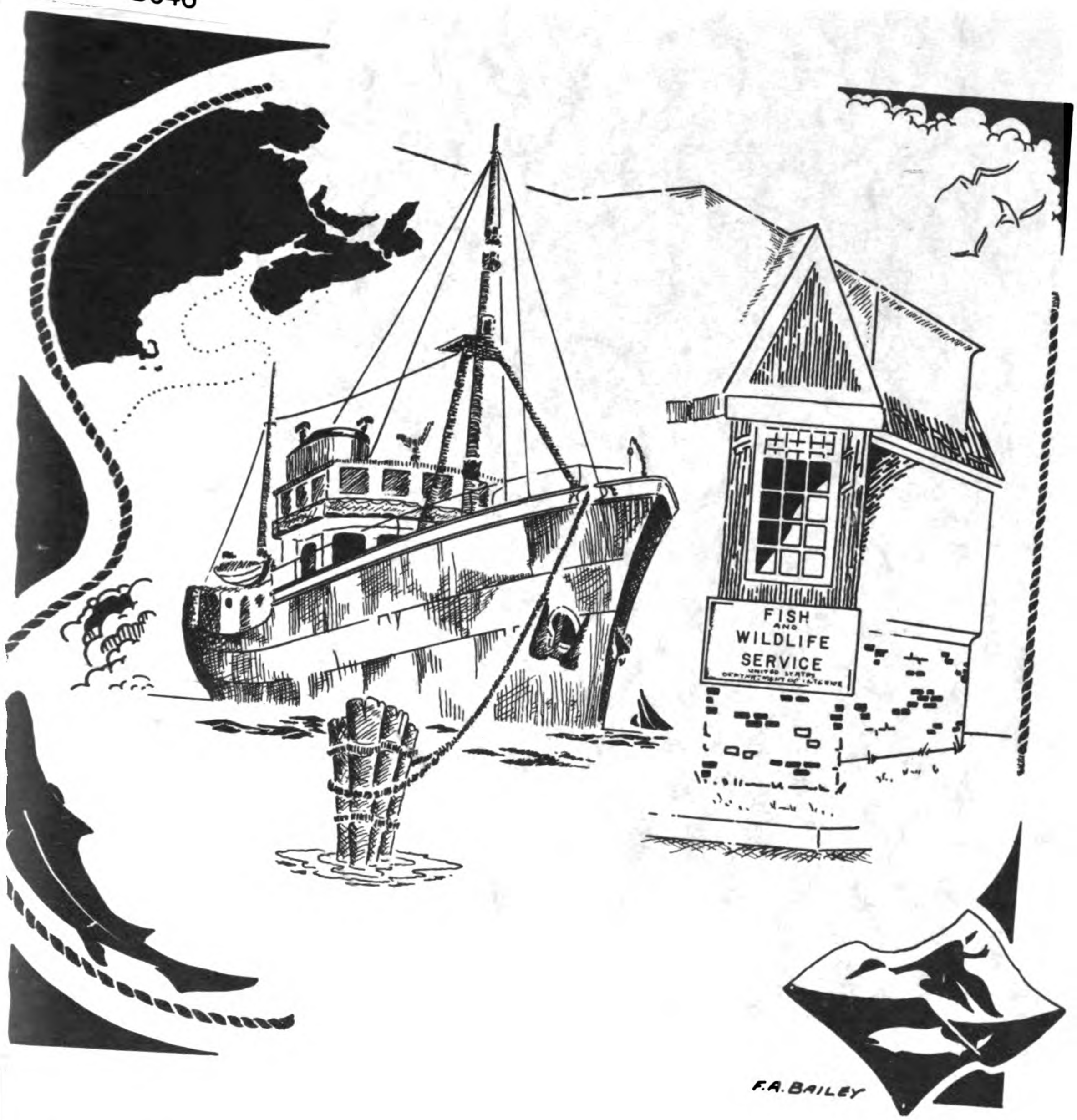
ANNUAL REPORT

WOODS HOLE LABORATORY
JUNE 30, 1959



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH & WILDLIFE SERVICE
UREAU OF COMMERCIAL FISHERIES
IRCULAR 80

United States Department of the Interior, Fred A. Seaton, Secretary
Fish and Wildlife Service, Arnie J. Suomela, Commissioner

ANNUAL REPORT

of the

BIOLOGICAL LABORATORY

Woods Hole, Mass.

for the year ending June 30, 1959

Herbert W. Graham, Director
Bureau of Commercial Fisheries

Circular 80

Washington, D. C.
January, 1960

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Fourth Annual NAFI Conference

Front row: Wentworth, Couture, Philbrook, Mahoney, Jensen, Graham, Moore, Mackesy, Oberacker, Merrill, Livingstone, Donovan, Haberland, Cogswell. Rear: Wigley, Thibodeau, Bocken, Posgay, Bailey, Chase, Clarke, Gallagher, Malone, Watson, Kallio, Fritz, Lux, Barker, Crossen, Theroux, Marak, Lawday, McDermott, Swain, Callahan, Kelly, Horrell, Dreyer, Nichy.

REPORT OF THE LABORATORY DIRECTOR

Herbert W. Graham

Introduction

As in past years, the research program of the Laboratory has been directed primarily toward problems associated with the offshore groundfish and sea scallops upon which the New England fishing industry is mainly dependent. The major groundfish species concerned are cod, haddock, redfish, whiting, and the species taken by the industrial trawl fishery.

Since the bulk of the groundfish are landed from offshore grounds our researches on these species are necessarily concentrated in the offshore areas. However, this year a number of activities have focused attention on the inshore areas as well.

Cod and haddock are protected by international mesh regulation in offshore waters but not in U. S. territorial waters. Some of the haddock continue to elude complete and uniform protection by moving inshore during part of the year. Our research group was called upon to identify the stocks which are taken within the inshore areas. The fish taken inshore are part of the offshore stock, but there is no evidence yet that lack of protection in these areas constitutes a serious conservation situation. The quantity of small haddock taken here is not at present sufficient to cause alarm.

To obtain more information regarding the seasonal migrations of haddock and their relation to environmental conditions a fishing station off Provincetown, just at the edge of territorial waters, was selected for year-round observation. The species composition of the groundfish in the area and environmental conditions were recorded monthly. Details of this study are reported on page 18.

Whiting is another species which does not honor state lines. This past summer it was fished in the territorial waters of the State of Maine in considerable quantity, and questions were raised concerning its protection. These fish move offshore in winter. Here was another instance where the biologist was compelled to turn his attention shoreward to obtain information required for the study of offshore populations. Whiting are not now under regulation and no recommendations for management can be made until the various stocks concerned are more clearly defined and their seasonal migrations worked out in more detail.

An outstanding example of the fruits of inshore studies has been our recent redfish research. The commercial stocks of redfish are in deep water, and the fish cannot easily be brought to surface alive. Consequently, our knowledge of migrations and delineations of stocks has been extremely limited. However, concentration of effort on a shallow-water stock at Eastport, Maine, has been most rewarding. Information on growth rate and migrations, or lack of migration in this case, obtained from this stock is extremely valuable in understanding the nature of the deep-sea stocks which are exploited by the commercial fleets. Details of these studies are reported on page 25.

The industrial trawl fishery exploits stocks of fish which violate state lines also. In addition to whiting, a number of species such as red hake, eelpout, and skates come into shallow water seasonally and return to deep water later. This mixed fishery, especially in southern New England, depends upon food fish also, among which are several species of flounders. Some of these such as the blackback and fluke are vitally dependent upon not only inshore areas but even estuaries for their nursery grounds.

One might even mention codfish in relation to the inshore environment. At least one of the cod stocks makes a seasonal migration to spawning grounds in New Jersey waters and is taken along shore on its way south and on the return trip north.

This laboratory has even become involved in what has been called the "inshore dragging problem." This problem has concerned dragger fishermen, lobstermen, and sportsmen for many years. It has to do with the effects of dragging within territorial waters and is limited to these waters simply because the states have jurisdiction here.

Actually, the problem is much broader. One is concerned about the effect of dragging at any distance from land or in any depth of water. There are many aspects to this problem such as the effect on the structure of the bottom, the bottom food organisms, and upon the exploited and unexploited stocks of fish themselves. No one has established definitely that otter trawls are injurious to the environment essential to the production of fish. What few studies have been conducted have indicated little or no effect on the bottom.

This Laboratory was asked by the Atlantic States Marine Fisheries Commission to use its facilities, which included an underwater television camera, to make direct observations of the immediate effect of dragging on the bottom and to observe the recovery of an area in the event any serious effects were observed. A test area was laid out and the initial observations made. The first stage of the project will be completed in the fall of the year. Whatever is learned from this research project will be applicable to deep water as well as shallow and to offshore as well as inshore areas.

There is a great deal of interest on the part of many nations to extend the limits of territorial waters. An expansion of territorial waters would greatly increase our management problems in the Northwest Atlantic and would make even more obvious the artificial nature of any separation of the ocean along political boundaries.

The foregoing remarks are not intended to carry any implications as to what political agency has the responsibility for marine research in the areas involved. They are only intended to point out that management of the offshore groundfish involves research on these species right up to our back doors so to speak.

International Commission for the Northwest Atlantic Fisheries

The ninth annual meeting of the Commission was held in Montreal, Canada, during the period June 1 to 6, 1959. During the week preceding this the Committee on Research and Statistics and groups of Advisers to Panels held meetings to review program and outline research for the coming year. The extent of the Committee's work can be judged by the fact that topics were assigned to thirteen subcommittees ranging from statistical subdivisions to assessment of fishery regulations.

The Commission noted that landings from the Convention Area are increasing, largely as a result of increased effort. The yield per unit of effort in many cases is decreasing, a trend which is also observed in the Northeastern Atlantic. In its report to the Commissioners the Committee on Research and Statistics stated,

"Profitable fishing depends upon a state of equilibrium between fishing effort - which man can control - and the size of the stock. After a major reduction of stock size, the fleets become more dependent upon the results of natural fluctuations - which man cannot control - and even upon single year classes. With increased pressure on a stock - and the stocks in the ICNAF area are being subjected to increasing effort - the more rapidly these changes appear and the sooner does the well known sequence of events show itself.

"A study of environmental factors which control the distribution of a fish population will lead to the knowledge of what alternative species, or sizes of a given species, will be available to ships finding unsuitable conditions on their traditional grounds."

The decline of the Georges Bank haddock fishery is an example. Mesh regulation results in greater landings than if the populations had been fished with small mesh. However, a series of poor year classes has resulted in a decreased population size so that the catch per day has fallen to a new low.

We should like to know whether other species have replaced the haddock in the bottom fish community, whether the quantity of available food has changed, or whether the hydrographic system has altered materially during recent years to bring about this lowered abundance of one of our most important food fishes. We have only partial answers to these questions due primarily to the fact that we have not been making the necessary observations for a sufficient number of years.

It goes without saying that estimates of the total potential of an area is of the greatest interest to those who invest their capital in harvesting the resource. Any change in the size of this potential that is likely to persist for any length of time should be reported as soon as possible.

At its last annual meeting the Commission stressed the need for environmental studies. Although this aspect of fishery research has been in the Commission's long-range research program for many years, it was felt that it had not been sufficiently implemented. Hydrographic research and plankton research should be given greater emphasis. Observations must be made on a continuing basis in order to provide the background necessary for an understanding of the fluctuations in the fishery resource.

The Commission expressed great interest in extending conservation measures to all parts of the Convention Area and asked the Committee on Research and Statistics to report at the next annual meeting on the effects of uniform mesh size through the Convention Area. Scientists of member countries are now compiling data for calculations of short-term and long-term effects of mesh sizes of 4 to 6 inches on the major species of fish in the Area.

The United States reported on its research on the sea scallop populations of Georges Bank exploited by the United States and Canada. The Committee agreed that the growth rate of the sea scallop is now known with sufficient precision to be used in population equations. There is still need for greater precision in estimation of mortality rates. It is the opinion of the Committee that no regulation should be promulgated until it is possible to assess the effects with a high degree of accuracy. In this case, it should also be possible to measure the benefits of regulation as well. Research which the United States is now conducting should provide the necessary information.

S T A F F
Woods Hole Biological Laboratory

Herbert W. Graham, Laboratory Director
Clyde C. Taylor, Assistant Laboratory Director (Detailed to Washington, D. C., June 22, 1959.)

Fishery Research Biologists

Allan M. Barker
John R. Clark
John B. Colton, Jr.
Lawrence H. Couture
Robert L. Edwards
Raymond L. Fritz
Albert C. Jensen
George F. Kelly
Robert Livingstone, Jr.
Fred E. Lux
Robert R. Marak
John P. McDermott (Reappointed from Fishery Aid to Fishery Research Biologist, July 27, 1958.)
Arthur S. Merrill
David Miller
Fred E. Nichyparowich
Julius A. Posgay
Roland L. Wigley
John P. Wise

Fishery Aids

Claude F. Bocken, stationed at Gloucester, Massachusetts.
Philip H. Chase, Jr., stationed at Woods Hole, Massachusetts.
George M. Clarke, stationed at Gloucester, Massachusetts.
John R. Donovan, stationed at Woods Hole, Massachusetts.
Theodore Gallagher, stationed at Point Judith, Rhode Island.
Harry C. Horrell, stationed at Point Judith, Rhode Island.
John R. Kallio, stationed at Gloucester, Massachusetts.
John C. Malone, stationed at Boston, Massachusetts.
Charles L. Philbrook, stationed at Rockland, Maine.
Paul Swain, stationed at New Bedford, Massachusetts.
Roger B. Theroux, stationed at Woods Hole, Massachusetts.
Albert F. Thibodeau, stationed at Portland, Maine.
Clinton E. Watson, stationed at Boston, Massachusetts.

Fishery Aids (Student Assistants)

Joseph B. Cushing (June 9 to August 29, 1958)
Joel S. O'Connor (June 30 to October 3, 1958)
Donald Oberacker (June 9, 1958, to January 16, 1959)
Edward H. Shenton (June 16 to August 13, 1958)

Statistical Staff

E. Marvalee Brown (Resigned September 5, 1958.)
William H. Callahan
Frank A. Dreyer
Lewis M. Lawday
Harriett E. Murray
Palma L. Sargent (Appointed October 13, 1958.)
Ruth R. Stoddard

Technical Assistants

Frank A. Bailey, Scientific Illustrator (Statistical Draftsman)
Robert K. Brigham, Photographer
Sterling L. Cogswell, Fishery Methods and Equipment Specialist
James M. Crossen, Electronics Equipment Specialist
Elizabeth B. Leonard, Librarian
Samuel R. Nickerson, Fishery Methods and Equipment Specialist

Administration and Maintenance

August F. Almeida, Maintenanceman
Kathleen J. Blair, Clerk-Stenographer
Alice M. Cairns, Personnel Clerk
Gilbert J. Costa, Building Repairman (Supervisor)
Robert N. Hersey, Guard
Dorothy C. Johnson, Clerk-Typist (Appointed April 21, 1959.)
Sally H. Jones, Clerk (Stenographer)
Grace F. Juszczyk, Temp. Clerk-Typist (Supply) (Resigned March 17, 1959.)
Helen I. Kiernan, Procurement and Supply Assistant
Vincent A. Mackesy, Administrative Assistant
Betty Jean Mayes, Temp. Clerk-Typist (Supply) (Appointed April 13, 1959.)
Dorice A. McLachlan, Clerk-Typist (Resigned April 17, 1959.)
Harold M. Neal, Maintenanceman
Robert E. Polley, Guard
Neil S. Rosenberg, Guard (Resigned March 31, 1959.)
Harold W. Ruschky, Maintenanceman (Termination of appointment August 1, 1958.)
Ralph E. Sliney, Guard (Appointed April 2, 1959.)
Mary C. Thompson, Clerk (Typing)
Ruth M. Young, Clerk-Stenographer

Vessel Albatross III

Deck Department

Emerson H. Hiller*, Master
William J. Bruce*, First Officer
Austin J. Powers*, Second Officer
Glenn H. Sturgeon, Second Officer (Temporary September 20 - November 3, 1958.)
Robert R. Allen, Fisherman (Temporary September 8-18, 1958.)
Maurice Doyle*, Fisherman
Joseph C. Ferreira*, Fisherman
Robert S. Grant*, Fisherman
Harold V. Janson, Fisherman (Temporary October 11-16, 1958.)
Amos C. Jones*, Fisherman
John L. Keough*, Fisherman
Ronald M. Lahey, Fisherman (Temporary October 20-29, 1958.)
George H. Landry, Fisherman (Temporary September 22 - October 3, 1958.)
John J. Malaquias, Fisherman (Transferred to FWS Vessel Delaware, August 25, 1958.)
Eugene J. Murphy*, Fisherman
Gerhard A. Paulsen*, Fisherman (Transferred from Delaware to Albatross III, August 25, 1958.)
Daniel J. Saunders, Fisherman (Temporary January 21 - February 6, 1959.)
Philip Smith, Fisherman (Temporary October 21-29, 1958.)
Glenn H. Sturgeon, Fisherman (Temporary September 9-19, 1958; December 3-14, 1958; and January 12 - February 9, 1959.)
Grandison R. Taber, Fisherman (Temporary July 28 - August 1, 1958, and September 8, 1958 - February 20, 1959.)
John J. Walsh*, Fisherman

Engineer Department

Franklin A. Macaulay, Chief Engineer
Earl G. Rich*, Assistant Engineer
Peter A. Sutherland*, Assistant Engineer

*Reduction in Force March 9, 1959.

Mess Department

Floyd L. Merchant*, Cook
Glenn H. Sturgeon, Cook (Temporary December 15, 1958 - January 2, 1959.)
Chester W. Cannon, Mess Attendant (October 11, 1958 - March 6, 1959.)
Joseph J. DeSorbo, Mess Attendant (Temporary September 8, 1958 - October 3, 1958.)
Gordon R. Houston, Mess Attendant (Resigned September 5, 1958.)
Donald D. Johnson, Mess Attendant (June 9 - August 29, 1958.)
Daniel T. Lowney, Mess Attendant (September 8, 1958 - January 20, 1959.)
Warren A. Nelson, Mess Attendant (October 7-11, 1958.)
Philip F. Pietrafetta, Mess Attendant (Temporary July 21-24, 1958.)
Robert D. Powers*, Mess Attendant (October 11, 1958 - March 9, 1959.)
Henry Wasierski, Jr., Mess Attendant (January 21 - March 6, 1959.)
Peter D. Williamson, Mess Attendant (Temporary July 21-24, 1958.)

Shellfish Laboratory

Paul S. Galtsoff, Chief
William N. Shaw, Fishery Research Biologist
Veronica S. Denkewitz, Clerk (Resigned May 15, 1959.)
Patricia A. Philpott, Clerk (Appointed May 25, 1959.)

*Reduction in Force March 9, 1959.

VESSELS AND SHORE FACILITIES
V. A. Mackesy, Administrative Assistant

Vessels

As in previous years, there was an extensive offshore field program during the year. In all, there were 170 days spent at sea on various government and chartered vessels.

Government vessels. --Albatross III made 15 cruises.

Cruise No.	Purpose	Dates
115	Industrial demonstration cruise	July 23
116	Vertical distribution of postlarval redfish	July 28-Aug. 1
117	--------------do--------------and IGY section	September 9-16
118	Distribution of young-of-the-year haddock	Sept. 22-Oct. 2
119	-------------------do------------------	October 6-16
120	-------------------do------------------	October 20-28
121	Underwater television instrument calibration	November 4-6
122	Survey of fish and bottom fauna, haddock tagging	November 17-26
123	Yellowtail flounder and whiting survey	December 4-11
124	Bottom sampling and gear testing	December 16-17
125	Industrial fish survey	January 13-15
126	Fish distribution vs. temperature	Jan. 21-Feb. 4
127	Buoy recovery	February 10-11
128	Bell Telephone exercise	February 15-20
129	E. Boston Laboratory for deactivation	February 27

Delaware made 2 cruises for this laboratory.

Cruise No.	Purpose	Dates
59-3	Yellowtail flounder tagging	March 18-27
59-4	Vertical distribution of spawning haddock	April 2-17

Chartered vessels. --Two New Bedford scallopers, the Dartmouth and the Whaling City, each made a 7-day trip to collect data on the population structure of the Georges Bank sea scallop beds. The Silver Mink of Provincetown, Mass., made seven 1-day trips to observe seasonal changes in the haddock population of the Highland Ground. Three 1-day trips were made on the Jacquelyn of Point Judith, R. I., to collect data on the groundfish and sea scallop populations off Block Island. The Karl Brooks of Eastport, Maine, made 6 trips tagging redfish. The Asterias and the Dolphin of Woods Hole were used for testing gear and making observations in the local area.

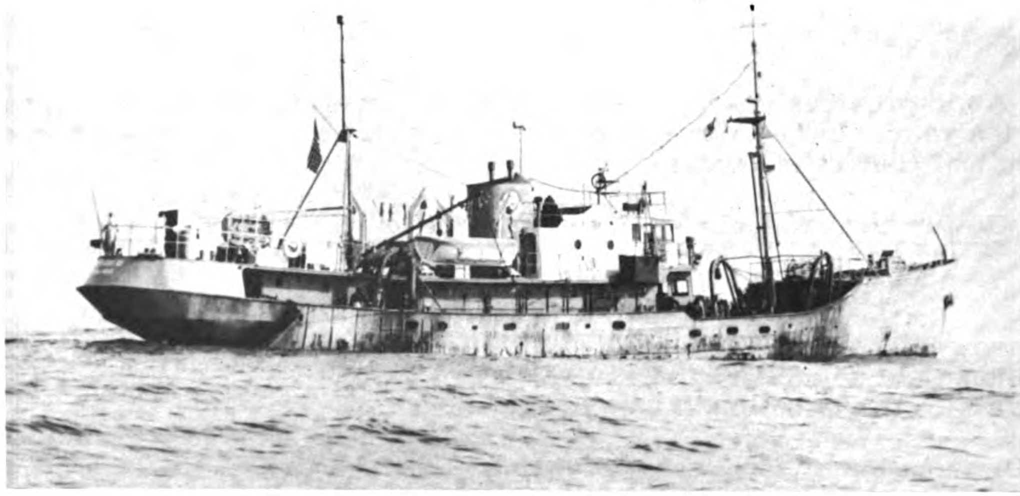

Figure 1. --The research vessel Albatross III.

Deactivation of the Albatross III. --The research vessel Albatross III, which the Bureau has operated sporadically since 1948, was deactivated on March 9, 1959. The advanced age of the vessel and resulting high maintenance costs made it uneconomical to operate further. The Laboratory's sea program is now being conducted on the Bureau's trawler Delaware based in Gloucester, Mass., and on chartered commercial vessels. The Laboratory looks forward to acquiring a new vessel designed and built for our needs in the near future. Funds have already been appropriated for design and it is hoped that construction might begin within a year.

The Albatross III has had a long and varied career. Built in 1926 as the steam trawler Harvard, she caught and landed about 35 million pounds of groundfish before she was sold to the Bureau of Fisheries in 1939 for one dollar. War broke out while she was in the shipyard being converted to a research vessel and the Navy requisitioned her for the Coast Guard. She was completely rebuilt from keel to masthead, converted to diesel propulsion, and put into service as the C. G. C. Bellefonte.

Returned to the Fish and Wildlife Service in 1944, she was laid up at Woods Hole in a semi-operating condition until plans could be made and funds obtained to reconvert her to a fishery research vessel. In March 1948, she was commissioned the Albatross III and assigned to the North Atlantic Fishery Investigations. For several years she operated on a part-time basis due to insufficient funds. In 1951 and 1952 she was operated by the Woods Hole Oceanographic Institution under contract with the Office of Naval Research for trans-Atlantic hydrographic cruises. During this period she covered a good part of the Atlantic touching at ports in Iceland, England, Gibraltar, Africa, South America, and the Caribbean.

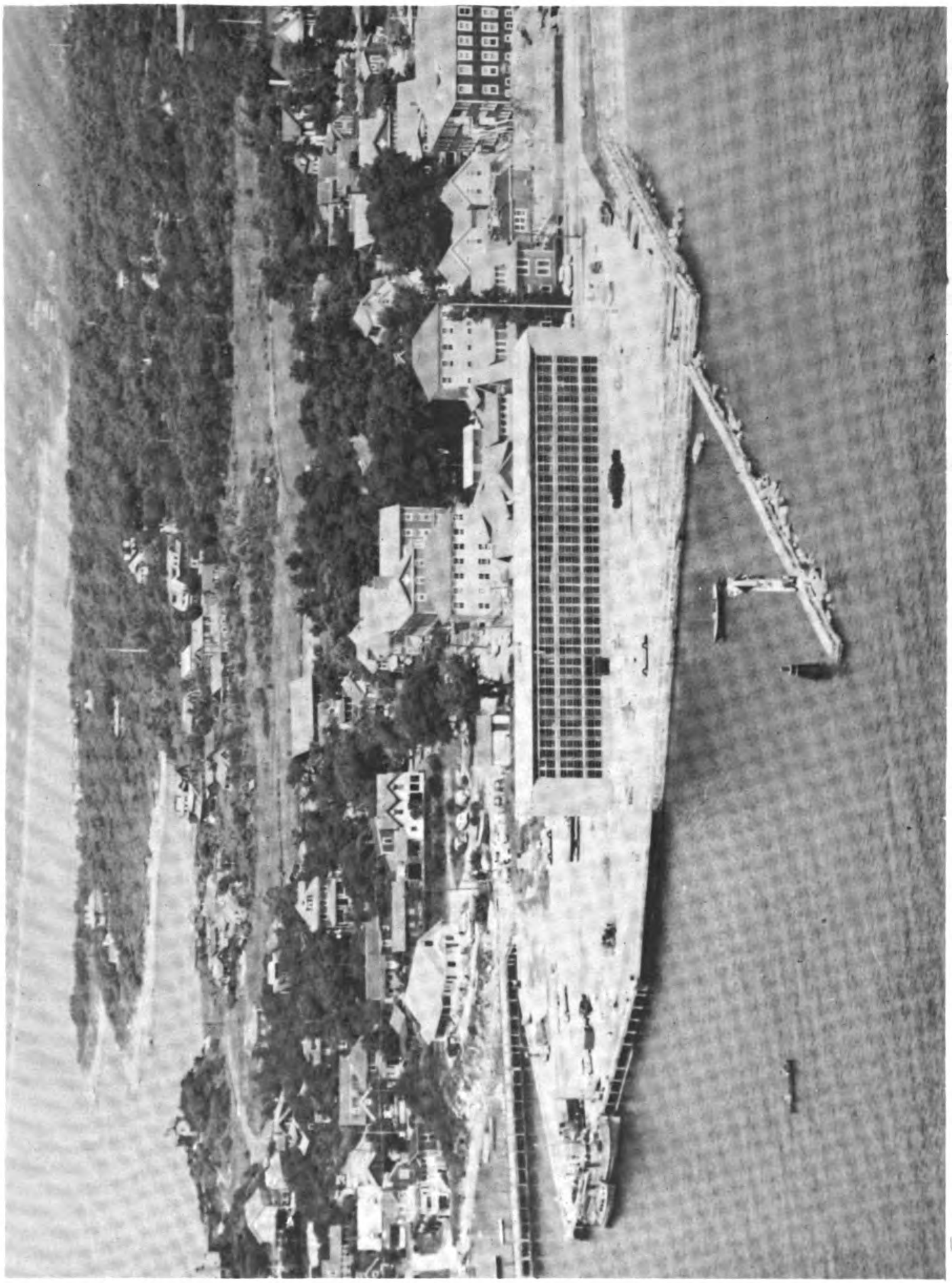

Figure 2. --Aerial view of the new laboratory, July 1, 1959.

In 1955, supported by funds received under the Saltonstall-Kennedy Act, the vessel was put into full-time operation under the Fish and Wildlife Service, and she remained in full-time operation until March 1959 when the decision was made to deactivate her. During her service as a fishery research vessel she made 128 cruises, most of them to Georges Bank and other areas within the Gulf of Maine. Her observations of oceanographic conditions and her collections of groundfish, bottom fauna, and plankton constitute an extremely valuable contribution to our knowledge of the oceans in our area and will continue to serve workers in the field for a long time in the future.

Shore Facilities

Laboratory. --The entire year was spent in the temporary quarters at Quissett, the cottage at Woods Hole, and in rented space in the Marine Biological Laboratory.

A great deal of progress has been made on the construction of the new laboratory in Woods Hole. On the site where the old wooden buildings had been since 1883, there has now risen a 3-story masonry structure which we expect to occupy in November 1959.

The new laboratory, in addition to providing much more comfortable working space, will expand the opportunities for research. For the first time in many years, it will be possible to keep live fish in tanks supplied with running sea water. Temperature-controlled recirculated water will also be available. The sea water system will be completely nonmetallic and capable of pumping up to 300 gallons per minute.

Aquarium. --Our aquarium was for many years one of the attractions of Woods Hole. It was closed following damage caused by the hurricane of 1954. Construction has started on a replacement which is expected to be completed by May 1960.

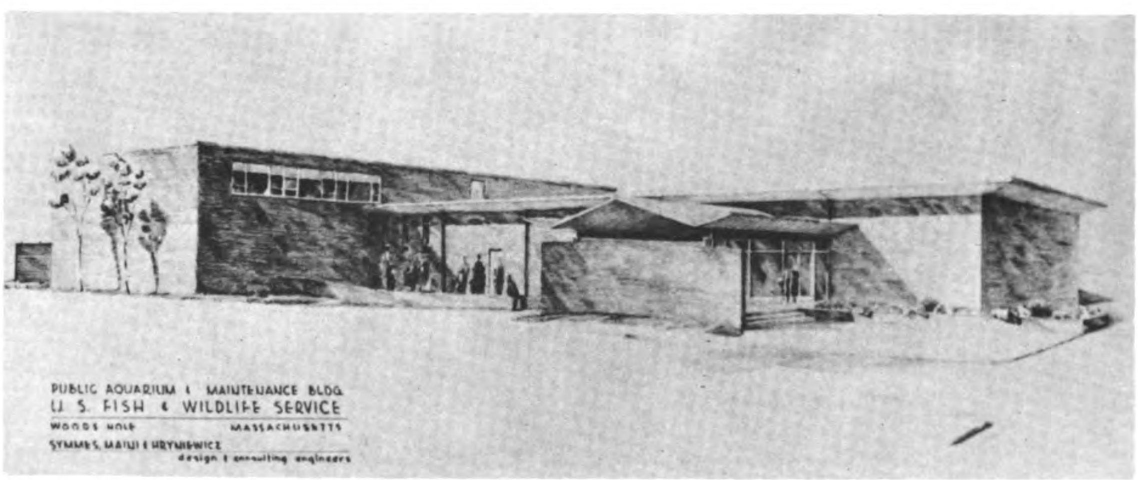

Figure 3. --Architect's drawing of aquarium and maintenance building.

COD INVESTIGATION

J. P. Wise, Chief
H. E. Murray

State of the Fishery

Total landings of cod at New England ports for the year ending December 31, 1958, were about 30 million pounds, an increase of 6 million (about 25%) over the previous year. A large part of this increase was caused by the New Bedford landings, particularly in the "scrod" category, which increased by a factor of about 25.

In early 1959, there was no sign of weakening in these trends. While data on the age composition of the cod landings are not available, there is strong evidence that one or more highly successful year-classes have entered the fishery.

Larval Drift

In February, two airships from the U. S. Naval Air Station at Lakehurst, New Jersey, dropped 1,260 drift bottles over the waters of the continental shelf from Sandy Hook, New Jersey, to Chincoteague Bay, Virginia. Previous tests by the Navy, using bottles containing sea marker dye, had shown that with properly controlled airship speed and height, breakage of the bottles would be negligible.

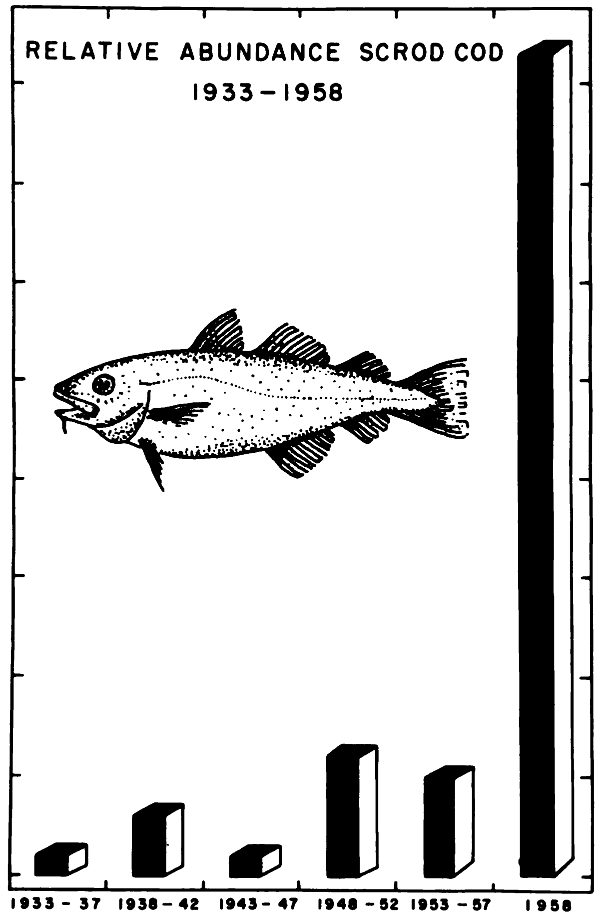

Figure 4. --Relative abundance of scrod cod, 1933-1958.

A field of over 10,000 square miles of ocean surface was covered in one night's flying. At least 12 bottles were dropped at every station and the stations were spaced not more than 20 miles apart, in most cases only about 10 miles apart.

Results from this drop will clarify the nature of the surface currents in this area in winter, particularly important since the eggs and larvae of the cod spawning off the Middle Atlantic coast are at the mercy of these currents.

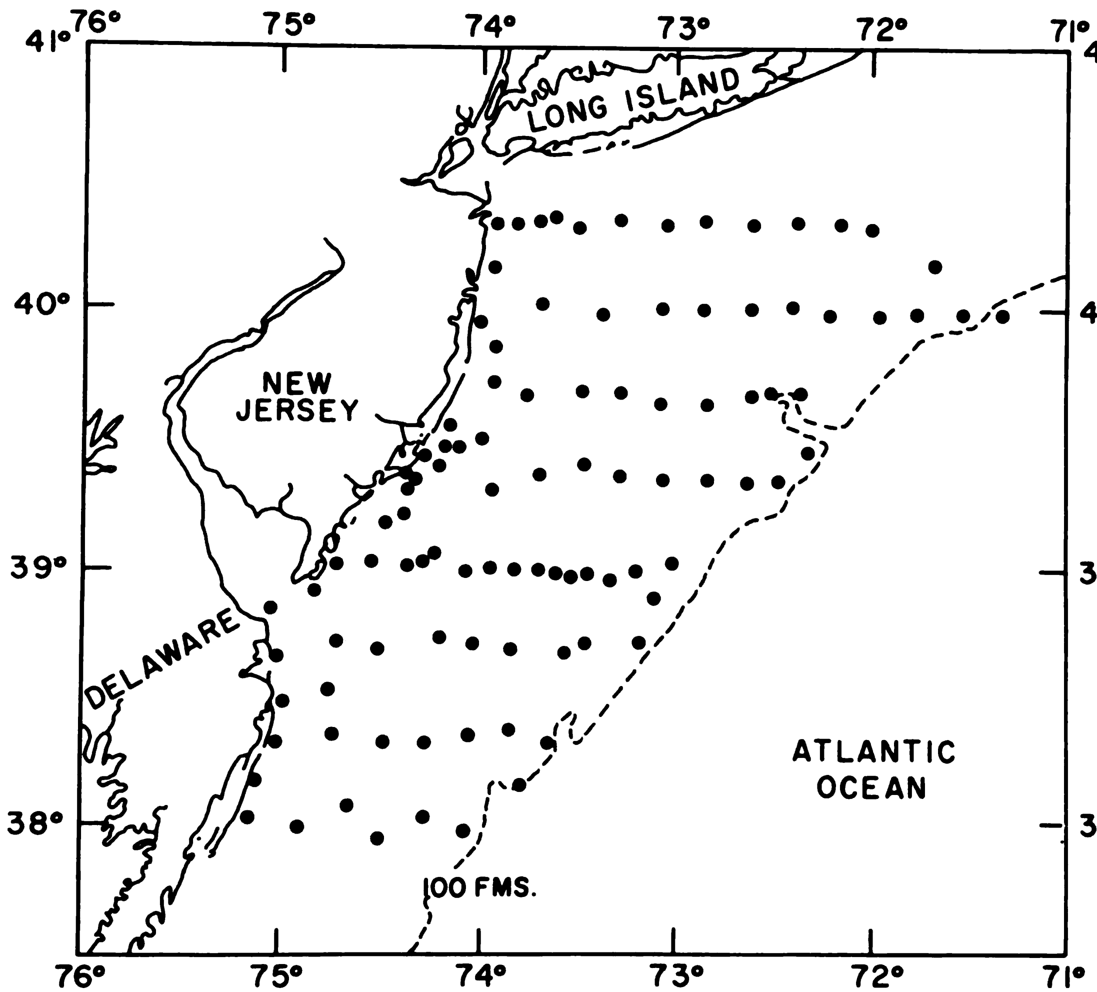

Figure 5. --Locations where drift bottles were dropped from blimps

Mesh Regulation

Although the 4-1/2-inch mesh regulation has been applied to cod for several years, previously it has had very little effect on the fishery because there were so few small fish present on the fishing grounds. The increase in abundance of small cod has markedly changed this picture. It is possible to calculate that in 1958 the 4-1/2-inch mesh permitted over half a million individual small cod to escape. This is not a loss to the fishery, however, since a great many of these fish will be recaptured at larger sizes.

Tag Returns

Although cod tag returns during the year were fewer than in previous years, the total number has now reached nearly 500. We have started some analysis of these returns. For instance, during tagging operations about 1,300 cod were tagged alternately with Petersen discs on stainless steel wire through the dorsal muscles and with Lea tags anchored internally. A comparison of the cumulative percentage of returns by 5-week periods shows that the discs yield consistently better results regardless of the time between tagging and recovery, at least up to 90 weeks--that in fact the advantage seems to increase after the first year.

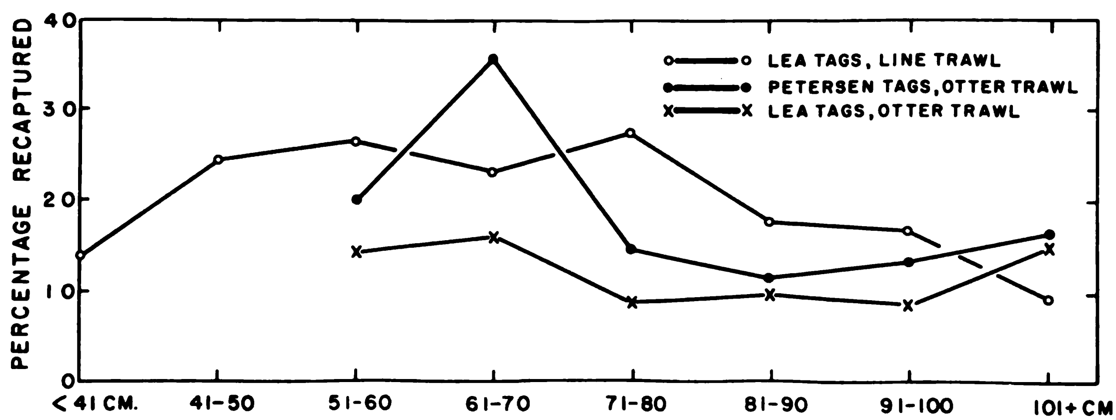

Figure 6.--Rate of return of different sizes of codfish caught in different manners and tagged with different tags.

When the size of fish tagged is taken into consideration together with the method of capture for tagging, several interesting comparisons may be made. Best returns have been obtained from fish which were 51 to 70 centimeters long when tagged. Line trawl caught fish yield better returns than otter trawl caught fish, including some substantial percentages of returns in the smaller sizes where otter trawl tagging gives little or none. Thus, line trawling appears a far superior method of capture for tagging, either because of the inherent differences in the gear or because of the shallower depths fished. (In these experiments the line trawl was fished at 6-25 fathoms while the otter trawl was fished at 40-56 fathoms.)

FLOUNDER INVESTIGATIONS
F. E. Lux, Chief

The Flounder Fisheries

Although 1958 landings of blackback, fluke, dab, and gray sole were more than 18 percent below 1957, large increases in yellowtail catches caused a 9-percent increase in total flounder landings. Yellowtail landings were the highest in ten years. Preliminary analysis of the age distribution of the yellowtail catch indicates that the increase is due to very successful year classes in 1955 and 1956 which entered the fishery in force last year. Fluke landings have been unusually high in recent years so that it is possible that the decline in catch of this species is the result of normal fluctuations in abundance. Catches of dab and gray sole have dropped steadily for the past few years. Since these two flounders are not heavily fished, it seems unlikely that overexploitation can account for the decline.

Species	1957	1958	Percentage Change
	Million pounds		
Yellowtail	22.3	32.8	47.0
Blackback	14.2	14.1	- 0.7
Fluke	8.1	5.5	-32.0
Dab	4.8	3.0	-37.5
Gray Sole	4.4	3.1	-29.5
Total	53.8	58.5	+ 8.7

Figure 7. --Measuring and tagging flounder.

Figure 8. --Chuting tagged flounder overboard.

Tagging Experiments

Most of the yellowtail flounder landed in New England are caught either on the southeast part of Georges Bank or off southern New England from Nantucket to Long Island or off Cape Cod from Stellwagen Bank to Nauset. Past marking experiments have shown that there is some seasonal movement of fish between Georges Bank and southern New England but that the fish off Cape Cod do not mix with those from the other two grounds. In order to reinforce these conclusions, 3,100 yellowtails of all sizes were tagged in March off southern New England and Cape Cod.

In addition to defining the stocks, the results of these tagging experiments will give us estimates of fishing mortality. About 10 percent of the fish tagged last March were returned by commercial fishermen within six weeks.

Growth Rate

The growth rate of yellowtail flounders from the three grounds has been tentatively estimated from the examination of scales and otoliths. Since females grow faster and live longer than males, their growth rates have to be estimated separately. In general, while fish from all three grounds reach marketable size, about 32 centimeters, during their third year, southern New England fish grow more slowly after this than fish on Georges Bank or off Cape Cod.

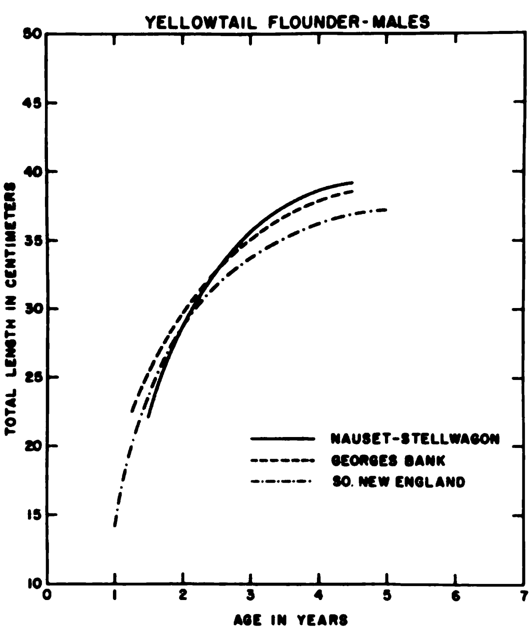

Figure 9. --Growth rate of yellowtail flounders.

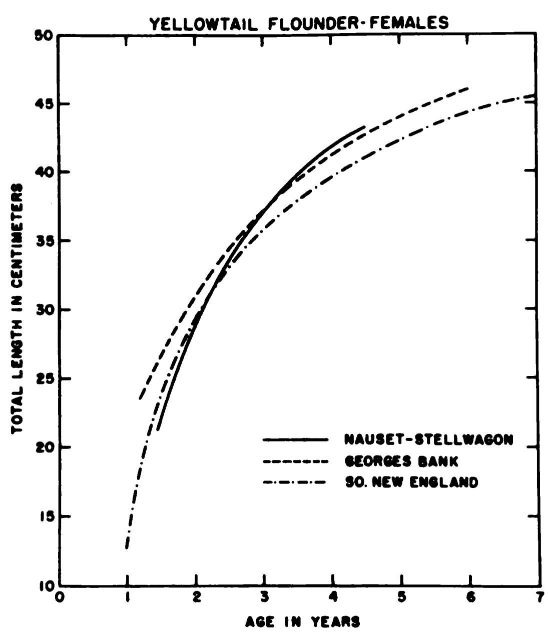

Figure 10. --Growth rate of yellowtail flounders.

HADDOCK INVESTIGATION

J. R. Clark, Chief
A. C. Jensen, J. R. McDermott, F. A. Dreyer, P. L. Sargent

State of the Fishery

The abundance of haddock on Georges Bank, which has been declining since 1955, reached an all-time low in the last six months of 1958. The abundance index, the average catch per day of large otter trawlers, dropped to 6. 5 thousand pounds. The 1931-1958 average for the July-December period is 12. 8 and it had never dropped below 9. 5.

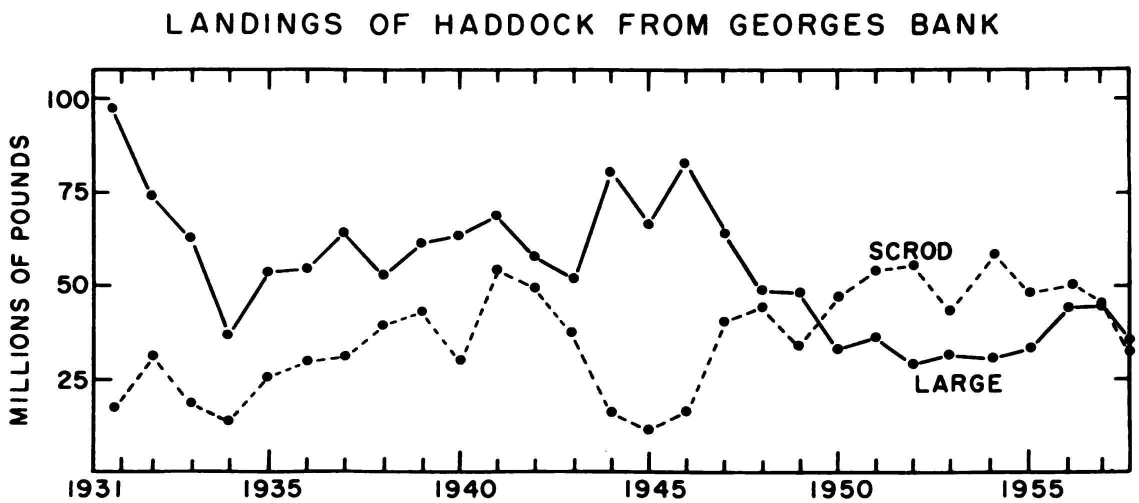

Figure 11. --Landings of haddock from Georges Bank.

The decline has continued during January-June 1959. The average for this period is 14. 1, but the 1959 figure was only 9. 7. For the whole year, July 1958 to June 1959, abundance was 60 percent below average.

The drop in abundance is attributed to the poor survival of the 1955, 1956, and 1957 broods. The future of the fishery now depends upon the success of the 1958 brood which we believe to be above average strength (see page 37). These fish, however, will not enter the fishery until 1960. We, therefore, believe that haddock fishing on Georges Bank will continue poor through 1959, show some improvement during the first half of 1960, and become moderate to good in the last half of 1960.

Age by Fin Rays

Many of the hard parts of fishes exhibit the effects of cyclical phenomena which can be used to determine the age of any individual. We have for many years used either the scales or the otoliths of haddock for routine age reading but have found that the results of reading both the scales and otoliths do not always agree. We have, therefore, conducted a study of the marks on fin rays to see if they could be used to resolve the differences.

The first ray of the first dorsal fin was removed from the fish and stored dry. The rays were later cut about 1/4 inch from the base with an electric jeweler's saw, the cut face moistened with 50% glycerine, and examined at 30X under reflected light. The sections showed a series of alternating dark and light bands similar to the otoliths of some fish. The dark bands, which are quite narrow compared to the light bands, were taken as the year-marks and counted to estimate the age of the fish. Another estimate was made by reading scales from the same fish.

Figure 12. --Scale.

Figure 13. --Otolith.

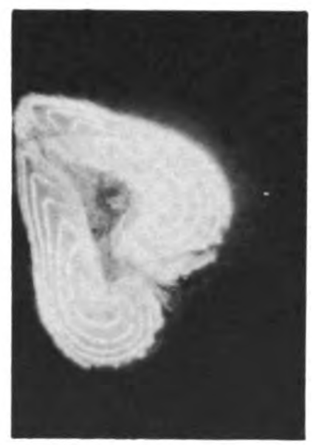

Figure 14. --Fin ray.

Seasonal Changes on the Highland Ground

The series of monthly surveys and collections which was started in 1958 (see 1958 Annual Report) was completed in January 1959. These cruises were designed to collect data on the changes in species composition and abundance of the groundfish population of the area with special reference to the sex, age, and length composition of the haddock present. Samples of haddock were taken to study the seasonal changes in various body organs. The analysis of these data has so far been concentrated on the seasonal changes in the liver weight of haddock and variations in the species composition and abundance.

Liver Weight

Fishes like haddock and cod store most of their fat reserve in the liver. These fat reserves build up during the year until just before spawning when there is a transference of the stores to the rapidly developing gonads. Both the accumulation and use of the fat can be measured by weighing the livers of fish of the same size taken at different times of the year. Male haddock appear to have smaller livers than females at all times of the year.

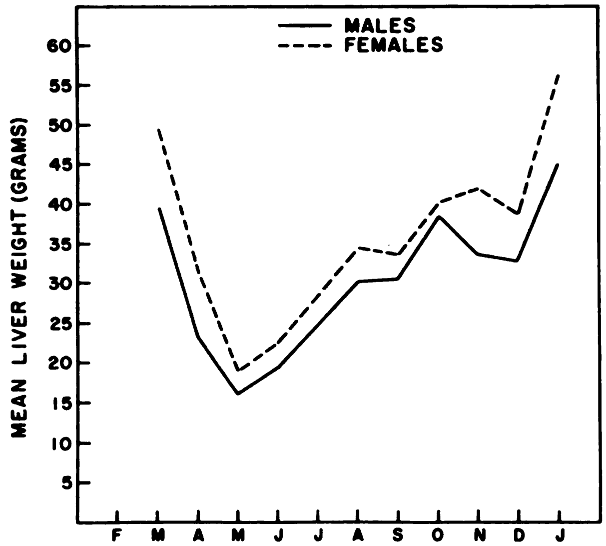

Figure 15. --Monthly change in liver weight.

The seasonal variation in liver weight is closely related to the average condition factor. This average condition factor is obtained by dividing the weight, less the weight of the liver, by the cube of the length. It is thus an index of relative well-being; a heavy fish will have a high condition factor and a light fish a low condition factor. The condition factor is lowest when the liver weight is lowest, indicating that stored reserves have also been withdrawn from the other tissues.

Abundance

The catch of fish per acre trawled varied from 33 pounds per acre in November to 141 pounds per acre in April with an average catch of 59 pounds. The greatest abundance was associated with the lowest water temperatures and the least with highest temperatures.

The variations in abundance were accompanied by great changes in the species composition. Only 8 of the 31 species taken were found in every month of the year and even these varied in abundance by factors of 6 to 19. Each of the major species seemed to be present on these grounds in maximum abundance during its spawning season.

The problem of where the fish were when they were scarce on the Highland Ground was determined for haddock but no other species. Several hundred were tagged and we have had enough returns to come to some tentative conclusions. After spawning, their time of maximum abundance, about half of the haddock moved short distances inshore. The rest scattered in all directions and some have been recovered as far as 250 miles apart.

HAKE INVESTIGATION

R. L. Fritz, Chief
W. L. Callahan

One of the purposes of Albatross III Cruise 126, made in January, was to locate the winter grounds of the silver hake or whiting, *Merluccius bilinearis*, and determine their relation to temperature and depth. The New England fleet catches large numbers of silver hake from June to September in 15 to 50 fathoms, but they disappear from these grounds in late fall not to reappear until spring.

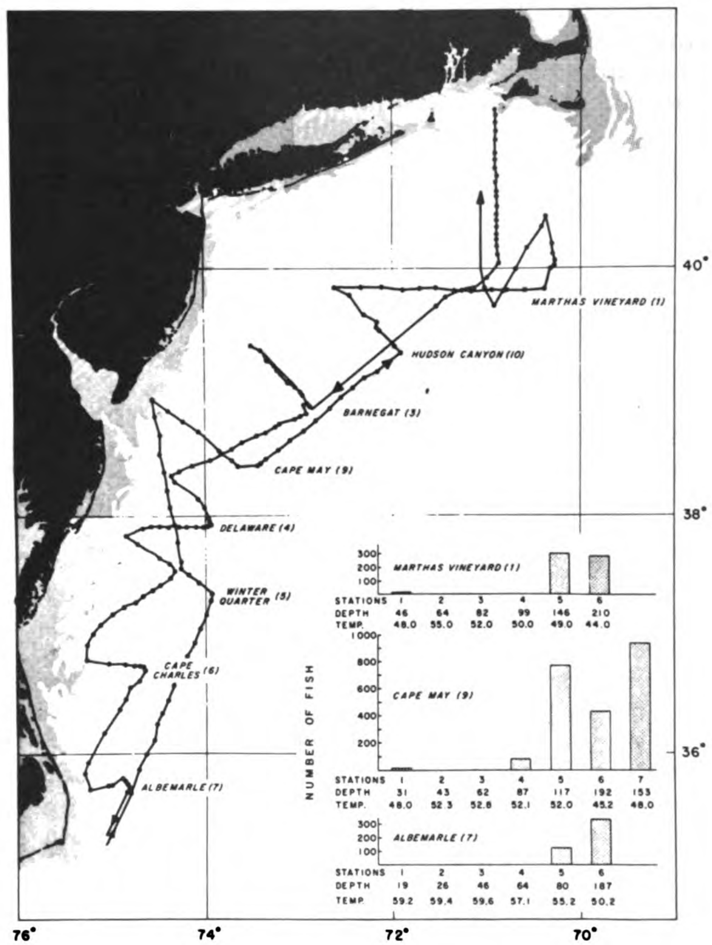

Figure 16.--Cruise track of Albatross III Cruise No. 126 with abundance of silver hake along three transects.

Fifty-three stations along 9 transects were occupied with a number 36 otter trawl with a 1/2-inch stretched mesh liner in the cod end. The 3 transects shown in the figure are typical of all. In general, the silver hake winter in water whose temperature is between 44° and 55° F. and are most abundant in water over 100 fathoms.

INDUSTRIAL FISHERY INVESTIGATION

R. L. Edwards, Chief
L. M. Lawday

The industrial trawl fishery is unique in that it does not discard any of the fish that are caught. All of our other groundfisheries are more or less selective in the species and sizes that are retained for the market. This characteristic poses special problems in any attempts to predict the future of the fishery or to make recommendations for management. The industrial fishery exploits an entire community of fishes which is constantly changing both in composition and abundance. One of our major efforts has been to measure these changes and attempt to determine the environmental factors which affect them.

Species Composition

There is as yet no really satisfactory method of quantitatively analysing the species composition of a community. During the past year we have used Fisher's index of species diversity (a) on some of our data and it shows considerable promise.

The basic equation is $S = a\,[\ln(1+N) - \ln a]$, where S is the number of species, N is the number of fish in the sample, and a is the index of diversity. It has some useful properties. All samples taken from the same population will have the same value of alpha and if two or more of the samples are combined, the combined sample will have the same alpha as the individual samples. Different populations may, by chance, have the same alpha but when these are combined the alpha of the combined samples will be larger than that of the original samples. If two populations are entirely separate, the alpha obtained by combining a sample from each will equal the sum of the alphas of the two original samples.

Our best and longest series of data on change in species composition is that from the Southwest Ground off Pt. Judith, R. I. We have over 3 years data collected by months. This is obviously not enough for a long-term change analysis, but it is enough to permit a study of seasonal change and its relation to temperature.

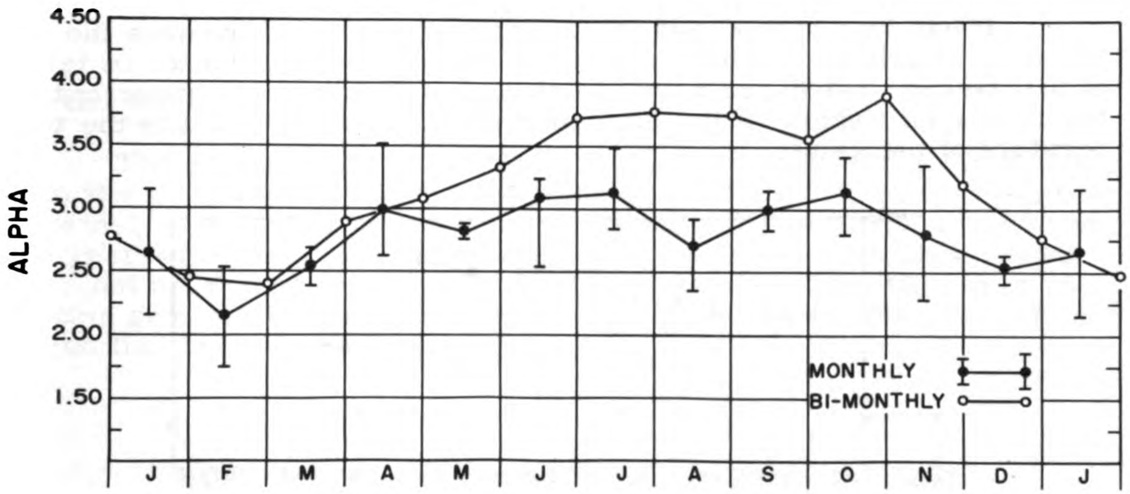

Figure 17. --Monthly and bimonthly values of the index of species diversity, alpha, on the Southwest Ground.

The closed circles give the monthly values of alpha with the vertical bar showing the range from 1956 through 1958. Some of this variation is caused by sampling variation, but it is also the result of different water temperatures occurring during the same month of different years.

The open circles show the results of combining the samples for two successive months and calculating their alpha values. The departure of these bimonthly alpha values from the monthly values is a measure of the change in species composition during that period. If, for instance, there had been a complete change, the bimonthly alpha value would equal the sum of the monthly values. If, on the other hand, there had been no change, the monthly values and the bimonthly value would all be the same.

It appears that the fish population of this ground slowly becomes less diversified (alpha decreasing) from October through February. From February to October, however, the population changes considerably from month to month, becoming more diversified in the summer months. The pronounced increase in species diversity in October-November is the result of fishes which had been living in the estuaries passing through the Southwest Ground on their way offshore. The estuaries cool down quite rapidly at this time of year forcing many species to leave.

The index of species diversity appears to be related to the water temperature. There are relatively fewer species present on this ground in the winter than are present in the summer. In general, a sample of 1000 fish in winter will be made up of about 15 species while a summer sample of the same size will include about 21 species.

Temperature vs. Abundance

It has long been known that water temperature influences the distribution of fishes. We have measured the relative abundance, in terms of the average catch-per-hour of fishing, of four species important to the industrial fishery of the Southwest Ground and related it to the temperature of the water.

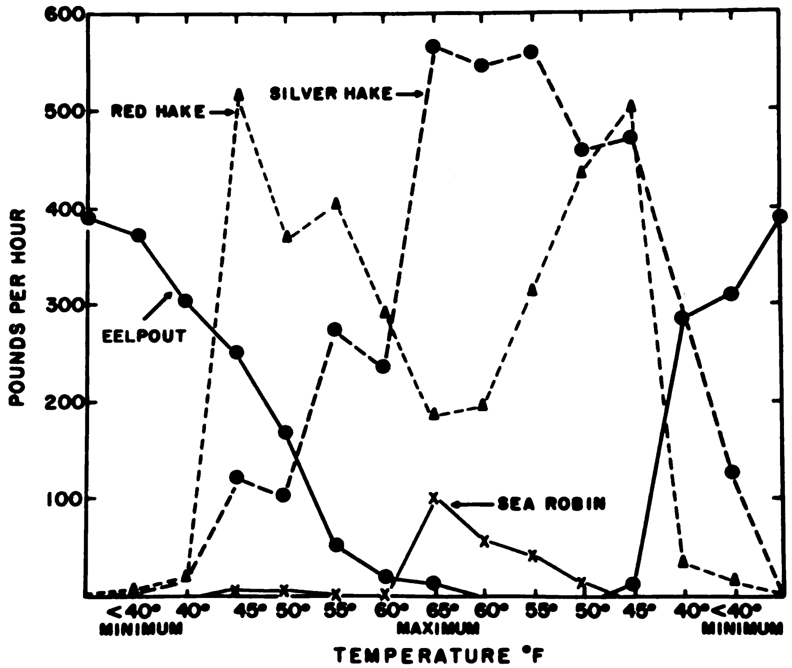

Figure 18.--Change in abundance of four species of fish with change in temperature.

The eelpout, Macrozoarces americanus, is most abundant at the time of minimum temperature, usually in February, but practically disappears by the time of maximum temperature, usually in late August. Its numbers gradually increase again during the fall. The sea robin, Prionotus carolinus, is not present in the winter and reaches its maximum abundance at the time of maximum temperature.

The red hake, Urophysis chuss, has two peaks of abundance, one in the spring and one in the fall. It seems to prefer a temperature between 45° and 50°F. The silver hake, Merluccius bilinearis, presents a more complicated pattern. The young-of-the-year prefer water about 45°F.; older but still immature silver hakes are most abundant between 50° and 55°F.; still larger fish prefer still warmer water.

Since there are over 30 species of fish involved in the fishery on this ground, it is obvious that a relatively small change in temperature would have a marked effect on the species composition.

REDFISH INVESTIGATION
G. F. Kelly, Chief
A. M. Barker

The Growth Rate of Tagged Redfish

The growth rate of the tagged redfish which have been recaptured from the population we have been studying off Eastport, Maine, has been extremely slow. There has been an average increment of about 1 mm. per year with many negative values. We had expected a slow growth rate, but not that slow. In an attempt to determine if the tags were inhibiting growth, we removed the otoliths from 85 tagged fish and 70 untagged fish from the same population.

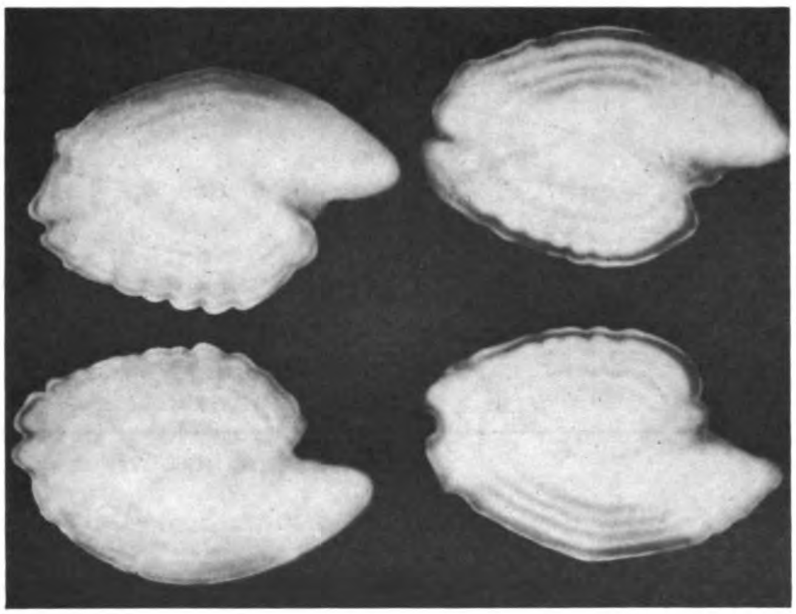

Figure 19. --Otoliths from untagged redfish (1.) and tagged redfish (r).

Almost all of the otoliths from the tagged fish showed an abnormal pattern of deposition. Redfish normally deposit a hyaline zone in the winter and an opaque zone in the summer. The discontinuity layer between the hyaline and opaque zones is taken as the year-mark. The outer margin of the otoliths from the tagged fish showed a rather broad band of hyaline material occasionally interrupted by thin bands of opaque material. This "tagged zone" was so characteristic that two different investigators were able to separate a mixed sample of otoliths from tagged and untagged fish with better than 85 percent accuracy.

This suggests that the growth rate was depressed during the time that the fish was tagged since the material deposited on the otolith is characteristic of the slow-growing winter period. Comparisons of the length at age for the untagged group and the length at age when tagged for the tagged group lead to the same conclusion. The growth rate of the tagged fish before tagging was the same as that of the untagged fish but was depressed after tagging.

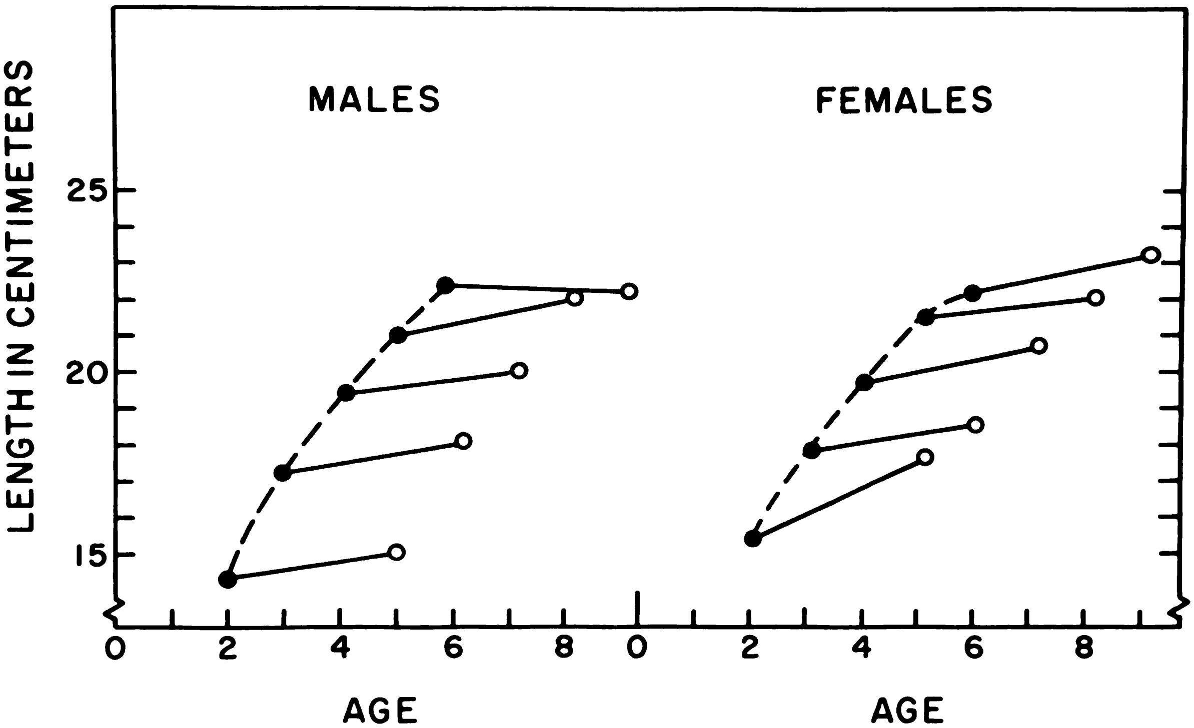

Figure 20.--Growth rate of redfish before and after tagging. The solid circles along the broken line show the length at age when the fish was tagged. The solid lines show the growth during the three years that the fish were at large with the tags on.

It is difficult to understand the reason for this lowered growth rate. The tag on the gill-cover does not appear to affect the feeding, movement, or ventilation of the fish. They have been observed to feed actively while tagged. It is possible, though not very probable, that the more active, faster-growing redfish leave the area after being tagged and are not recaptured.

Racial Studies

Fish of the genus Sebastes, to which our local redfish (S. marinus) belong, are found in the deep waters of the North Atlantic Ocean from Cape Cod to the Barents Sea. Only one other species, S. viviparus, is currently recognized but some people believe that a subspecies, S. marinus mentella, should be a separate species. Throughout the wide range of the genus, local types which differ in color, growth rate, size at maturity, time of spawning, and incidence of certain parasites can be recognized, but these differences are not considered sufficient for separation into species or subspecies.

During the past year, we have been attempting to clarify some of these taxonomic problems. We have collected samples of S. marinus from several areas spread over the whole range and compiled data on their meristic and morphometric characteristics. Meristic characters are those which can be counted such as the number of fin rays, gillrakers, or vertebrae; morphometric characters are those which can be measured such as total length, head length and eye size.

None of the meristic counts showed much variation. The main difference found in the morphometric measurements was a relatively larger eye and longer chin spine for fish of the same total length in those groups which were of the "mentella type." These fish generally came from deeper water than the "marinus type" and there are indications that the size of eye and length of chin spine are influenced by the depth at which the fish lives during its early life. Although it is comparatively easy to separate the extreme forms of the two types by eye size alone, there are many intermediate types which confuse the picture.

SEA SCALLOP INVESTIGATION

J. A. Posgay, Chief
A. S. Merrill, F. E. Nichy, P. H. Chase

Growth Rate

As reported last year, we have succeeded in interpreting marks on the shell and ligament of sea scallops as annual rings. During the past year we have validated the method by deriving independent growth rates from reading annual rings and measuring the growth increment on scallops which had been tagged, released, and recaptured. The two methods gave identical results.

The validation of the annual ring method of determining the age of scallops permits us to estimate the growth rate for any area from which we can obtain a sample. We have done this for 11 areas scattered throughout the range. The table shows how much an 85-mm. scallop will increase in length and weight in one, two, and three years. We do not yet have good length-weight data for all areas.

GROWTH OF SEA SCALLOPS

			+1 Yr	+2 Yr	+3 Yr
(1) Current Is., Nfdld.	L (mm.)	85.0	95.1	103.1	110.0
	W (gm.)	--	--	--	--
(2) Digby, Nova Scotia	L	85.0	97.6	107.6	115.5
	W	7.2	11.0	14.7	18.2
(3) Penobscot Bay, Maine	L	85.0	100.6	113.1	123.1
	W	--	--	--	--
(4) Cape Cod Bay, Mass.	L	85.0	102.7	116.6	123.3
	W	10.3	18.4	27.3	32.5
(5) Block Island	L	85.0	102.1	113.9	122.1
	W	8.5	15.3	21.5	27.4
(6) South Channel	L	85.0	100.5	111.5	119.2
	W	8.5	13.6	18.1	21.8
(7) Birds Bill	L	85.0	97.2	105.4	114.4
	W	7.4	11.3	14.5	18.6
(8) Northern Edge	L	85.0	98.8	109.3	117.2
	W	8.7	12.8	16.6	19.8
(9) Northeast Peak	L	85.0	100.9	112.7	121.5
	W	7.4	13.7	20.4	26.6
(10) Hudson Canyon	L	85.0	98.8	109.4	117.7
	W	--	--	--	--
(11) Virginia Capes	L	85.0	99.5	111.5	123.3
	W	--	--	--	--

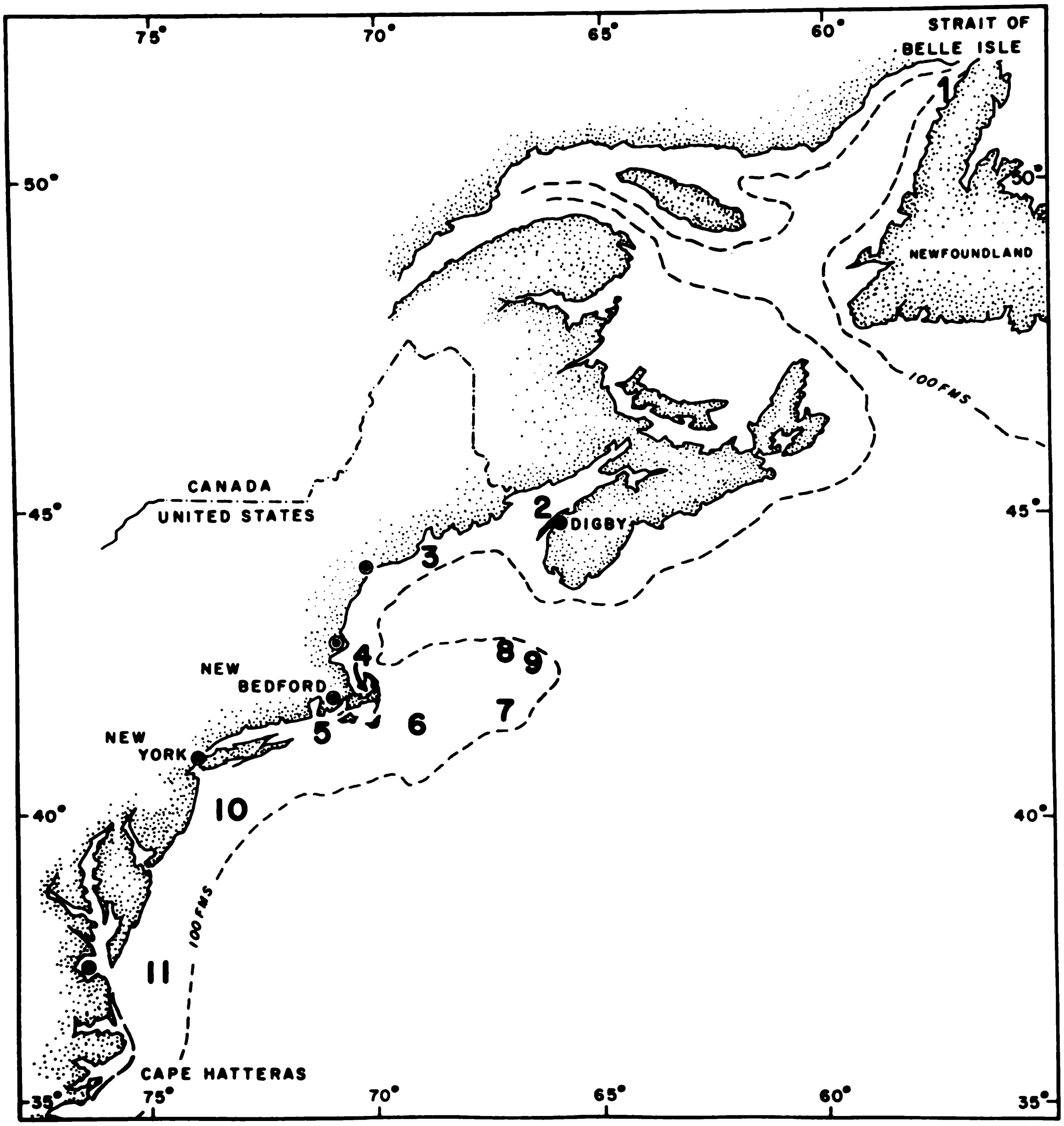

Figure 21. --The locations from which the samples were collected for the growth rate determinations in the table.

Scallop Spat

The whereabouts of sea scallops during their first few months of life has long been a mystery. Several years ago an investigator in Maine found some 2-mm. sea scallops attached to a bushy bryozoan, but these are the only ones less than about 5 mm. ever reported. Even 5-mm. sea scallops are rather scarce.

We know that they are spawned about the first of October, pass a few weeks in the plankton, and then settle to the bottom to grow until they are big enough to be caught. These early years of life, particularly the first, are usually presumed to be the time of maximum natural mortality so that the smallest scallops should be present in much greater numbers than older scallops. Since about 200 million four-year-old scallops were removed from Georges Bank last year, their numbers must have been fantastic when they were 3 or 4 months old. Nevertheless, we have not been able to find them with any of the many different kinds of gear we have tried.

Last year we were lucky. One of our biologists was passing our local Coast Guard buoy base and wondered what he might find among the fouling organisms. He scraped off a few gallons and started to go through his sample at odd moments. Before he was through, he had found about 10,000 tiny sea scallops ranging from about 200 microns to about 15 mm.

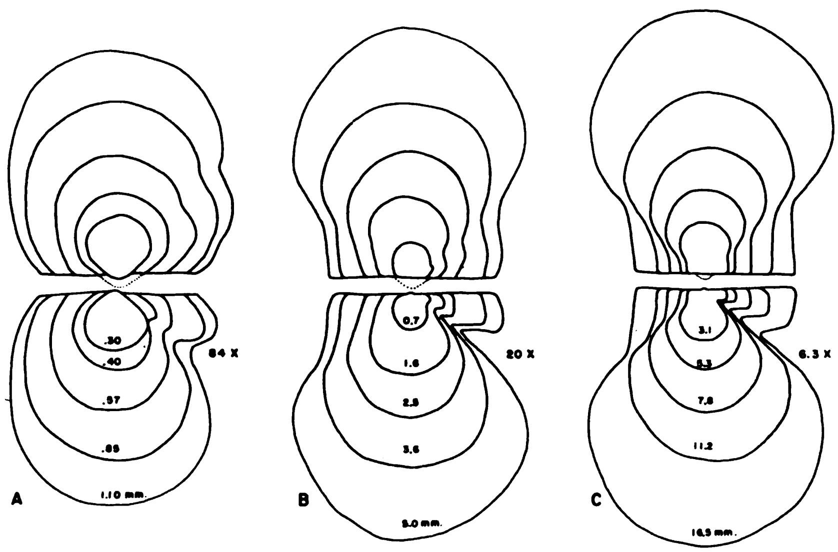

Figure 22. --Change in shape of sea scallop shell as it grows from 0.30 mm. to 16.5 mm.

While this has not solved our main problem, we are now sure that the pelagic stages take place in the upper water layer. We have been able to work out the changes in shape of the shell from the time it first sets. At first glance the setting stage looks more like a clam larva than a scallop but closer examination reveals differences which permit sure identification.

The Hudson Canyon Beds

While more than 80 percent of the sea scallop landings now come from Georges Bank, ten years ago a respectable percentage was landed at Middle Atlantic ports presumably from nearby grounds. A few boats still fish for sea scallops off the New York and New Jersey coasts but their yearly landings are insignificant.

We have area of capture information from these ports for only the past few years but it seems to indicate that these beds do not catch a set of sea scallops every year as seems to be true on Georges Bank. The current pattern is such that it is extremely unlikely that spawn from the Hudson Canyon beds would set out on these beds. It would most likely be carried on down the coast to the south. The Hudson Canyon beds are probably repopulated by spawn from the Georges Bank beds.

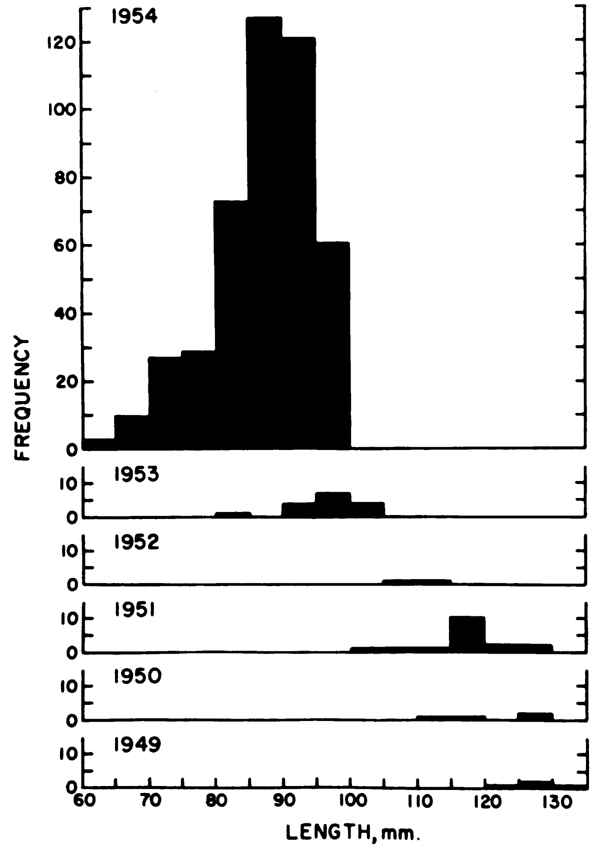

Figure 23. --Age structure of the sea scallops taken from the Hudson Canyon beds in the summer of 1958.

Apparently, there was a very successful set on these grounds in 1954 because the landings which had been coming in at the usual low level suddenly spurted up. In an area of about 900 square miles where the population seemed to be concentrated, landings increased from about 60 thousand pounds in March 1958 to 830 thousand pounds in April. Monthly landings from the area dropped steadily after that but in six months, 1, 260 thousand pounds of scallop meats were removed.

Our samples showed that over 90 percent of the sea scallops taken were three-year-olds. Calculating from the average weight, we estimate that over 50 million scallops of this year-class were removed. Fishing in the area ceased and has not been resumed. The New Bedford boats went back to fishing on Georges Bank; the New York boats have been fishing off Cape May.

BOTTOM ECOLOGY INVESTIGATIONS

R. L. Wigley, Chief
R. B. Theroux

Bottom Sediments

Bottom sediments are one of the major environmental factors that influence the occurrence of bottom-dwelling organisms, including some species of fish. Although a particular fish species may have a direct preference for, or restriction to, areas having a specific type of sediment, in many cases this association of fish to bottom type is a secondary relationship resulting from the occurrence of fish food-organisms. The principal foods of groundfish are the small- and medium-sized benthic organisms, many of which are not evenly distributed over the fishing banks; they are concentrated in specific areas, some of which correspond to particular types of sediment. In order to more clearly understand the factors affecting the distribution of bottom-dwelling animal life, part of our work is devoted to charting the bottom sediments on the offshore fishing grounds.

Georges Bank Sediments

Georges Bank, largest of the New England fishing banks, was selected as the first area to be charted. Sediment samples were collected at more than 200 locations and were carefully analyzed for particle-size composition and the amount of organic matter. Enormous variation was found in the composition of the sediments that make up the sea bed. Various grades of sand were, by far, the most common types, but gravel, silt, and clay predominated in certain areas.

Particle size.--Sediments can be classified in various ways; we have chosen to classify them by the predominant fraction. The predominant fraction is that particle-size class which is most strongly represented in the sample.

Predominant Fraction	Size in Millimeters
Clay	0.004
Silt	0.004 - 0.062
Very fine sand	0.062 - 0.125
Fine sand	0.125 - 0.25
Medium sand	0.25 - 0.5
Coarse sand	0.5 - 1.0
Gravel	2.0

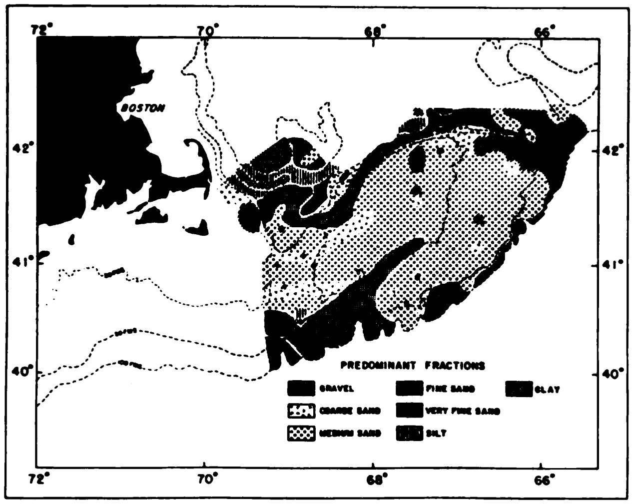

Figure 24. --Geographic distribution of the predominant sediment fraction.

Almost all the central area of the bank is covered by medium sand. Fine sand and very fine sand are found around most of the perimeter except along the northeastern edge where there is gravel. Silt and clay are found only in the deep-water basin to the northwest.

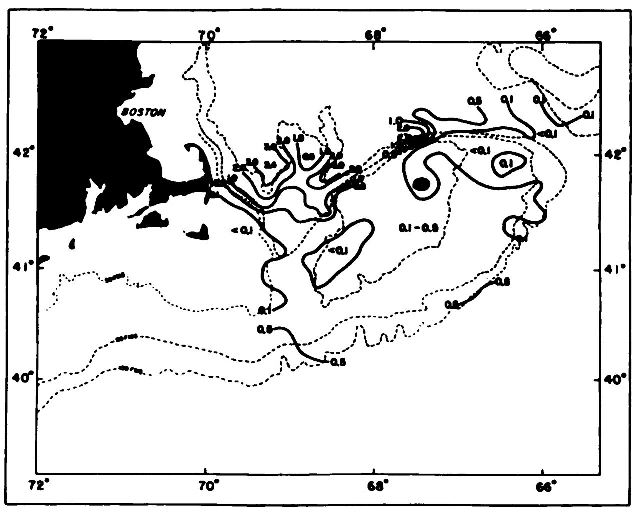

Figure 25. --Isopleths of the percent of organic matter in the sediments.

Organic matter in the bottom sediments is of special biological interest since many benthic animals feed on it. Nearly all sediments on the bank proper contain only very small quantities of organic matter, mostly less than 0.5 percent. High values are only recorded for the deep-water sediments northwest of Georges Bank.

Pandalid Shrimps

The pandalid shrimps grow large enough and form sufficiently dense aggregations to be the subject of a commercial fishery. Between 1930 and 1950 there was a small fishery for these shrimps in the western Gulf of Maine, but it has been neglected in recent years.

Collections of these shrimps were made incidental to a groundfish survey in November. A No. 36 otter trawl fitted with wooden rollers and a one-half inch mesh liner was used. This is not very efficient gear for catching shrimp, but the collection was large enough (1, 500) to give a clear picture of the distribution of the four most common species.

It is apparent from the catch records that each species has a characteristic geographic distribution at this time of year. Dichelopandalus leptocerus is widely distributed throughout the entire area. It is the only one common on Georges Bank and south of Cape Cod. Pandalus borealis was taken only in a limited area in the central and western Gulf of Maine. Of the four species, it has the most restricted distribution within the area sampled. Pandalus montagui occurred around the perimeter of the Gulf of Maine, with greatest numbers taken in the vicinity of Browns Bank. Pandalus propinquus was found in the central Gulf of Maine and along the northern edge of Georges Bank.

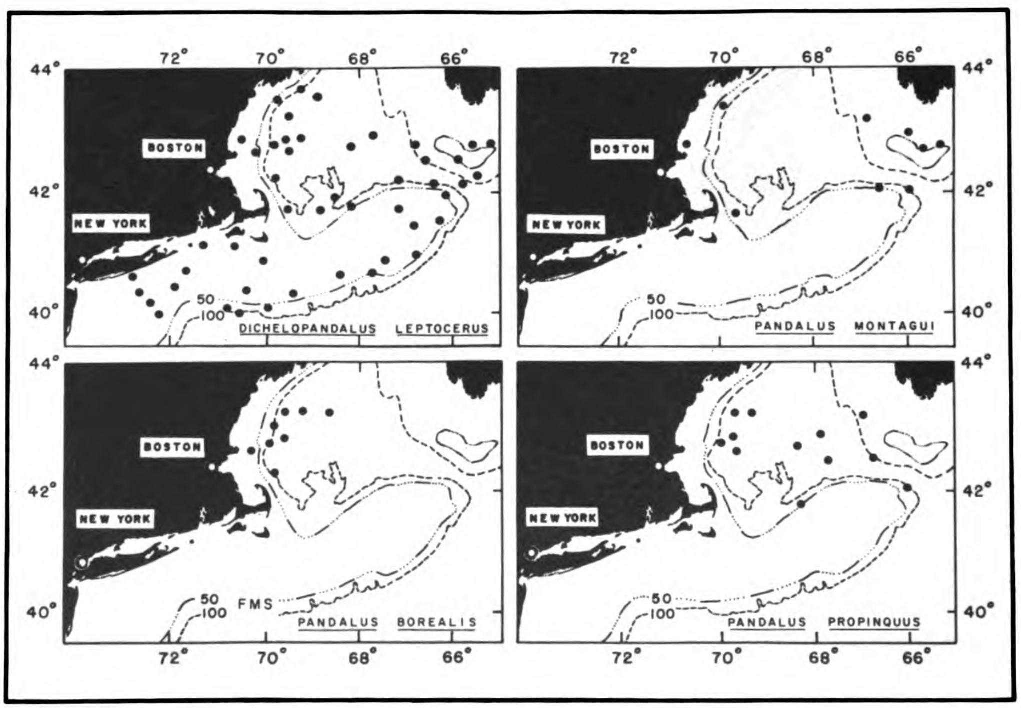

Figure 26. --Distribution of four pandalid shrimps in November. Each dot marks the location of the station where the animals were taken.

PLANKTON ECOLOGY

J. B. Colton, Chief
R. R. Marak, D. Miller

Larval Mortality

One of the interesting features of the hydrography of the Georges Bank area is the band of relatively warm slope water along the southern edge of the bank which is characterized by contrasting tongues of coastal and Gulf Stream water. In general, the northern boundary of this slope water band coincides with the 100-fathom contour line, but occasionally it extends over the southern edge of the bank. In May 1956, the intrusion of slope water over Georges Bank was quite extensive. Surface temperatures increased from 46° to 68° F. and surface salinities from 33 o/oo to 36 o/oo within a space of 10 miles. Thousands of dead whiting and yellowtail flounder larvae were found in this area, and it has been shown that these larvae died as a consequence of high temperature. This is the first observation which indicates a mortality of marine fish larvae as a result of warming. The consequences of this observation are very important as the larvae of other species such as haddock and cod may meet a similar fate, and the extreme fluctuations in their abundance from year to year may be related to such a mortality in the larval stages.

Vertical Distribution of Haddock Larvae

It has been generally believed that haddock spent their pelagic life in the upper part of the water column and then went more or less directly to the bottom. This belief had not, however, been rigorously investigated. Last year, we attempted to determine the vertical distribution of young haddock by towing seven Miller high-speed samplers (see 1958 Annual Report) at 0, 10, 20, 30, 40, 50, and 75 meters.

This survey showed that, while larval haddock (3.5 to 20.0 mm.) were more abundant at 10 meters for two of the three stations occupied, the catch per tow for all stations was similar for 10 and 20 meters. Juvenile haddock (30-100 mm.) taken with an Isaacs-Kidd trawl in 1957 were most abundant at 20 meters. The juveniles also spent more time in the midwater than we had previously suspected. We now believe that it may be late rather than early summer before the entire brood is on the bottom.

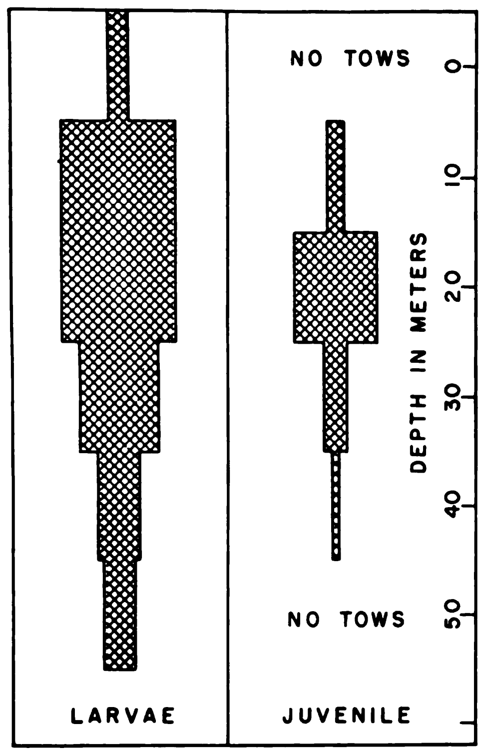

Figure 27. --The vertical distribution of larval and juvenile haddock.

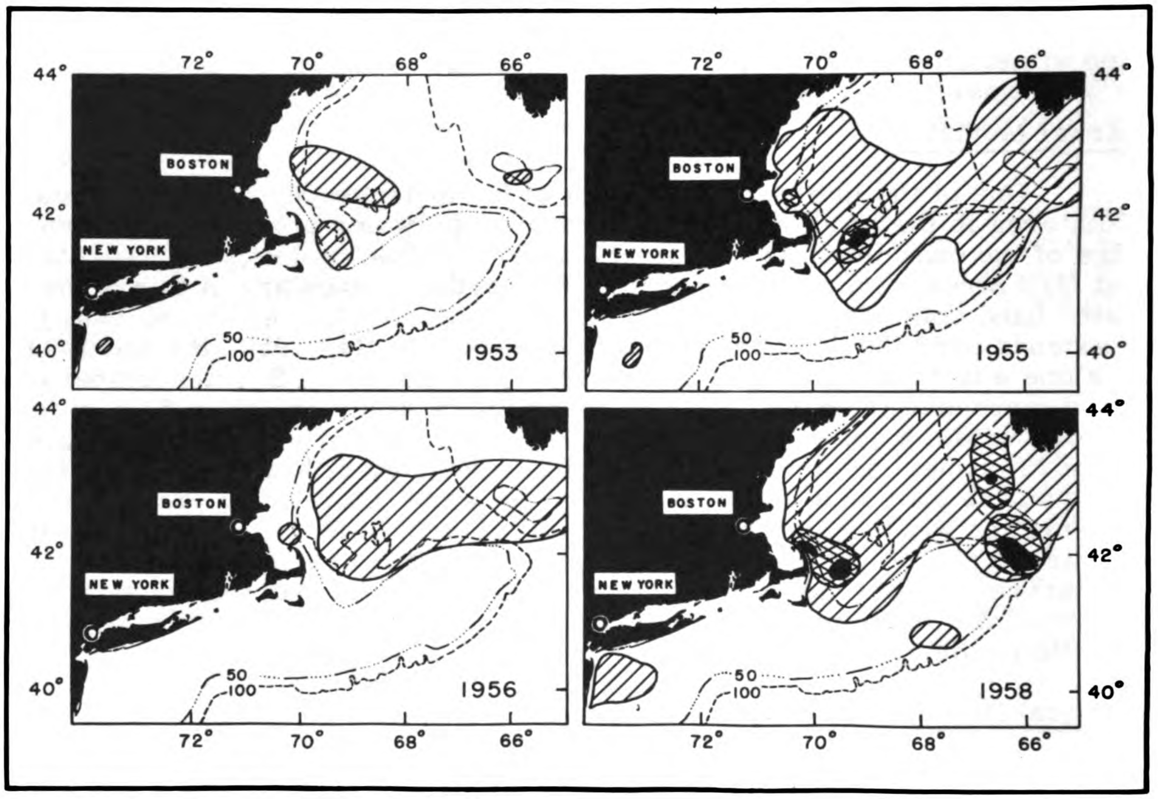

Figure 28. --Geographic distribution of young-of-the-year haddock in four years. The single-hatched area gave catches of 0-50 per tow; double-hatched, 50-100; and black over 100.

Pre-recruit Haddock Survey

As a continuation of our efforts to trace a new year-class of haddock through its planktonic stages, we have conducted otter-trawl surveys of the Gulf of Maine-Georges Bank area in the fall when most of the young-of-the-year can be expected to be on the bottom.

The 1958 survey showed that this brood had been very much more successful than those previously surveyed. The high abundance of young haddock on the northeastern part of Georges Bank is particularly interesting. This area has a history of providing good catches, but it has been relatively nonproductive since 1954. If the 1958 brood remains in the area, the commercial catch should improve when these fish are recruited to the fishery in late 1960.

Identification of Eggs and Larvae

We have firmly established the identity of the early larval stages of two more common fish, the red hake, Urophysis chuss, and the four-spotted flounder, Paralicthys oblongus. Ripe males and females were stripped, the eggs fertilized, and early development observed and recorded.

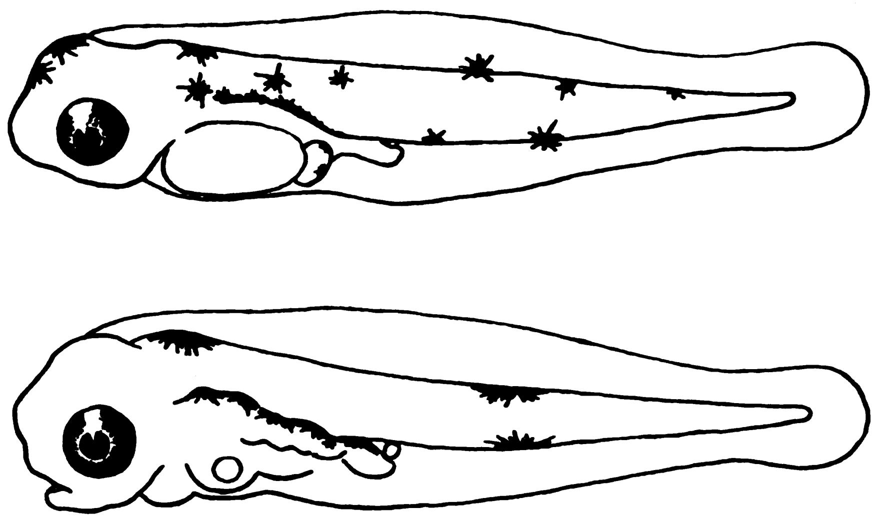

Figure 29. --Red hake larvae 22 hours after hatching (upper) and 16 hours later (lower).

The red hake exhibits a striking change in pigmentation in less than 24 hours. As a consequence of this change, these larvae have been misidentified in several instances in the literature.

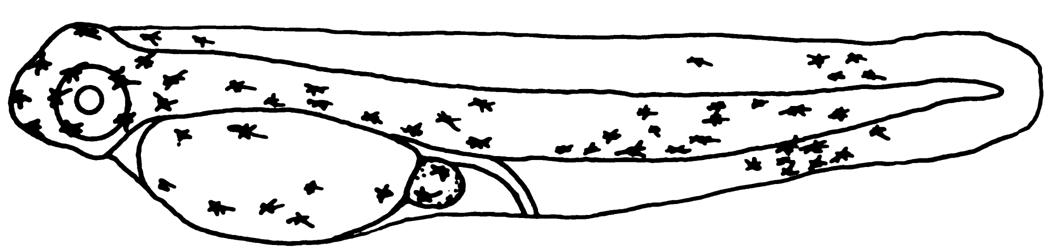

Figure 30. --The larva of the four-spotted flounder.

The early larval stages of the four-spotted flounder have never before been described. They average about 2.6 mm. long at hatching, and maintain a stable pigment pattern for at least the first 5 days of development.

FISH BEHAVIOR INVESTIGATION
R. Livingstone, Jr., Chief

Most of the work of this investigation has been concerned with the analysis of underwater television films. These films were made to observe the behavior of groundfish in the cod end of an otter trawl and passing through covers and chafing gear.

Cod End

After a standard otter trawl has been fishing for a while and has taken some fish, it assumes the shape of a somewhat triangular, elongated tunnel with a swollen after-portion. This tunnel or throat pulsates rhythmically as the net is towed along.

We have placed the television camera forward of the cod end and watched the actions of fish as they entered the throat. The cod end was 21 feet long, and we could only see the beginning of the tunnel about 12 feet away. Most fish that came into view heading upstream, haddock in particular, explored around for a short period and then entered the throat heading downstream. Those fish that came into view heading downstream usually swam directly through the throat without hestiation. We believe that once fish pass through the tunnel, they remain in the after-portion unless they escape through the meshes.

Covers

Many fishermen use a more or less loose piece of netting over the top of the cod end as a chafing gear. Experiments to measure the selectivity of various sizes of mesh in the cod end are usually conducted with a fine mesh cover over the cod end to retain those fish which have escaped through the meshes of the cod end. The behavior of fish when they are between the two pieces of netting therefore has obvious scientific as well as practical implications.

The covers we have observed form a long, shallow tunnel over the cod end, open at the rear when used as chafing gear and closed when used as a retaining cover. The cover undulates in long waves as the net is towed. The frequency and amplitude of these waves vary with towing speed and the amount of slack in the cover.

We have not conducted as many observations of the behavior of fish in covers as we believe necessary, but it seems that more fish may re-enter the net from the cover than was previously thought. Sand launce and alewives, which usually escape from an uncovered cod end very quickly, have been observed to re-enter when they become aware of the cover.

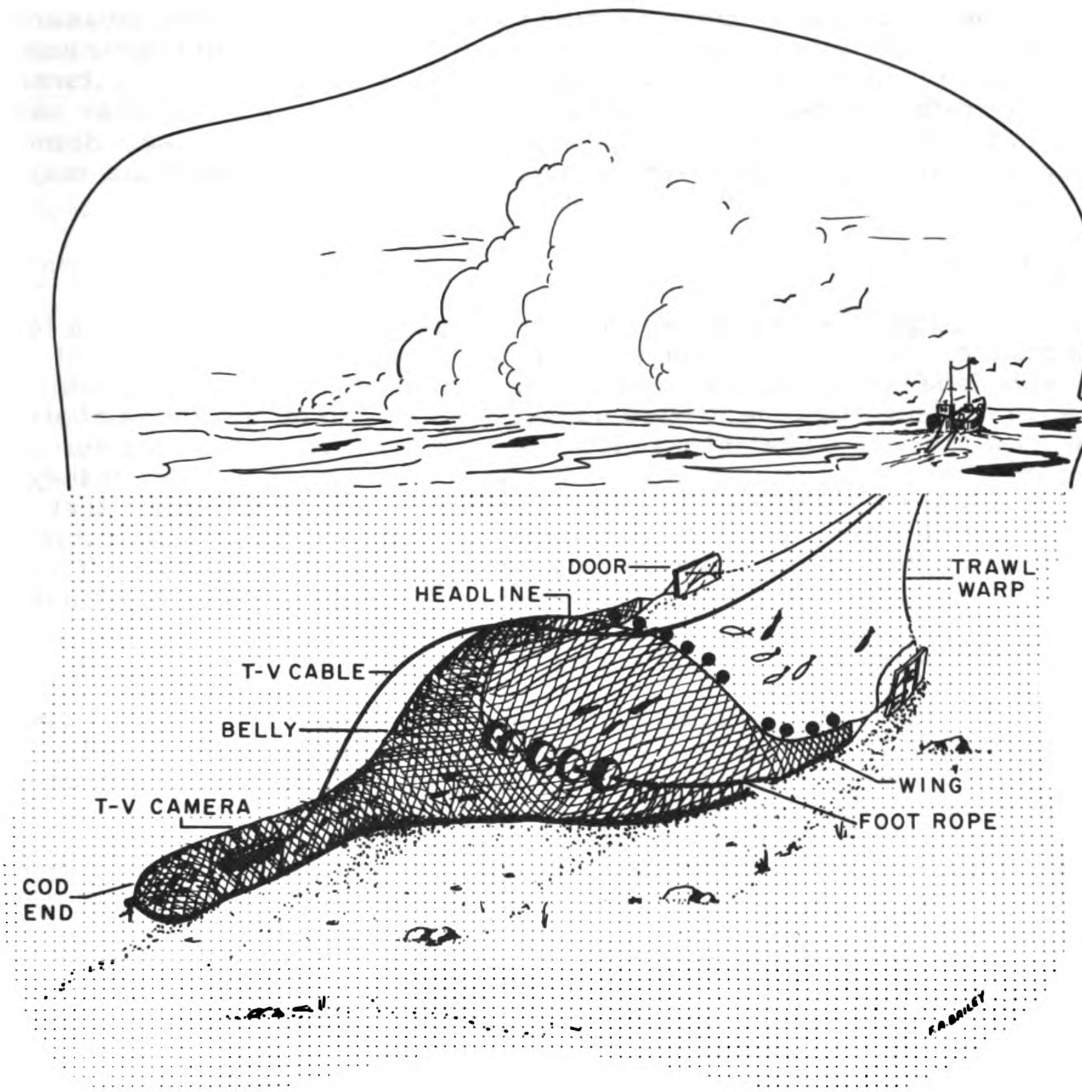

Figure 31.--An otter trawl with the underwater television camera in the cod end.

POPULATION DYNAMICS INVESTIGATION

C. C. Taylor, Chief
R. R. Stoddard

The population dynamics models that we have been using measure the change in bio-mass available for exploitation of a single year-class throughout its life span. They assume that the growth rate, the natural mortality rate and the fishing mortality rate vary only within rather narrow limits, at least during the early part of the exploited phase. Some of our work during the past year indicates that these assumptions may not apply to natural populations of marine fishes.

Growth Rate

Although it is well known that the growth rate of marine fishes is a function of temperature, many biologists believe that the amount of available food and the numbers of fish sharing it are more important. We have evidence that the growth indices for anabolism (K) and catabolism (E) in the von Bertalanffy equation are linearly related. This implies that fish in nature either are not exposed to excess food or, if they are, do not use it. On the other hand, substantial evidence exists that rate of growth can vary widely with different environmental temperature. This implies that we may have to make separate calculations for different areas and different years if they have different temperature regimes.

Natural Mortality

The growth rate studies also showed that faster growth rates usually mean shorter life-spans. We believe that annual natural mortality within a species may be a function of growth rate. This means that we should be able to estimate the natural mortality rate if we have a minimum of growth rate data. If this theory is confirmed by further study, it will be a major advance in fishery biology. In general, our estimates by this method give higher natural mortality rates than those derived by other methods.

Haddock Mesh Regulation

Our efforts to assess the effects of the 4-1/2-inch mesh regulation for Georges Bank haddock have continued. It has been observed that 2- to 4-year-old haddock landed in recent years have been heavier for their age than they were in the years before regulation. There has not been a sufficient change in the growth rate to account for the increase in weight.

We have predicted that there would be an increase in the average size of 2- and 3-year-old fish landed because of the large mesh gear selecting out the larger fish of these ages, but all 4-year-old fish are retained by the large mesh. We believe that the persistence of the increase in weight to age 4 is presumptive evidence that large numbers of small fish are escaping the 4-1/2-inch mesh and surviving to be caught at a larger size.

SHELLFISH LABORATORY

P. S. Galtsoff, Chief
W. N. Shaw

The major portion of our work for the past few years has been devoted to the preparation of a monograph on the biology of the oyster, Crassostrea virginica. In addition to an exhaustive review of the literature, this has entailed a good deal of original research and the repetition of critical experiments. We have also been studying the culture of oysters suspended from rafts and means for protecting oyster beds from the predation of whelks.

Oyster Biology

The chapters on taxonomy, shell morphology, the ligament, anatomy, the mantle, the labial palps, the gill, the adductor muscle, and the function of the gill have been completed. The research work on the development of the egg and larva is under way. Those on the digestive tract and feeding, the kidneys and excretion, blood, circulatory and nervous systems, sex and sex change, and the ecology of the oyster are in first draft and being revised. Only the chapters on oyster development, the effect of pollution, and the enemies of the oyster remain to be written.

The investigation of spawning and fertilization of the egg has led to the discovery of a hitherto undescribed structure within the sperm head. This "axial body" was discovered while examining several hundred cross sections of sperm photographed at about 100,000 diameters by the electron microscope.

The axial body is located inside the nucleus just under the acrosome. It is believed to be involved in the formation of the acrosome filament which is used by the sperm to penetrate the egg membrane just before actual fertilization. Further study of this structure should lead to a better understanding of factors affecting success of fertilization.

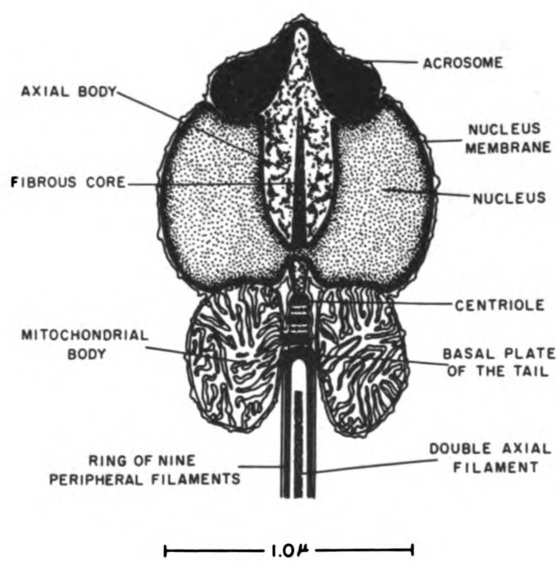

Figure 32. --Structure of an oyster spermatozoan.

The study of the relative significance of ecological factors which affect the productivity of oyster bottoms has led to the development of a method for evaluating the quality of any given area. The method uses five positive factors: the character of the bottom, temperature, salinity, water movements, and food, as well as five negative factors: sedimentation, disease, predators, pollution, and competition with other species.

Each factor is evaluated by observation and experiment on a scale descending from 1, the optimum. The absence of a negative factor is considered optimum. The positive and negative factors are summed separately and the sums multiplied to obtain a single value expressing the quality of the ground. This method has been tested with satisfactory results on various Atlantic coast oyster grounds of known productivity. It should prove valuable in assessing any location in which it is proposed to establish or extend an oyster bed.

Raft Culture

Experiments conducted during the past year at Oyster River, Chatham, Massachusetts, have shown that oysters grown on strings suspended from rafts grow much faster and have a lower mortality rate than those on the bottom. The suspended oysters reached a mean size of 2-5/8 inches in one year; oysters grown on the bottom require 3 years to grow to the same size. Ninety percent of the oysters on the bottom near the raft died as compared to 17.5 percent of the suspended oysters.

Figure 33. --Oysters growing on strings which had been suspended from a raft.

Predator Control

We have studied the habits of the channeled whelk, Busycon caniculatum, in an effort to devise some method of controlling this predator of the Cape Cod oyster beds. So far, the most promising method seems to be the use of a wooden trap which we designed and built. The best season and most efficient ways of using the traps are still being investigated.

INSTRUMENTATION
J. M. Crossen, Electronic Specialist

Underwater Television

The underwater television chain was operated for about 82 hours during the past year. No major modifications have been made on the gear, but the image-orthicon pick-up tube is about at the end of its useful service and the aluminum pressure case is showing severe signs of corrosion. Both of these will have to be replaced in the near future.

Underwater Television Operations

Date	Vessel	Area	Operation
7/58	Albatross III	Stellwagen Bank	Demonstration Cruise - Camera with Gurley current meter in cod end of a #41 trawl
8/58	U. S. S. Guide MSO 447 U. S. S. Mulberry AN 27	Off Santa Barbara, California	Searching for lost mines (U. S. Navy operation)
11/58	Albatross III	Off Provincetown, Mass.	Current measurements of water flow through cod end of #41 trawl
1/59	Albatross III	Off Morehead City, North Carolina	U. T. V. and telemeter in cod end and telemeter on headrope of #41 trawl
5/59	Asterias	Buzzards Bay north of Nashawena Island	U. T. V. bottom observations
6/59	Oyster raft	Oyster River, Chatham, Massachusetts	Observation of conchs in relation to traps
6/59	Delaware	Off Gloucester, Ipswich Bay, Massachusetts	Bottom observations

Temperature-depth Telemeter

The temperature-depth telemetering equipment, described in the 1958 Annual Report, has been used several times to record these data in conjunction with underwater television operations.

As now rigged, either temperature or depth can be continuously recorded on a strip-chart while the other parameter is read from the dial of a micro-ammeter. The synchronous motors, previously used to permit alternate recording of both kinds of data, interfered with the television signals and have been eliminated. Use of another strip-chart recorder would, of course, permit simultaneous recording.

Although we have only used this equipment with an otter trawl, it would be extremely useful on a mid-water trawl. It would provide a continuous record of the depth fished and the temperature of the water the gear passed through. Two telemeters would give the vertical spread of the mouth of the trawl.

Current Meter

We are now able to record the rate of flow of water passing through the net. A single conductor from a Gurley current meter passes into the television camera housing through watertight connectors. The signal is then passed up to the surface on one of the conductors in the television cable.

Radiological Monitors

The Regional Office has received a variety of radiological monitoring equipment from the Office of Civil Defense Mobilization. Included are: survey meter types CDV-700, 710, 720, and 740; three training kits; a No. 456 counter with radium and uranium samples for calibration; dosimeters of 0-20 and 0-100 roentgen range. All of this equipment was checked and tested by us.

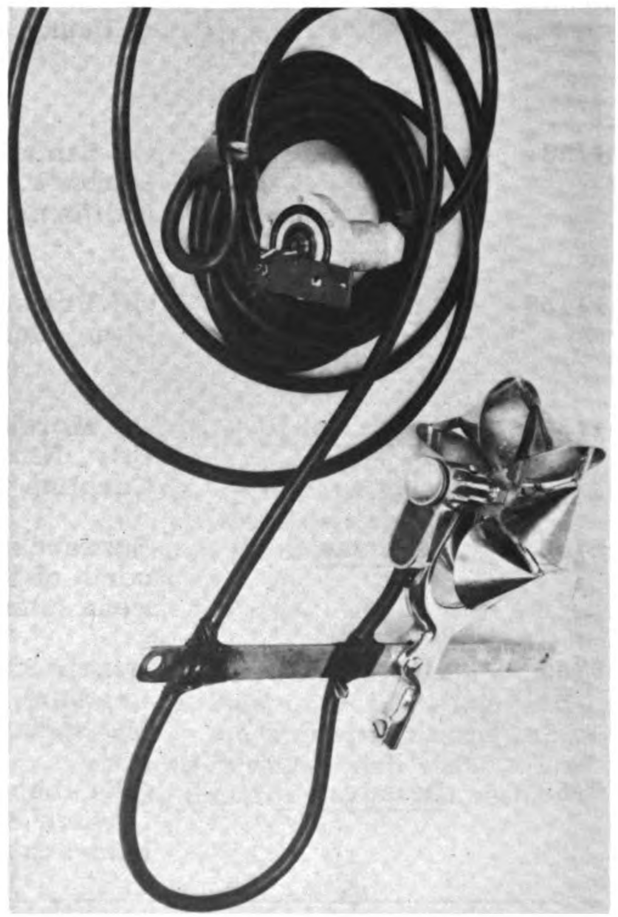

Figure 34. --Gurley current meter.

PORT SAMPLERS POOL
L. H. Couture, Chief

T. Gallagher (Pt. Judith, R. I.)
H. C. Horrell (Pt. Judith, R. I.)
J. R. Kallio (Gloucester, Mass.)
J. C. Malone (Boston, Mass.)
C. L. Philbrook (Rockland, Maine)
P. Swain (New Bedford, Mass.)
A. F. Thibodeau (Portland, Maine)
C. E. Watson (Boston, Mass.)

The port samplers pool is responsible for the routine collection of length-frequency, scale, and otolith samples of the commercial landings of all major species of fish landed in New England. The samplers, permanently stationed at the six main ports, also collect special samples of stomachs, gonads, and other organs as requested for special studies. In some ports, they also interview fishing captains to obtain information on area of capture, fishing effort, and total catch by species. For convenience and to avoid delays in payment, they also act as agents for the collection of recaptured tagged fish and pay the rewards.

During the past year, the Pool made 13,568 interviews, collected 1,697 samples, 11,617 scales, 9,129 otoliths, and made 186,896 length-frequency measurements.

Tagging Section - S. L. Cogswell

Over 13,000 tags were placed on twelve species of fish last year. Haddock (4,159), whiting (2,488), yellowtail flounder (3,100), scup (1,923), winter flounder (986), and redfish (367) accounted for the majority of these. The rest were put on cod, halibut, pollock, herring, and white hake.

Returns from these and previous tagging programs have been excellent. United States and Canadian fishermen turned in 3,114 tags during the past year. The experiment of offering to pay an extra dollar for the return of the fish as well as the tag has been very successful. Increasing the amount available in the imprest fund has helped greatly by avoiding the bad impression created by delay in paying the rewards.

SEMINAR PROGRAM

The seminar program is offered to give station biologists the opportunity to present the results of their current research to their colleagues and other interested persons of the Woods Hole scientific community. Guests and visiting scientists are also invited to speak on their specialties. Last year's program had fourteen talks almost equally divided between station biologists and others.

Circulation in the Gulf of Maine, Dean F. Bumpus, Woods Hole Oceanographic Institution.

Comparisons of methods for sampling industrial catches, Joel O'Connor, University of Rhode Island.

Panel discussion: Lines of approach for estimating relative abundance in exploited animal populations, Clyde C. Taylor, R. L. Edwards, and J. A. Posgay, Fish and Wildlife Service.

Raft culture of oysters in Cape Cod waters, William N. Shaw, Fish and Wildlife Service.

Suggested mechanisms of the formation of aggregations of sedentary marine invertebrates, Harry J. Turner, Woods Hole Oceanographic Institution.

Review of Russian book edited by M. M. Kamshilov: Regularities and migrations of commercial fishes in coastal waters of Murman, Paul S. Galtsoff, Fish and Wildlife Service.

The food of larval haddock, cod, and pollock, Robert R. Marak, Fish and Wildlife Service.

The identification of haddock stocks from vertebral counts, John R. Clark and John P. McDermott, Fish and Wildlife Service.

Results of studies of Georges Bank bottom sediments, Roland L. Wigley, Fish and Wildlife Service.

A new method of predicting the effect of a mesh regulation, J. A. Posgay, Fish and Wildlife Service.

Methods for measuring intermixing between different populations of a fish species, Saul B. Saila, University of Rhode Island.

Serological studies of marine fish populations, Carl J. Sindermann, Fish and Wildlife Service.

Haddock fishery economics and some implications of fisheries research findings, Edward J. Lynch, Jr., Boston College.

Film: Effects of wave action on Georges Shoal, underwater movie by Harris Stewart, U. S. Coast and Geodetic Survey.

SATURDAY SCIENCE SCHOOL

Fishery biologists of this Laboratory and Col. Eugene S. Clark (ret.) of Sandwich, Massachusetts, in cooperation with the Standard Times of New Bedford, conducted a series of ten lectures on marine biology and fisheries for a group of junior and senior high school students in Fairhaven, Massachusetts.

Under the general title, "The sea at our doorstep," eleven of our biologists volunteered to plan and give lectures, discussions, demonstrations, moving pictures and exhibits for a pilot group of 55 pupils. Clyde C. Taylor supervised the program. The meetings were held on Saturday mornings from 10:00 to 12:00.

"The sea at our doorstep"

The resources of the sea	John P. Wise
Whales	Col. Eugene S. Clark
Exploring the sea	Robert Marak and David Miller
Why and how we study fish	Albert C. Jensen
Fish in the net	Robert Livingstone, Jr., and James M. Crossen
The sea scallop fishery	Arthur Posgay
Our international fisheries	John R. Clark
Sea and shore birds	George F. Kelly
Sea shells	Arthur S. Merrill
Biological exploration in the Arctic	Robert L. Edwards

The program was received enthusiastically by the students. Not one dropped out. There was a very favorable response from both teachers and parents not only locally but also from other areas. Partly because the local newspaper was sponsoring the series, press coverage was extensive and picked up by a national magazine. We have had many requests to repeat the lectures in other schools in the area.

Figure 35.--Lecturing at the Fairhaven Science School.

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