		
1945	1,158	57,925	141,533	974,631	3,241	259,296	534,254	1,707	400,210	481	33,649

1/ North Carolina State bushel 2801.9 cu. in.

Table 91 (contd).

	Scallops		Sea bass		Shad 1/		Shrimp		Spanish mackerel	
	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value
1887	4	160	15	575	4,746	298,069	120	4,503	-	-
1888	4	180	15	610	5,693	295,029	124	4,650	-	-
1889	16	700	29	939	5,356	280,198	135	5,100	63	5,165
1890	18	800	33	1,158	5,768	306,015	144	5,435	92	6,254
1897	118	5,653	189	5,564	8,963	362,811	146	5,885	331	18,017
1902	13	980	57	1,929	6,567	384,808	84	2,700	354	19,948
1908	-	-	72	3,200	3,942	373,000	371	9,000	457	34,000
1918	423	31,618	112	10,928	1,657	376,696	940	23,485	149	14,270
1923	554	46,214	102	8,217	2,370	582,591	1,658	50,772	183	18,740
1927	835	119,767	316	25,248	2,387	475,292	1,276	45,706	200	21,163
1928	1,394	125,845	424	27,874	3,118	573,007	845	30,447	176	15,079
1929	686	37,960	261	20,354	1,913	350,424	897	30,560	142	14,024
1930	432	53,925	173	7,975	1,172	209,989	1,299	40,752	131	11,776
1931	495	50,250	157	5,910	883	139,409	338	13,975	84	6,332
1932	91	6,560	202	6,251	925	125,926	292	9,393	78	3,660
1934	36	6,000	75	3,045	1,274	193,187	2,564	80,367	48	2,358
1936	99	14,175	107	4,280	1,095	176,627	3,815	119,541	433	21,614
1937	62	11,680	118	5,735	698	106,151	4,184	125,502	219	10,930
1938	30	7,971	66	3,320	1,032	164,571	4,569	137,469	271	13,520
1939	33	6,660	107	4,355	859	157,310	4,811	161,122	232	11,103
1940	34	3,685	306	13,784	801	119,505	4,156	124,695	141	8,466
1945	22	7,770	191	28,590	912	193,613	10,614	849,160	507	60,804

1/ N. C. shad in 1896: 8,842,708 lbs., $417,243. (Stevenson, Rept. U. S. Comm'r. Fish., 1898 (1899), p. 122.)

Table 91 (contd).

	Spot		Squeteague 3/		Spotted trout		Gray trout	
	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value
1887	- 2/	- 2/	766	22,473	-	-	-	-
1888	- 2/	- 2/	811	24,284	-	-	-	-
1889	360	8,797	1,707	44,129	- See	-	- See	-
1890	408	10,862	1,886	48,856	-	-	-	-
1897	850	14,197	3,090	95,219	- note	-	- note	-
1902	873	20,116	3,731	156,247	-	-	-	-
1908	852	16,000	4,635	206,000	- 3/	-	- 3/	-
1918	1,236	56,299	3,361	209,493	-	-	-	-
1923	1,751	60,397	3,984	250,847	914	116,316	3,070	134,531
1927	1,959	45,531	4,534	263,233	953	101,018	3,581	162,215
1928	2,954	66,182	5,127	297,308				
1929	3,310	80,528	5,090	254,593				
1930	2,237	38,034	3,027	140,884	694	58,271	2,333	82,613
1931	1,715	25,754	4,102	169,463	1,108	65,537	2,994	103,926
1932	1,587	17,821	5,532	142,460	1,896	78,363	3,636	64,097
1934	4,788	73,035	9,578	276,753	1,849	96,165	7,729	180,588
1936	7,443	166,633	10,368	402,661	1,399	88,409	8,969	314,192
1937	5,270	91,195	8,426	287,730	901	73,701	7,525	214,029
1938	5,738	88,677	5,943	262,980	848	67,131	5,095	195,849
1939	4,469	78,378	4,174	171,977	1,334	84,694	2,840	87,283
1940	4,081	72,032	4,787	274,317	1,158	92,672	3,629	181,645
1945	6,265	314,235	5,237	625,073	500	99,651	4,737	525,422

2/ Spot and Croaker combined in the records of 1887 and 1888.

3/ Spotted and gray "trout" combined as Squeteague and not shown separately prior to 1923.

Table 91 (contd).

	Striped bass		White perch	
	Quantity Pounds (000)	Value	Quantity Pounds (000)	Value
1887	500	24,944	410	14,991
1888	560	27,981	437	15,975
1889	531	30,611	583	21,998
1890	568	32,138	609	22,769
1897	845	58,035	806	24,044
1902	1,175	113,631	941	62,666
1908	510	36,000	993	44,000
1918	286	46,030	617	31,150
1923	477	75,953	438	33,749
1927	738	119,481	505	40,574
1928	507	71,935	458	30,367
1929	246	41,224	221	15,439
1930	457	60,550	442	32,992
1931	326	34,526	328	13,025
1932	507	54,516	832	21,302
1934	362	35,675	522	22,343
1936	768	61,257	193	10,217
1937	713	69,424	161	6,481
1938	523	48,628	146	6,212
1939	339	33,755	111	4,001
1940	540	59,389	108	3,795
1945	608	121,156	501	60,240

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