1960

ANNUAL REPORT

ureau of Commercial Fisheries

Biological Laboratory

Woods Hole Massachusetts

CIRCULAR 99

ERRATA

Page 8 The following cruises should be included:

Cruise number 59-9. - To survey the bottom sediments and benthic fauna in the vicinity of Browns Bank and southern Gulf of Maine.

Cruise number 59-12. - To investigate the distribution of young-of-the-year and older haddock on Browns Bank, Georges Bank, and the Gulf of Maine.

Cruise number 59-13. - To investigate the distribution of young-of-the-year and older haddock on Browns Bank, Georges Bank, Gulf of Maine, and the offing of New York.

Cruise number 59-14. - To develop and perfect hydrographic and fish-survey techniques.

"Whaling City" cruise number 4. - To collect length frequency and age frequency samples from the Georges Bank sea scallop beds.

Page 22 Line 16, "fishes" should read "fisheries".

Page 24 Line 2, "fig. 15" should read "fig. 16". Line 3, "fig. 16" should read "fig. 15".

Page 32 In the leaderwork, "°C" should read "°F".

Page 35 Line 14, "specimens" should read "species".

#893 - 2/21/61

FOCUS

United States Department of the Interior, Fred A. Seaton, Secretary
Fish and Wildlife Service, Arnie J. Suomela, Commissioner
Bureau of Commercial Fisheries, Donald L. McKernan, Director

ANNUAL REPORT
BIOLOGICAL LABORATORY

Woods Hole, Massachusetts

for the year ending June 30, 1960

Herbert W. Graham, Laboratory Director

Circular 99

Washington, D. C.
December 1960

FOCUS

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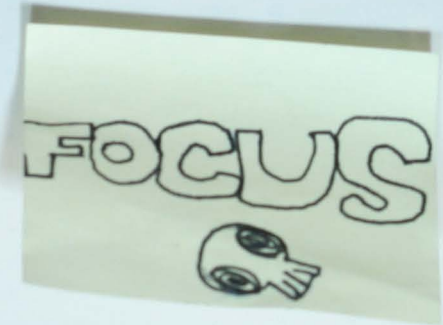
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REPORT OF THE LABORATORY DIRECTOR

Herbert W. Graham

Management Biology

Studies relating to the management of the groundfish of the Northwest Atlantic continue to occupy an important place in the Laboratory program. Evaluating the benefit of mesh regulation on the Georges Bank haddock fishery and assessing possible benefits of uniform mesh size for the area covered by the International Commission for the Northwest Atlantic Fisheries (ICNAF) were the two most important problems in this field this year.

Ralph Silliman made a complete review of the international mesh regulation as it effects the Georges Bank haddock fishery. This regulation has been in effect since 1953 and has been beneficial in many ways. Discard of small, unwanted fish has been reduced to a negligible quantity on the vessels using the large mesh, alleviating the necessity of culling at sea. The catches are cleaner and contain fewer fish of unwanted species such as hakes and herring.

The regulation was intended, of course, to increase the yield from a given population by delaying capture of the younger fish. Evaluation of this benefit is of the greatest interest to modern marine fishery biologists. There has been only one outstandingly large year class, the 1952 year class, to pass through the fishery since regulation. All studies of the effect of saving the small fish have dealt with comparing yields from this year class with yields of similarly large year classes before regulation.

Silliman compared the 1952 year class with the 1948 year class. On the basis of a length-frequency method, he concluded that the 1952 year class was 1.07 times the size of the 1948 year class. Taylor had given a figure of 0.9 and Paleheimo 1.0. Silliman concluded that the two year classes were of about equal size. He then pointed out that the two year classes produced about the same number of fish, but the 1952 year class produced about 20 percent greater weight of fish. Fewer fish were caught at age 3 but increased yields at ages 4 and 5 more than compensated for the lower catches at age 3. This is what had been predicted for the use of larger mesh gear when the regulation was first recommended.

Silliman also reviewed the assessment of the regulation, that is, the expected benefit computed on the basis of growth rates, mortality rates, and availability of fish. He took into account the differential distribution. Biological knowledge of differential availability of the smaller sizes on the banks was not used in the original computation of expected yields. The original theory assumed an availability of 1.0 for all ages. It now appears that age 1 has an availability of about 0.4 and age 2 about 0.7. Using these figures Silliman arrived at predicted benefits somewhat smaller than had the original computations and more in line with the amount of benefit which evaluations now indicate.

At the June 1959 meeting of ICNAF the Commissioners asked the scientists to determine possible effects, beneficial and harmful, of a uniform mesh size throughout the Convention area. An international assessment committee was set up to conduct these studies. Silliman was the U. S. representative on this committee. The committee submitted a preliminary report of its findings to the Commission in June 1960 and will have a final report for the June 1961 meeting. The committee confined its attention primarily to cod, haddock, and redfish but considered also halibut and flounders. Preliminary tables were compiled showing initial and long-term effects of mesh change and change in fishing effort over the present. Since mortality rates are not known for many of the stocks of fish in the area, calculations were made for a series of probable rates. It will be another year before the results of the committee's work will be ready for critical review. Their preliminary findings are given in the report of the Committee on Research and Statistics as follows:

A. In most cod fisheries changes in the landings for the total fisheries would be small for mesh sizes up to 5 inches. At larger mesh sizes losses might be experienced, especially by the trawl fisheries.

B. In most of the haddock fisheries moderate or substantial losses to trawl fisheries would result from increases in mesh size above 5 inches. For increases up to 5 inches, changes for the total fishery would probably be small but predictions are generally more variable than for cod.

C. In the redfish fisheries for which quantitative assessments were possible (Gulf of Maine and Nova Scotia banks), long-term losses would be likely to result from an increase of mesh to 4 inches.

D. In those fisheries pursued both by trawls and by nonregulated gear (e. g. lines, traps), any increase in the trawl-mesh size would usually result in long-term gains to the nonregulated gears.

These conclusions may be modified when the committee's analysis of available data has been completed, but they do give the general conclusions reached at this point in the study.

At the last annual meeting of ICNAF, the Committee on Research and Statistics considered at some length the need for more research in the Convention area on environmental studies. Changes in the abundance and distribution of commercial fish depend not only on the amount of fishing but also on changes in the environment. This aspect of the Commission's scientific work has been lagging and should be stimulated. The Commission set up a working party to organize a symposium on environmental studies from which it is hoped a definitive program will evolve which can be pursued in the Convention area by member countries. With the acquisition of a new research vessel in the near future and with the cooperation of other government activities in the Convention area, the United States should be able to accomplish its share of any fishery-environmental program which the Commission might endorse.

Rehabilitation of Physical Facilities

The year was marked by notable progress in replacing the laboratory's physical plant, both ashore and at sea. The Woods Hole staff moved into the new laboratory building March 1, 1960, the maintenance-aquarium building was brought near to completion, and the preliminary drawings for a new research vessel were drawn.

The new laboratory is a three-story brick and glass structure providing a total of 24,000 square feet of floor space. On the first floor are 9 research rooms and a large tank room all of which will be provided with running salt water from a storage standpipe. On the second floor are 5 research rooms, administrative offices, library, and meeting room. There are 16 research rooms on the third floor plus specimen storage room and rooms devoted to photography and drafting. A walk-in refrigerator for frozen specimens is located on the first floor. Pending the completion of the maintenance-aquarium building the first floor of the laboratory is being used largely for shops and storage.

Figure 1.--The Bureau of Commercial Fisheries new laboratory building at Woods Hole, Mass., was occupied on March 1, 1960. Landscaping of the building will follow completion of the entire rebuilding program.

Figure 2.--General view of construction of aquarium and maintenance shop building at the end of June.

A contract for design of a new fishery-oceanographic research vessel was signed with Dwight S. Simpson and Associates of Boston, Massachusetts, February 23, 1960. The contract calls for completion of working drawings in October. Funds in the amount of $2,055,000 have already been appropriated for construction. Present schedule calls for signing a construction contract by the first of the year.

The design shows a vessel about 175 feet long at the water line with a beam of 33 feet. Displacement is 1000 tons, service speed 12 knots, and range 9000 miles. Maneuverability will be accomplished by use of a Kort rudder and some kind of bow propulsion.

The main deck is designed with the open work area at the stern where 56 feet is available for fishing and other operations. Most collecting gear, including trawl nets, will be handled over the stern. Immediately forward of the trawl deck is about 1275 square feet of laboratory space. Berthing is provided for a normal complement of 17 crew members and 11 scientists. Total complement could be increased to 39. The vessel will be completely equipped for trawling, dredging, plankton and hydrographic work, and will have the most modern navigational and underwater equipment available. Live tanks, chilled sea water supply, and ample freezer space are some of the features included in the design.

Woods Hole Oceanographic Institution Contract

The Woods Hole Oceanographic Institution continued work for the Bureau on the hydrography of our area in relation to fisheries. Close liaison was maintained with this laboratory in these studies.

Annual Conference

The annual conference of personnel attached to the Woods Hole Laboratory was held February 2 and 3, 1960. All biological port agents attended as well as the statistical agents from the ports. A comprehensive program was scheduled in which each biologist reviewed his work for the year. The conferences are considered essential to keep the port agents up-to-date on the utilization of the data which they collect for the laboratory.

Seminar Program

Twenty-two seminars were given by our own staff members and visiting scientists.

Fishery oceanography in Japan, Michitaka Uda, Tokyo University of Fisheries.

Salmon problems in the North Pacific, Felix Favorite, Fish and Wildlife Service, Seattle.

Problems of estimating errors in age determination of fish, Marvin Grosslein, Cornell University and Fish and Wildlife Service.

Plankton investigations at the Oceanographic Laboratory, Edinburgh, Scotland, R. S. Glover, Oceanographic Laboratory.

Some results from cod tagging, John P. Wise, Fish and Wildlife Service.

Salmon fisheries of Alaska, John B. Skerry, Fish and Wildlife Service.

Marine fishery laws and regulations--What purpose do they serve? Charles L. Wheeler, Fish and Wildlife Service.

Report on the 1959 ICES-ICNAF redfish symposium in Copenhagen, George F. Kelly, Fish and Wildlife Service.

Observations on the stomach contents of the silver hake, Albert C. Jensen, Fish and Wildlife Service.

Preliminary review of the Atlantic Seriola, rudder fishes, with notes on possible relationships to Pacific species, Frank J. Mather, III, Woods Hole Oceanographic Institution.

The fishery and fishery research in Iceland, Dr. Jakob Magnusson, Reykjavik.

Some applications of invertebrate larval studies to the problems of fishery research, James Hanks, Woods Hole Oceanographic Institution.

Underwater observations on the behavior of fish in the cod end of commercial trawls, Robert Livingstone, Jr., Fish and Wildlife Service.

Yellowtail flounder studies, Fred E. Lux, Fish and Wildlife Service.

Vertical distribution of haddock larvae, David Miller, Fish and Wildlife Service.

Salt Pond ecology, Robert Conover, Woods Hole Oceanographic Institution.

A review of the distributional studies of larval redfish in the North Atlantic, George F. Kelly, Fish and Wildlife Service.

Quantitative survey of haddock foods on Georges Bank, Roland L. Wigley, Fish and Wildlife Service.

Results of the 1959 drift-bottle campaign, Dean F. Bumpus, Woods Hole Oceanographic Institution.

Spontaneous rhythm in worm behavior, Dr. G. P. Wells, University of London.

Oceanic tuna explorations, James L. Squire, Jr., Exploratory Fishing and Gear Base, Gloucester.

Seasonal changes in the internal anatomy of haddock, John P. McDermott, Fish and Wildlife Service.

A review of the natural history of the spiny dogfish and economics of the fishery, Albert C. Jensen, Fish and Wildlife Service.

Student Assistants

The laboratory continued its policy of employing a limited number of students during the summer to work on research problems.

Marvin Grosslein, graduate student at Cornell University, worked in the haddock investigation on an age-error model relating to age determination in fishes.

Richard Cooper, graduate student at the University of Rhode Island, studied the spawning runs of alewives in New England streams.

John Casey, graduate student at the University of Massachusetts, worked in the cod investigation on the incidence of parasites in New England codfish.

William Evoy, graduate student at Reed College in Oregon, worked in the sea scallop investigation studying techniques for age and growth studies in that mollusk.

Ruth Henderson, undergraduate student at Wellesley College, worked in the industrial fishery investigation compiling a file of fishing vessels in New England in connection with special effort studies.

John Hoberman was a student volunteer from Scarsdale High School who worked in the haddock investigation on preparation of scales for reading.

Vessel Operations

Six cruises of the research vessel Delaware were conducted by Woods Hole Laboratory personnel during the year. The Delaware is operated by the Exploratory Fishing and Gear Research Base, Gloucester, Massachusetts. In cooperation with the Woods Hole Laboratory the following cruises were made:

Cruise number 60-2. --To investigate the influence of the Gulf Stream on distribution and abundance of marine fishes and invertebrates along the Continental Shelf.

Cruise number 60-3. --To conduct a fishing survey of the Continental Shelf along the eastern side of Georges Bank and to determine the vertical movements of the silver and American hake.

Cruise number 60-4. --To make a survey of the spawning habits of haddock on Georges and Browns Banks.

Cruise number 60-5. --To collect adult haddock and haddock eggs, make bathythermograph transects, collect haddock ovaries, and obtain sex ratios and other data on haddock populations.

Cruise number 60-7. --Investigate the relative distribution and abundance of sea scallops and other invertebrates along the Continental Shelf from Block Island to Cape Hatteras.

Cruise number 60-8. --To collect quantitative data on the population structure and abundance of sea scallops on the Georges Bank grounds.

STAFF

Woods Hole Biological Laboratory

Herbert W. Graham, Laboratory Director
Clyde C. Taylor, Assistant Laboratory Director (Reassigned to La Jolla, California, September 19, 1959.)
Robert L. Edwards, Acting Assistant Laboratory Director

Fishery Research Biologists

Allan M. Barker
John R. Clark (Transferred to Washington, D. C., October 18, 1959.)
John B. Colton (Transferred to Boothbay Harbor, Maine, July 14, 1959.)
Lawrence H. Couture
Raymond L. Fritz
Albert C. Jensen
George F. Kelly
Robert Livingstone, Jr.
Fred E. Lux
Robert R. Marak
James A. McCann (Appointed June 15, 1960.)
John P. McDermott
Arthur S. Merrill
David Miller
Fred E. Nichyparowich
Julius A. Posgay
John B. Skerry (Transferred from Juneau, Alaska, August 22, 1959.)
Charles L. Wheeler (Appointed July 6, 1959.)
Roland L. Wigley
John P. Wise

Fishery Aids

Richard C. Barnard, stationed at Rockland, Maine. (Transferred from Division of Industrial Research and Services, Gloucester, Massachusetts, October 18, 1960.)
Claude F. Bocken, stationed at Gloucester, Massachusetts.
Philip H. Chase, Jr., stationed at New Bedford, Massachusetts. (Transferred from Woods Hole, Massachusetts, July 12, 1959.)
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 (Resigned February 19, 1960.)
John R. Kallio, stationed at Gloucester, Massachusetts.
Lewis M. Lawday, stationed at Woods Hole, Massachusetts.
John C. Malone, stationed at Boston, Massachusetts.
Joel S. O'Connor, stationed at Point Judith, Rhode Island. (WAE appointment, February 16 through June 16, 1960.)
Charles L. Philbrook (Formerly stationed at Rockland, Maine, transferred to Industrial Research and Services, Gloucester, Massachusetts, October 18, 1959.)

Fishery Aids (continued)

Llewellyn Porter, Jr., stationed at Boston, Massachusetts. (Transferred from Bureau of Sport Fisheries and Wildlife, February 23, 1960.)
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 (Formerly stationed at Boston, Massachusetts, resigned November 27, 1959.)

Statistical Staff

William H. Callahan
Frank A. Dreyer
Robert N. Hersey (Reassigned as Statistical Clerk, December 27, 1959.)
Henry W. Jensen (Appointed January 20, 1960.)
Lewis M. Lawday (Reassigned as Fishery Aid, June 14, 1959.)
Elizabeth M. Levangie (Resigned June 24, 1960.)
Harriett E. Murray
Palma L. Sargent (Resigned December 26, 1959.)
Ruth R. Stoddard

Administrative and Maintenance

August F. Almeida, Maintenanceman
Kathleen J. Blair, Clerk-Stenographer
Alice M. Cairns, Personnel Clerk
Gilbert J. Costa, Foreman I--Building Repairman
Robert N. Hersey, Guard (Reassigned as Statistical Clerk, December 27, 1959.)
Dorothy C. Johnson, Clerk-Typist
Sally H. Jones, Secretary (Stenographer)
Helen I. Kiernan, Purchasing Agent
Warren L. Loring, Building Repairman
Vincent A. Mackesy, Administrative Assistant
Betty J. Mayes, Clerk-Typist (Supply) (Resigned March 16, 1960.)
Harold M. Neal, Maintenanceman
Robert E. Polley, Guard (Reassigned as Janitor, March 6, 1960.)
Ralph E. Sliney, Guard (Termination of Temporary Appointment, March 5, 1960.)
Mary C. Thompson, Clerk (Typing)
Ruth M. Young, Clerk-Stenographer
Kenneth H. Weaver, Jr., Guard (Termination of Temporary Appointment, March 5, 1960.)
Emily B. Merrill, Clerk-Typist (Temporary Appointment-WAE-effective May 16, 1960.)

Technical Assistants

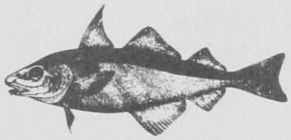
Frank A. Bailey, Scientific Illustrator (Statistical Draftsman)
Robert K. Brigham, Photographer
Sterling L. Cogswell, Fishery Methods and Equipment Specialist
James M. Crossen, Electronics Technician (Fishery Equipment)
Elizabeth B. Leonard, Librarian
Samuel R. Nickerson, Fishery Methods and Equipment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

Student Assistants (Fishery Aids)

John G. Casey (June 8 to September 8, 1959)
William H. Evoy (June 17 to August 28, 1959)
Marvin D. Grosslein (June 17 to September 15, 1959)
Ruth K. Henderson (June 15 to August 28, 1959)
Richard A. Cooper (June 15 to October 15, 1959)

Shellfish Laboratory

Paul S. Galtsoff, Chief
William N. Shaw, Fishery Research Biologist
Patricia A. Philpott, Clerk
Ruth L. von Arx, Scientific Illustrator (Temporary Appointment - WAE)



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 1959 edged slightly over last year's 30 million pounds, which had been the highest in nearly 10 years. There was a slight decrease in the landings of the scrod category (less than 2-1/2 pounds) as last year's abundant small fish grew to larger size. The first half of 1960 showed some diminution, but relatively high landings are expected to continue for another year at least.

Larval Drift

Although only 45 of the 1260 drift bottles (fig. 3) dropped off the New Jersey and Delaware coasts last year from Navy airships have been recovered, more than half of the bottles from some stations have been found on the beach. From a single station off Corson's Inlet, 10 out of 12 bottles have turned up. This is strong evidence that the technique of dropping drift bottles from airships flying at low altitudes causes little if any breakage.

The returns tell us something about the possible fate of cod eggs and larvae in the surface layers of the ocean at that time. Although bottles were dropped as far as 125 miles from shore, nearly all the returns were from stations 10 miles or less from shore. This is an indication that the surface waters over the Continental Shelf were probably swept out to sea.

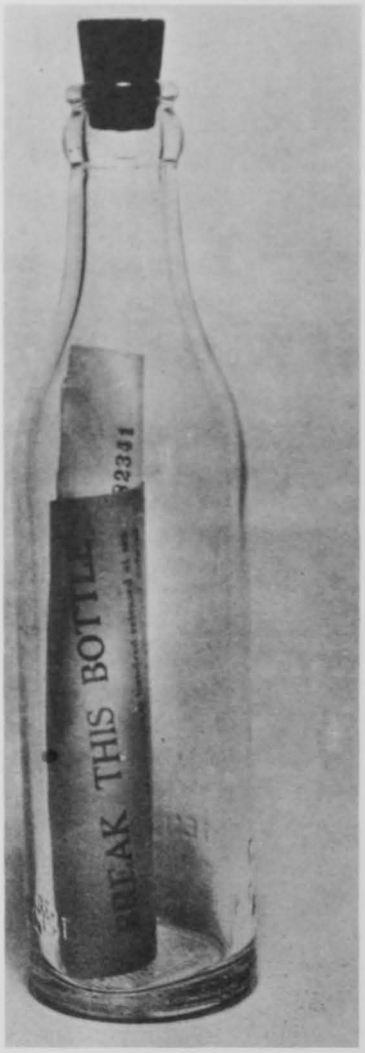


Figure 3.--Drift bottle.

Figure 4 shows the results after 13 months. Stations from which no bottles have been recovered are open circles, those from which recoveries have been made are closed circles with arrows indicating the direction of travel of the bottles. If more bottles are found on the shores of Europe this summer and autumn, as expected, the hypothesis of offshore drift of surface waters will be further borne out.

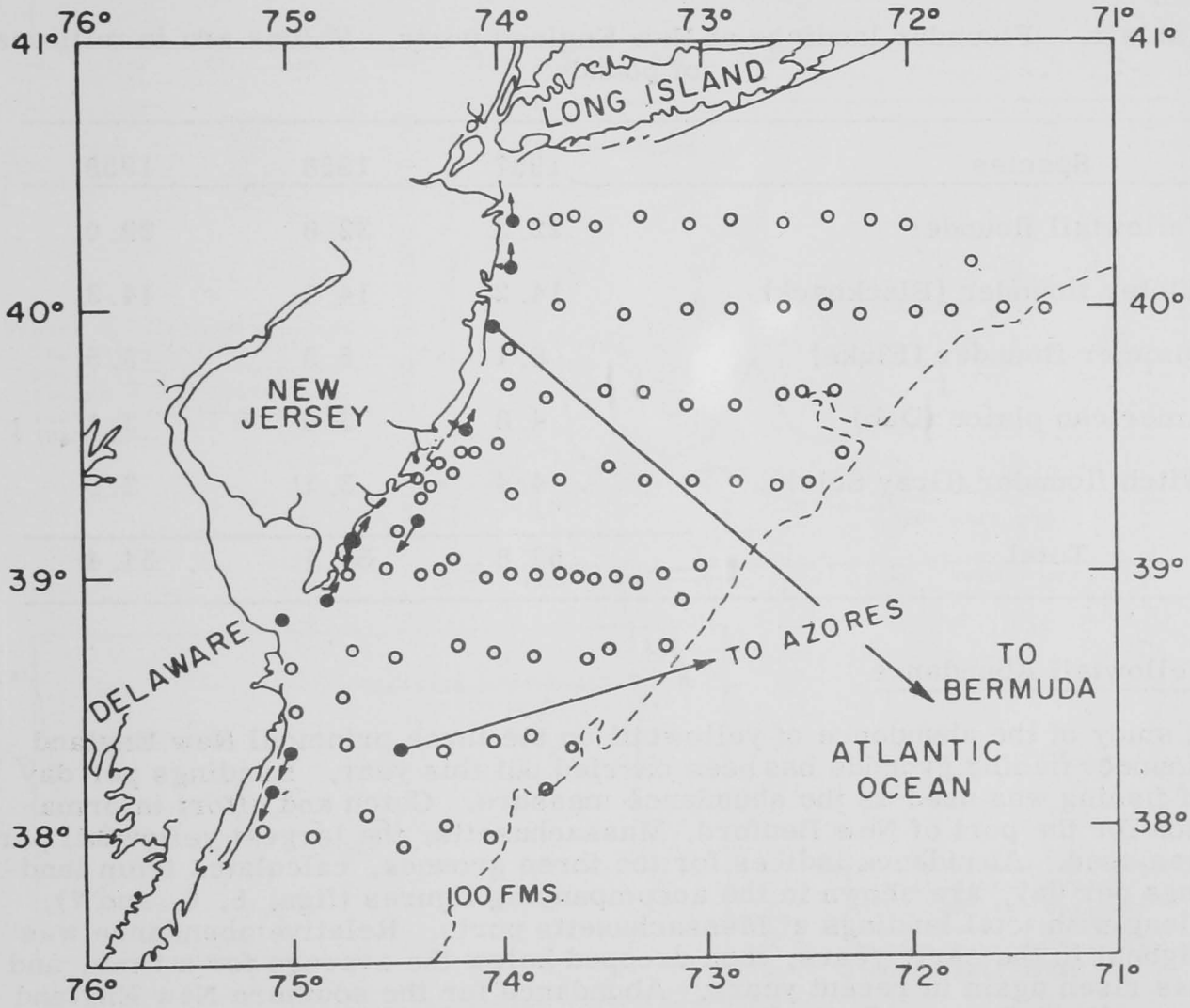


Figure 4.--Results from dropping drift bottles from blimps after 13 months. Open circles are stations from which no bottles have been returned.

FLOUNDER INVESTIGATION

F. E. Lux, Chief
E. M. Levangie

State of the Fishery

Lower landings of flounders at New England ports in 1959, compared with 1958, are due to the drop in yellowtail catch, since landings of other species were almost exactly the same in the two years. The abundant yellowtail year classes of 1955 and 1956 have now made their peak contributions to the fishery. As a result, the 1960 yellowtail catch will probably drop considerably inasmuch as no abundant incoming year classes are apparent.

Table 1. --Flounder landings at New England ports. Values are in millions of pounds

Species	1957	1958	1959
Yellowtail flounder	22.3	32.8	29.0
Winter flounder (Blackback)	14.2	14.1	14.3
Summer flounder (Fluke)	8.1	5.5	5.5
American plaice (Dab)	4.8	3.0	3.1
Witch flounder (Gray Sole)	4.4	3.1	2.9
Total	53.8	58.1	54.4

Yellowtail Abundance

A study of the abundance of yellowtail on the three principal New England flounder fishing grounds has been carried out this year. Landings per day of fishing was used as the abundance measure. Catch and effort information for the port of New Bedford, Massachusetts, the largest yellowtail port. was used. Abundance indices for the three grounds, calculated from landings per day, are shown in the accompanying figures (figs. 5, 6, and 7), along with total landings at Massachusetts ports. Relative abundance was highest in the early years, then dropped below the average for a time, and has risen again in recent years. Abundance for the southern New England ground and Georges Bank, the most important areas, has generally followed total landings within each area. Abundance indices for the three grounds have paralleled one another quite closely, suggesting that conditions governing abundance on one ground do so on other grounds as well.

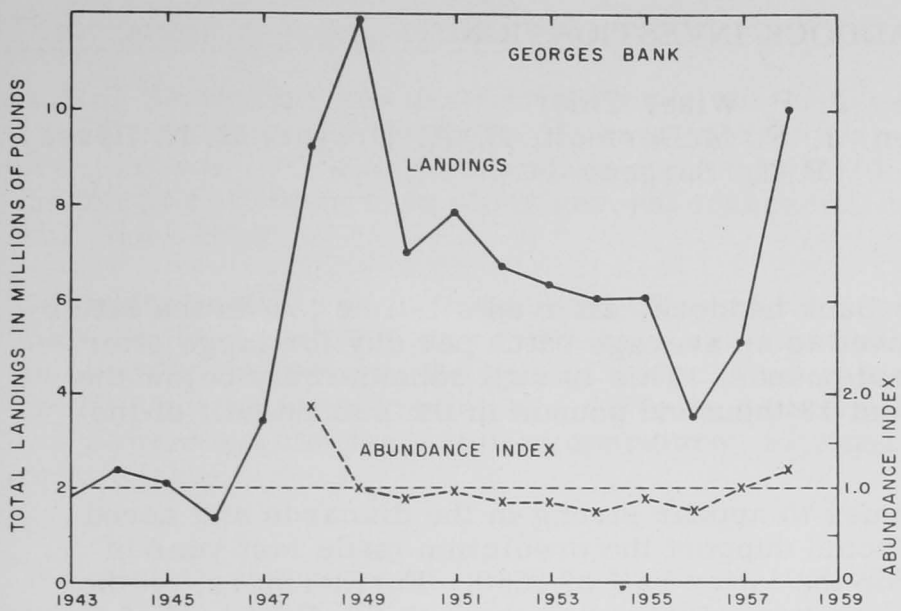


Figure 5.--Yellowtail landings at Massachusetts ports from Georges Bank, 1943-1958, and abundance index for subareas XXII M and N of this ground, 1948-1958.

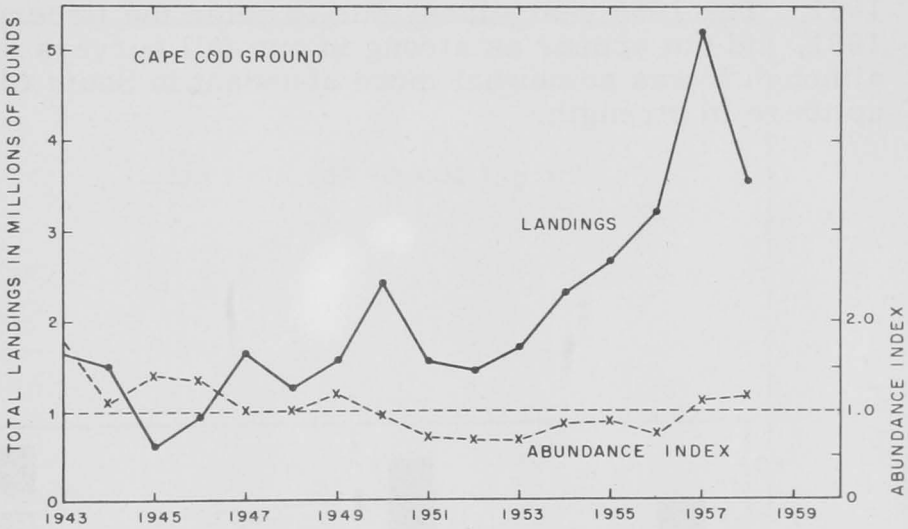


Figure 6.--Yellowtail landings at Massachusetts ports from the Cape Cod ground and abundance index for this ground, 1943-1958.

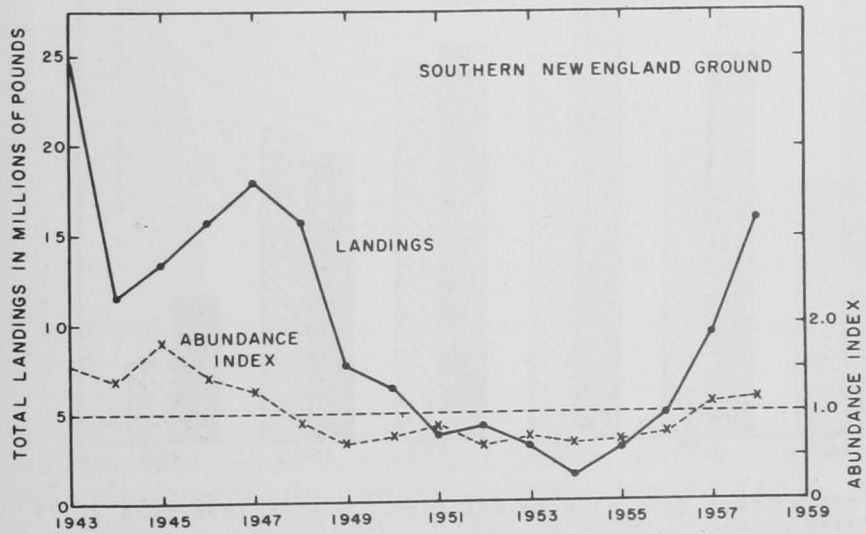


Figure 7.--Yellowtail landings at Massachusetts ports from the southern New England ground and abundance index for this ground, 1943-1958.

HADDOCK INVESTIGATION

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

State of the Fishery

The abundance of Georges Bank haddock, after an all-time low in the latter half of 1959, slowly improved to an average catch per day for large otter trawlers of about 8 thousand pounds. This is still considerably below the 1931-1958 average of almost 13 thousand pounds in the second half of the year.

The 1958 year class continues to appear strong in the discards and scrod catch of spring 1960 and should support the prediction made last year of moderate to good fishing for the latter half of 1960. Furthermore, we believe that fishing will continue reasonably good through the first half of 1961. The 1959 year class, due to enter the fishery around the middle of 1961, did not appear as strong in our fall surveys as the 1958 year class, although it was somewhat more abundant in South Channel and might show up there in strength.

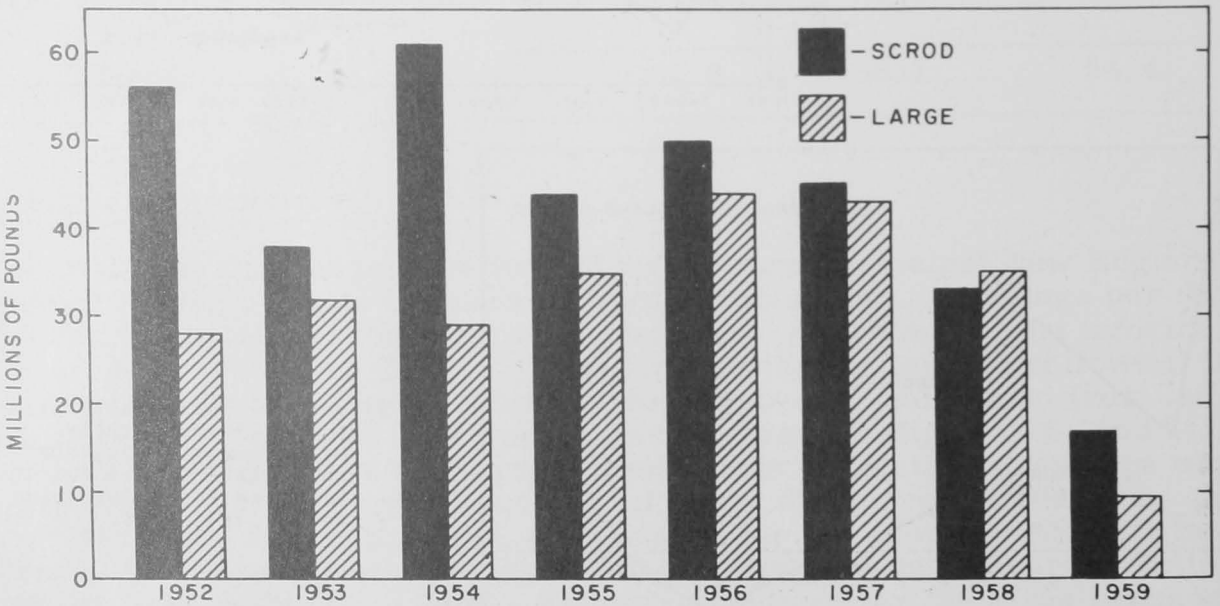


Figure 8.--Landings of haddock from Georges Bank by size category. Scrod: less than 2-1/2 pounds, large: greater than 2-1/2 pounds.

Distribution of Young-of-the-Year

During September and October we made two cruises (Delaware 59-12 and 59-13) to assess the numbers of young-of-the-year haddock hatched out the previous winter. Using a standard otter trawl with a fine mesh liner, we made 134 half-hour tows along several transects from Nova Scotia to the New York Bight.

Complete analysis of the data from these and several previous cruises remains to be done, but, on preliminary examination of the 1959 data, we found an association between the bottom water temperature and the number of young-of-the-year haddock in each tow. Figure 9 shows the number of haddock per tow plotted against the water temperature, together with a curve showing the relationship.

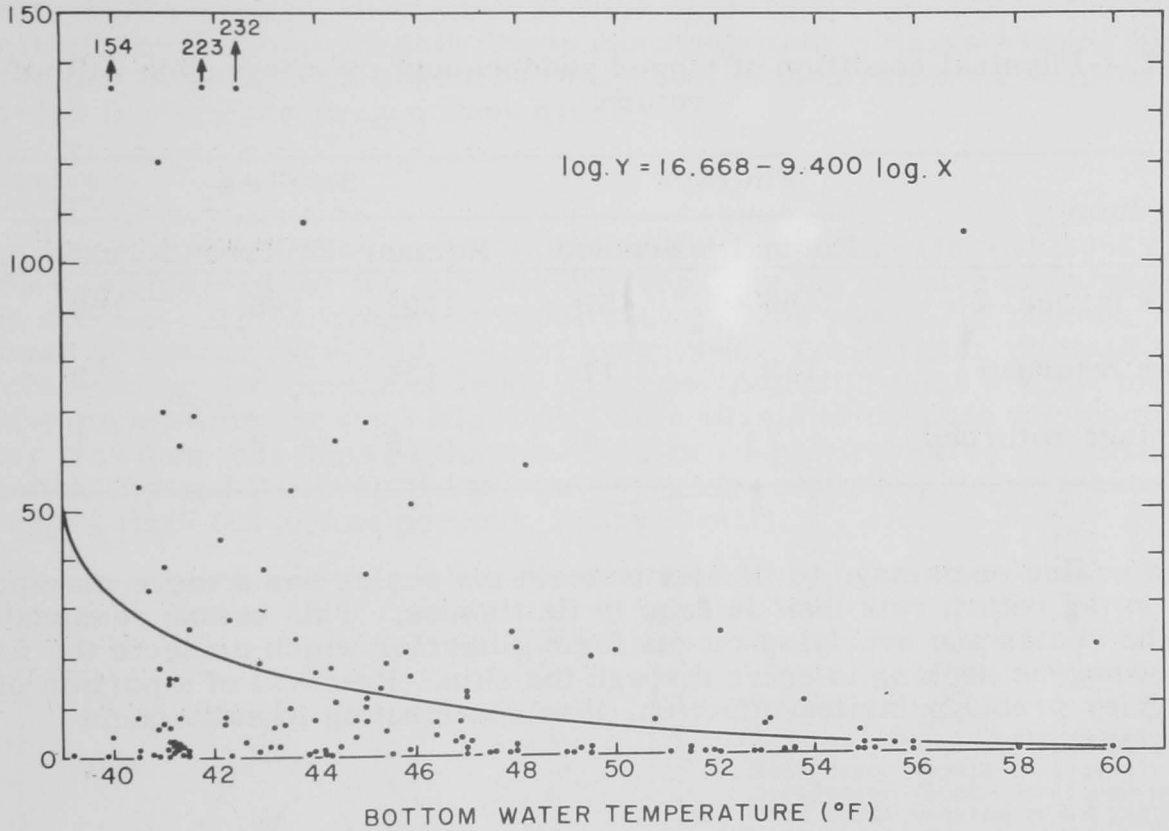


Figure 9.--Numbers of young haddock in relationship to bottom water temperature.

At the lower range, from 39° F. to perhaps 50° F., the water temperature apparently has an important effect, with more small fish found at lower temperatures. In contrast, at the higher range, from about 50° to 60° F., change in temperature seems to have little effect.

Factors Relating to Tagging Success

Fish tagging as a research technique for studying migrations, stock definitions, or growth is limited in its usefulness by the small number of returns (on the order of 10 percent for haddock). An important factor limiting the success of tagging studies is the physical condition of the fish at the time of tagging. Tag return data from nearly 2000 haddock tagged at sea were compared to data evaluating the physical appearance of the fish at time of release. The chief physical factors noted were the presence of blood within the tissues of the fins, loss of scales, and blood in the scale pockets.

Condition of the fins was recorded as follows: (1) bruised--tissues between fin rays red and apparently engorged with blood; (2) normal--no redness present. Condition of the scales was recorded as follows: (1) bruised--tissues in scale pockets red and apparently engorged with blood; (2) scraped--up to 10 percent of scales estimated missing (haddock with more than 10 percent of scales missing were not tagged); (3) normal--no scales missing. The results are shown in table 2.

Table 2.--Physical condition of tagged haddock and its effect upon rate of return

Item	Fin rays		Scales		
	Normal	Bruised	Normal	Bruised	Scraped
Number tagged	1492	457	1593	195	156
Number returned	112	17	123	4	2
Percentage returned	7	4	8	2	1

Loss of scales or damage to tissues beneath the scales has a more marked effect on tag return rate than damage to fin tissues. This seems reasonable since the scales and overlying mucus form a barrier which protects the fish from pathogens seeking to enter through the skin. Removal of a portion of the barrier probably invites infection, thus contributing to subsequent higher mortality.

HAKE INVESTIGATION

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

State of the Fishery

Total landings of silver hake, for human consumption, in 1959 did not differ significantly from 1958. Landings along the Atlantic coast amounted to 114 million pounds for 1959, compared to 111 million pounds for 1958, an increase of 2-1/2 percent. This increase was largely due to the added landings in Rhode Island. The quantity of silver hake landed for both mink food and industrial use (oil and fish meal) increased this year over last. The amount processed for mink food was 16 million pounds in 1958 and 20 million pounds in 1959. For industrial purposes, the landings were 22 and 26 million pounds in 1958 and 1959, respectively.

The Gloucester fleet shifted its area of fishing in 1959. Along the Maine coast the number of trips increased from 56 to 110 (96 percent); along the Massachusetts coast the number of trips decreased from 248 to 195 (21 percent). This shift was largely due to concentrations of large whiting along the Maine coast and the absence of the usual concentrations of whiting in Ipswich Bay and Stellwagen Bank areas.

Abundance

The catch of silver hake by small and medium otter trawlers in 1958 and 1959 was analyzed for the purpose of comparing the relative abundance of this species. The average catch per hour in 1959 was 3,700 pounds, an increase of approximately 12 percent over 1958. The largest increase occurred during the months of June, July, and August, which are the most active months for the fleet (fig. 10). An analysis of the data for medium otter trawlers only showed that the catch per hour decreased 33 percent in Ipswich Bay and Stellwagen Bank but increased along the Maine coast and Georges Bank (28 and 64 percent, respectively).

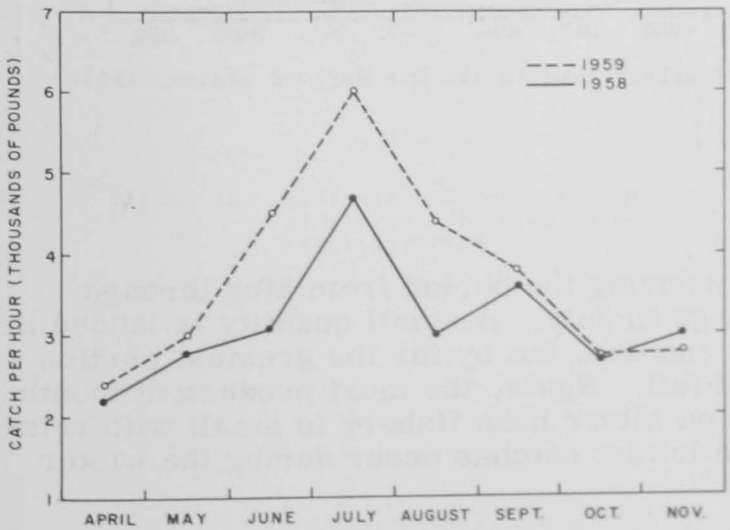


Figure 10.--Catch per hour of silver hake from vessels landing at Gloucester, Mass., during the months from April to November for the years 1958 and 1959.

Monthly Landings

The silver hake fishery along the New England coast is very seasonal, especially in the northern sections. Monthly landings of this species for the New England States in 1959 are shown in figure 11. Along the Maine

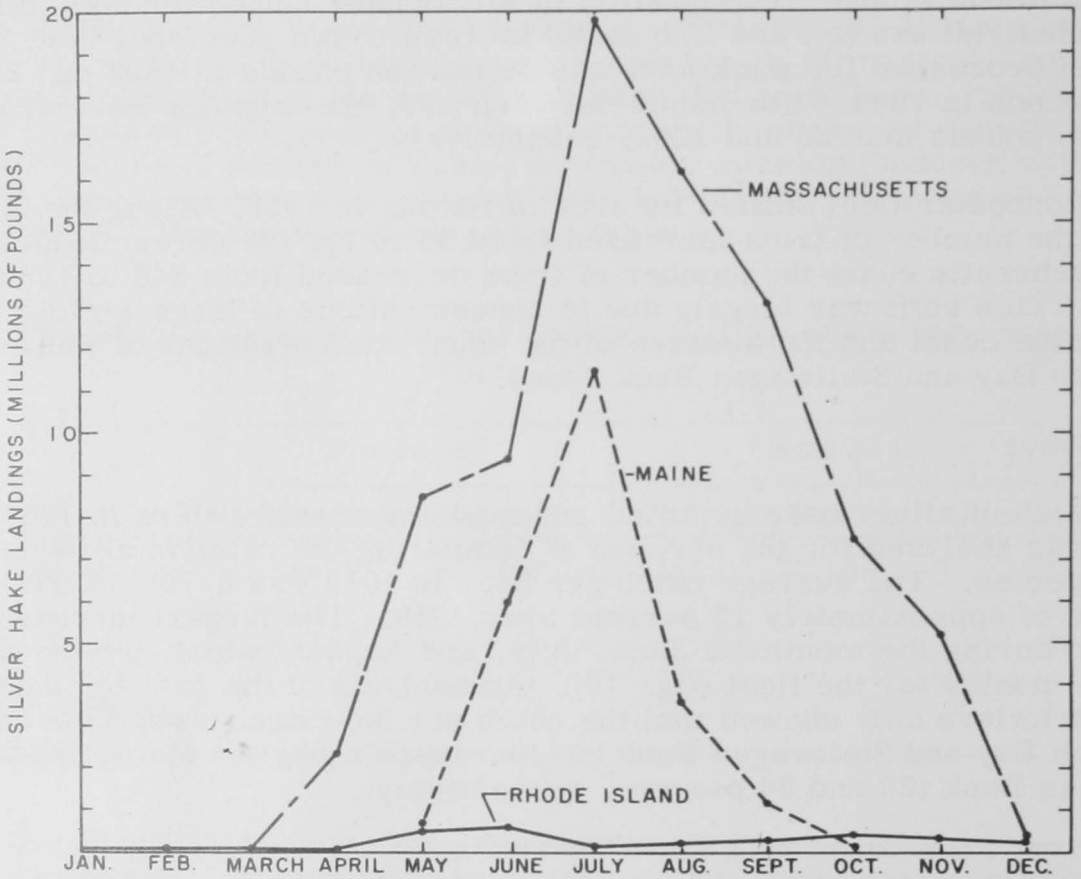


Figure 11. Monthly landings of silver hake in the New England States, 1959.

coast silver hake are caught only during the period from May through October, with the heaviest landings in July. A small quantity is landed in Massachusetts during the winter months, but by far the greatest portion is caught during the summer and fall. Again, the most productive month is July. Although the Rhode Island silver hake fishery is small with relatively little seasonal change, the lowest catches occur during the winter months.

Racial Studies

Among the many morphological characters which are used for distinguishing species of fish, or identifying stocks within a given species, the number of vertebrae has proved to be one of the most useful. Thus, in an attempt to determine if the population of silver hake inhabiting the northeastern coast of the United States was composed of more than one subgroup, the variation in number of vertebrae of specimens from several geographic areas has been studied. For this purpose, samples of approximately 50 hake were collected at three widely spaced localities: (1) Portland, Maine, (2) Cultivator Shoals on Georges Bank (Massachusetts), and (3) Belmar, New Jersey. The specimens were X-rayed (fig. 12) and vertebral counts made directly

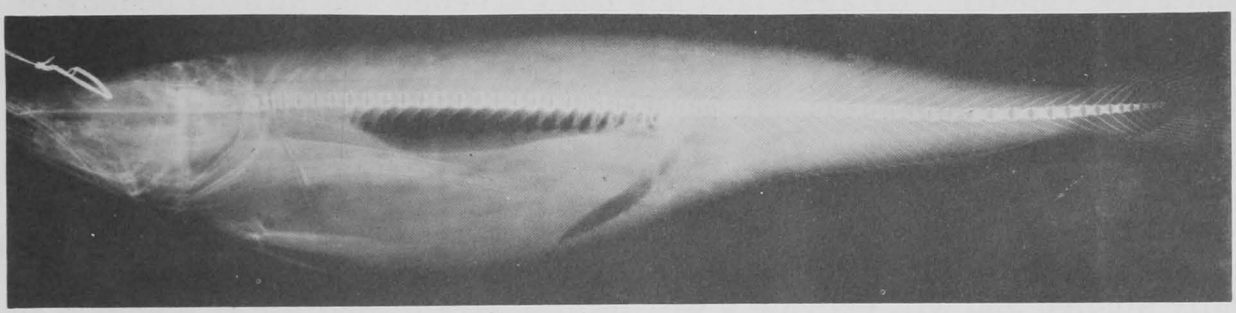


Figure 12. Radiograph of a silver hake.

from the plates. Differences in the average number and the range in number of vertebrae for these samples are exceedingly small. The results are as follows: Maine specimens averaged 53.95 vertebrae, with a range from 52 to 56; Massachusetts specimens averaged 54.02, with a range from 52 to 56; New Jersey specimens averaged 53.90, with a range from 52 to 55. These results (fig. 13) indicate that, on the basis of vertebral counts, the population of silver hake cannot be subdivided into subspecies or racial groups.

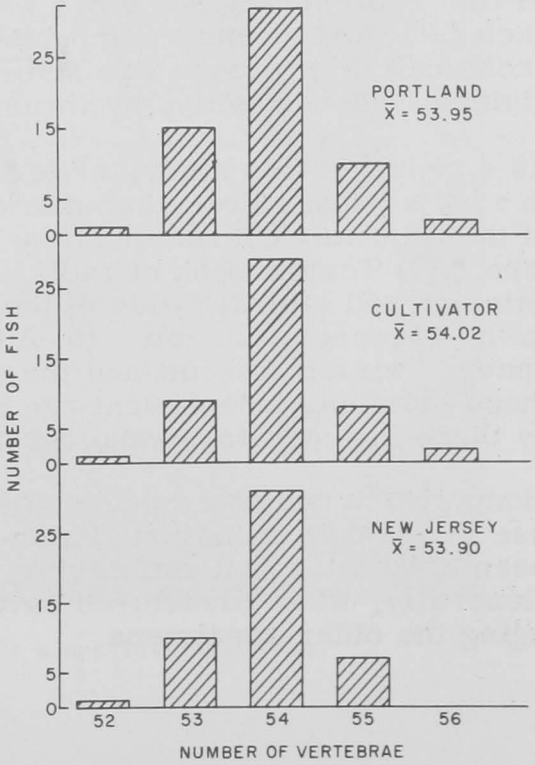


Figure 13. Histogram of vertebral counts of silver hake from three sampling areas.

INDUSTRIAL FISHERY

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

The industrial trawl fishery virtually ceased in September 1959 when it became economically unfeasible for the fish meal and condensed fish manufacturers to profitably market their products. Various small segments of the industry continued in being, amongst these the animal (mink) food and fish flour industries.

This fishery began to operate in New England waters over 10 years ago and grew rapidly. By 1957 landings had exceeded 150 million pounds of fish annually. These landings, as previously reported, were composed of many species, with the red hake and the silver hake contributing most (ca. 75%) to the catch.

The resource, in its general terms, is again not being exploited. However, during the past 5 years this laboratory has accrued an invaluable body of knowledge about the ecology of southern New England bottom fishes by continued sampling of industrial landings. These data are being carefully studied and will provide a worthwhile background for subsequent research on other mixed fishes.

Scup Studies

Age determination. --Counting annual rings on the scales of scup, *Stenotomus chrysops*, is the standard method of aging this species. Prior to the present study of age determination, the reliability of the scale reading method had not been evaluated. In order to establish objective criteria for defining annuli, the following procedure was carried out: A sample of 54 fish representing all sizes was chosen at random. Four scales from each fish were pressure-mounted on plastic and the projected image of each scale impression was studied. These scale impressions were examined, independently, by three investigators.

As a result of this study, criteria have been established for defining annuli in scup scales. True year marks are recognized by having all or most all of the following characteristics: (1) A definite change in the circuli pattern. (2) Termination of radii. (3) A mark visible completely around the anterior and lateral fields of the scale. (4) A break in the sculpturing due to the absence of circuli. (5) A banding pattern resulting from narrowly-spaced "winter" circuli and the widely-spaced "summer" circuli. Using these criteria, independent age readings of the above mentioned samples by three investigators resulted in 95-percent agreement.

Body structures other than scales have also been examined for possible use in age determination studies. Otoliths and fin rays from scup have been used and found satisfactory for aging specimens less than 6 years old. Generally, these structures have not proved to be as useful as scales for aging the older specimens.

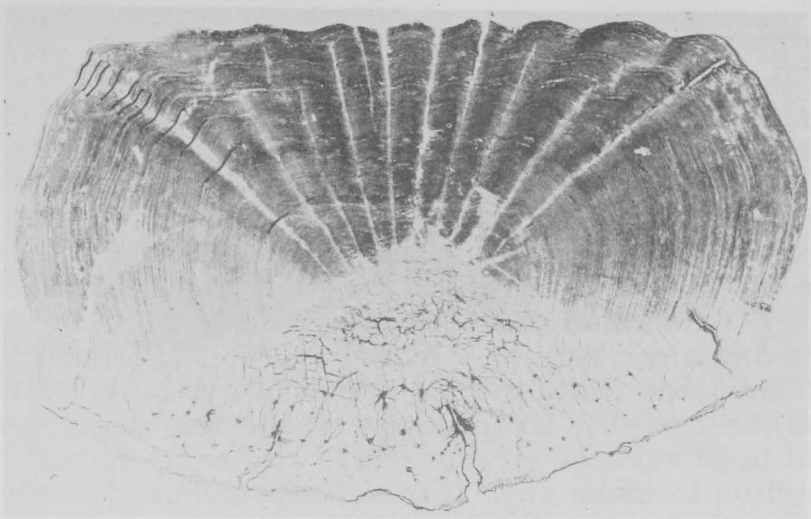


Figure 14.--Scale from a 12-year-old male scup; length 34.6 cm., weight 832 grams; from Newport, Rhode Island, May 28, 1959.

Tagging. --During the period from May 26 to June 4, 1959, a total of 1000 scup were tagged using the standard Atkins tag. Of this number, 149 fish obtained from a floating trap at Newport, Rhode Island, were tagged and released in West Passage, Narragansett Bay. At the present time there have been 4 recoveries from this group, a total of 2.7 percent. The remainder of the 1000 scup were obtained from a pound net located off Quissett Harbor, Falmouth, Massachusetts. These were tagged and released in Buzzards Bay, Massachusetts. Tags were attached to these scup in the dorsolateral musculature (fig. 15), above the lateral line, directly below the third and fourth dorsal spines. At this time there have been only 5 recoveries, a total of 0.6 percent. Additional tagging is currently in progress and will be continued for several years.

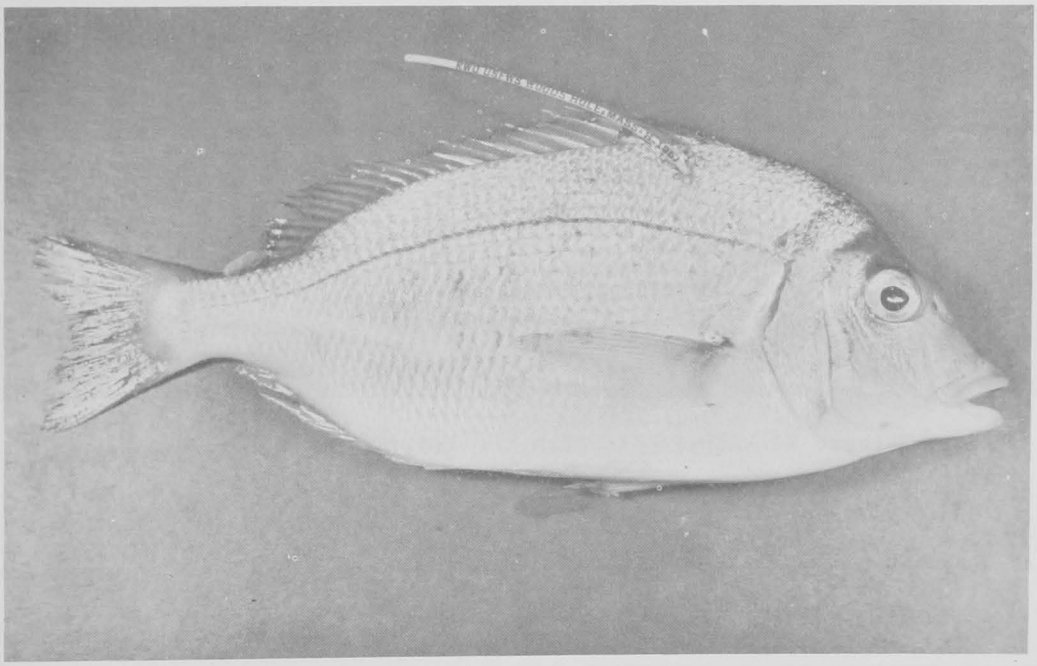


Figure 15.--Scup tagged with a spaghetti-barb tag.

Experimental tagging. --Fifty scup were tagged with nylon barbs attached to printed yellow plastic tubing (see fig. 15). These were inserted in the musculature just below the third and fourth dorsal spines (fig. 16). This method of tagging proved quick and easy for the person tagging and less injurious to the fish than older methods. The tagged fish were kept in a live car together with 100 untagged scup. Daily observations were made and recorded on the condition of the fish and the behavior of tagged and untagged specimens. Observations have disclosed that the wound caused by the insertion of the tag is slight and heals quickly. Initial mortality is low--2 fish died shortly after tagging--and most of the scup were feeding the day after tagging. A forewarning of a potential problem with this type of tag came to light when it was noticed that 20 tags had been shed during the first week. Examination of the fish concerned showed that the tag had not been secured firmly. It is advisable to pull back on the dart after insertion to make sure it is solidly anchored in the flesh. Because of the encouraging results of this experiment, this type of tag will be further tested in the spring along with the Atkins, Peterson disc, and looped spaghetti-type tags.

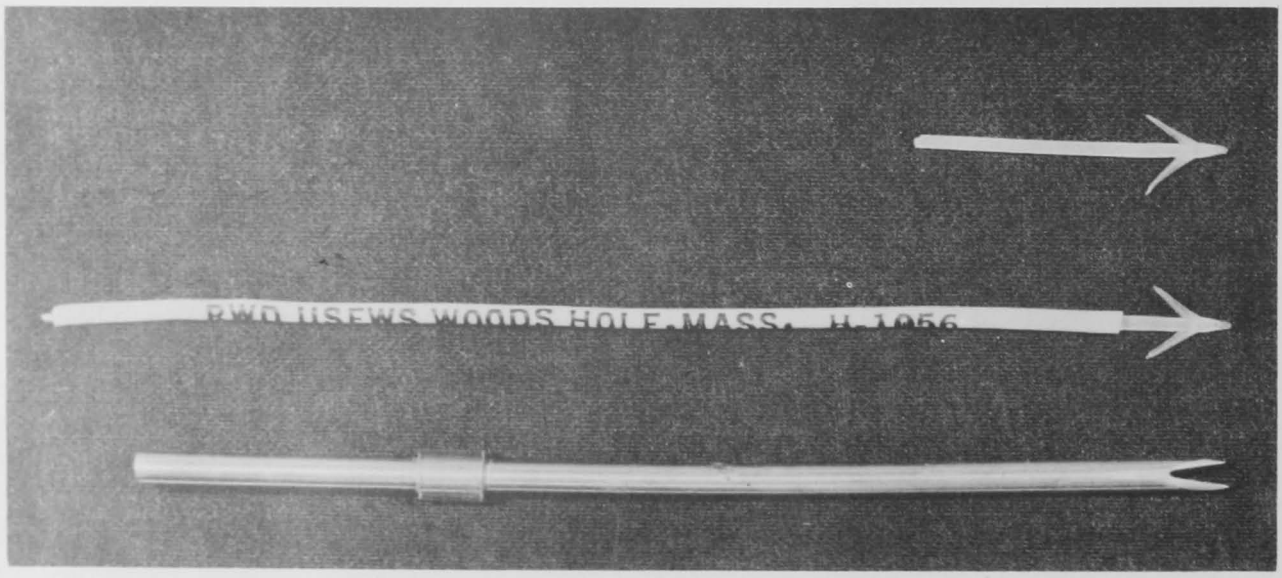


Figure 16.--Spaghetti-barb tag and (below) the tagging tool.

REDFISH INVESTIGATION

G. F. Kelly, Chief
A. M. Barker, G. M. Clarke

The Redfish Fishery

More than 3-1/2 billion pounds of redfish have been landed in New England since the inception of the United States redfish fishery in 1935, an average of 140 million pounds landed annually for the 25-year period. In 1959, 137 million pounds of redfish were landed by United States vessels--a value only slightly below the 25-year average but far below the highest value of 258 million pounds landed in 1951.

The redfish fishery began in the Gulf of Maine, expanding eastward to the Nova Scotian Banks, Grand Bank, Gulf of St. Lawrence and coast of Labrador. More than 82 percent of the 25-year total landings have come from the Gulf of Maine and Nova Scotian Banks (table 3). As a result of redfish exploitation, each of the fishing grounds have followed the same sequence of development. At first the landings climbed rapidly to a peak with increased effort; later the landings and catch-per-unit-effort declined toward equilibrium at a level well below the highest value. The peak in landings was reached in the Gulf of Maine in 1941, Nova Scotian Banks in 1949, Grand Bank in 1953, and the Gulf of St. Lawrence in 1955. The Labrador coast was heavily fished by several nations for the first time in 1958. The future of this fishery is uncertain, since virtually no redfish were found during the spring of 1959 on the banks where they had been heavily concentrated the previous fall.

Table 3. --Summary of United States redfish landings from 1935 through 1959, by area of capture

Area	Period fished	Pounds landed	Percent of total
Gulf of Maine	1935-1959	1,568,495,000	44.6
Nova Scotian Banks	1935-1959	1,322,089,000	37.6
Grand Bank	1950-1959	347,805,000	9.9
Gulf of St. Lawrence	1951-1959	272,273,000	7.8
Labrador Banks	1958	4,351,000	0.1
Total		3,515,013,000	100.0

The gradual decline in United States landings since 1951 represents the approach toward equilibrium of fishing effort and redfish abundance on the fishing grounds available to the United States redfish fleet. Although the catch-per-unit-effort has decreased on all grounds, it has not declined to a dangerously low level suggesting harmful depletion of the stocks in any area. The history of the Gulf of Maine fishery, the oldest fishery, indicates that after the initial decline in abundance the stocks can survive to support a profitable fishery for a longer period of time.

Redfish Racial Studies

Three species of redfish (genus Sebastes) have been reported from the North Atlantic Ocean, but there is disagreement among investigators regarding their taxonomic status. For over a century S. marinus was the only species of redfish recognized in the North Atlantic. In recent years, two additional species have been described. S. viviparus, which is a small, European form commonly found in shallow waters, is generally accepted as a valid species. S. mentella, which is a large-eyed, Barents Sea form, has an uncertain standing. Its status as a distinct species is questioned on the grounds that the variability of the characteristics used to describe it is not adequately known for populations of redfish throughout the North Atlantic.

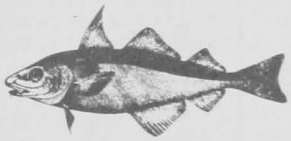
Although Gulf of Maine redfish have long been considered a stock of S. marinus, some investigators periodically suggest that these fish should be classified as S. viviparus. This suggestion is erroneous. Additional information on this subject has recently been obtained from a comparative study of redfish from widely separated areas in the North Atlantic. Collections of specimens from various localities were examined for the purpose of determining the differences in meristic and morphometric characteristics between the eastern and western populations. In order to find a natural separation of the two forms, in these characteristics, no attempt was made to sort marinus-type and mentella-type redfish in the samples.

The number of dorsal spines ranged from 13 to 18, with the mode at 15 in all samples. The modal number of soft rays in the dorsal fin was 13 for Gulf of Maine and Nova Scotian fish, but was 14 in redfish from areas to the north and east. The mean number of spines and rays in the dorsal fin showed a general increase from the Gulf of Maine northeastward to the Barents Sea. This suggests a possible clinal distribution of the characteristic in the whole marinus-mentella population. The mean number of dorsal rays for Faeroe Island viviparus is at the lower end of the marinus-mentella range, and is almost identical to the mean value for Gulf of Maine redfish.

The number of spines and rays in the anal and pectoral fins exhibits variations within each sample. Results of anal fin counts for viviparus are very similar to those of northern Gulf of Maine redfish, but the average number of viviparus pectoral fin rays is almost one less than that from any other sample.

The number of gill rakers ranges from 30 to 41. Sample modes for marinus-mentella range between 34 and 36 in all areas, as compared with 38 for viviparus. The mean number of rakers suggests a decreasing gradient from south to north. Viviparus is obviously different from all other samples in number of gill rakers despite its similarity to the Gulf of Maine redfish in number of spines and rays in the dorsal, anal, and pectoral fins.

The following morphometric characteristics were first used in 1951 to distinguish S. mentella from S. marinus: orbit diameter, head length, body depth, and schnabel length (jaw appendage length). The regression lines for these characteristics, plotted against standard length, are illustrated in figure 17. The greatest variation was in orbit diameter; least variation was in head length. Despite the wide range in lengths of specimens sampled from different areas, the regression lines have a high degree of overlap. There is no obvious separation of the data into two groups representing marinus and mentella.



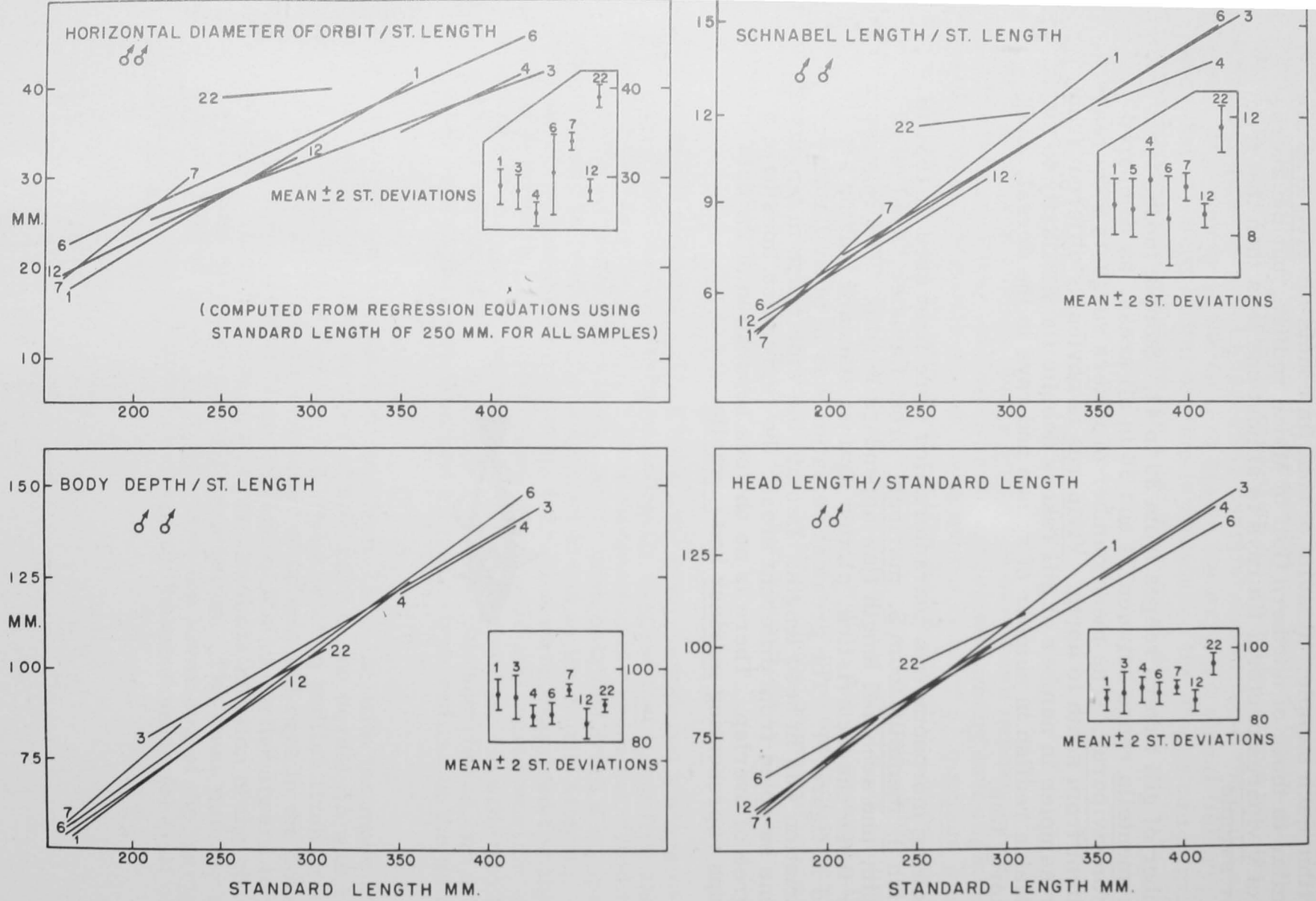


Figure 17.--Examples of morphometric regressions illustrating the variations between redfish from different areas of the North Atlantic Ocean. Collections 1 and 6 are from the Barents Sea; collections 3 and 4 from Labrador; collection 7 from Eastport, Maine; collection 12 from the Gulf of St. Lawrence (small-eye); and collection 22 from the Gulf of St. Lawrence (large-eye). ("Schnabel length" is the length of the external protrusion on the anterior tip of the lower jaw.

SEA SCALLOP INVESTIGATION

J. A. Posgay, Chief
A. S. Merrill, F. E. Nichyparowich, H. W. Jensen

State of the Fishery

Sea scallop landings during 1959 were the highest on record. There were 22.1 million pounds of meats landed in the United States and 5.0 million pounds landed in Canada. The total of 27.1 million pounds compares with a previous high of 24.0 million pounds in 1957 and a 1950-1958 average of 21.3 million pounds. Most of the catch, 24.1 million pounds, came from Georges Bank.

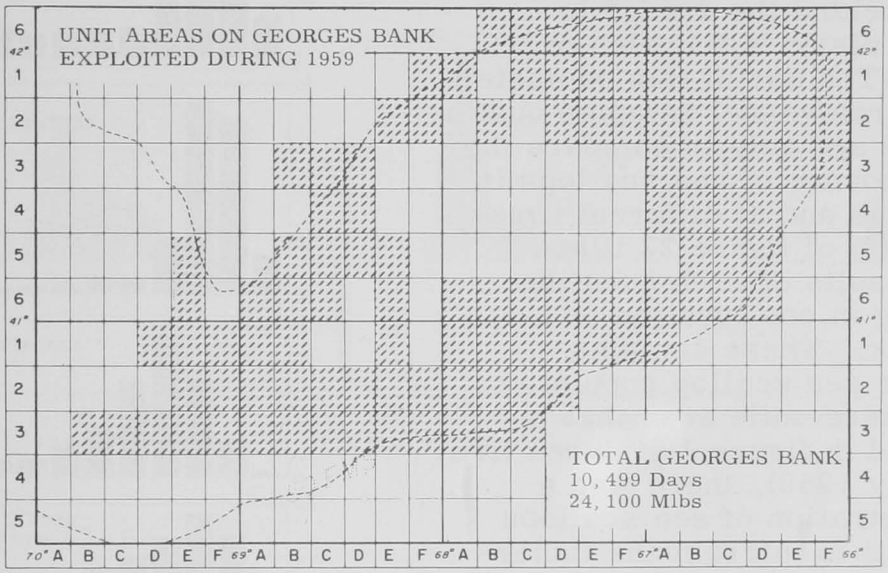


Figure 18.--The shaded unit areas (10 minutes of latitude by 10 minutes of longitude) are those from which at least one sea scallop trip was reported during the year.

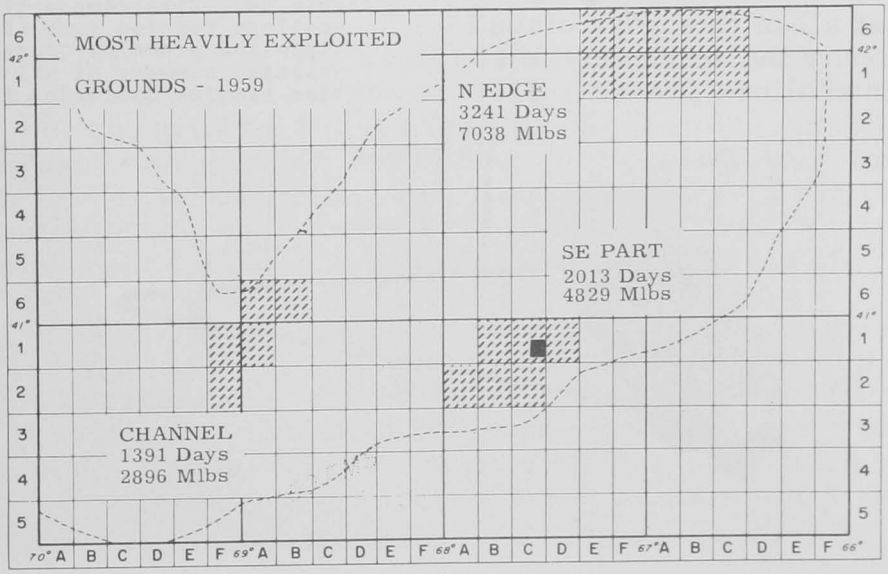


Figure 19.--The shaded areas produced over 60 percent of the total catch from Georges Bank.

Along with the increase in landings there was an increased tendency for the fishermen to concentrate their efforts in areas of limited extent where the newly recruited year class was abundant. Although there was some fishing on all parts of Georges Bank (fig. 18), the three areas shaded in figure 19 provided 14.4 million pounds for 6200 days spent on the grounds, 62 percent of the total landings from Georges Bank. Figure 20 shows the size composition of scallops removed from each of these areas and a weighted summary of all samples of the landings from Georges Bank collected during 1959.

Abundance and Mortality

A device (fig. 21) has been developed to be towed behind the dredge to measure the distance traveled over the bottom. The use of this odometer makes research vessel samples quantitative and we are able to compare the relative abundance of sea scallops in different areas and at different times. The upper part of figure 22 illustrates the results of such quantitative sampling in one location on Georges Bank. These samples represent the sea scallop population of the 16-square-mile area that is darkly shaded in figure 19. When first sampled (May 1959), there was a dense concentration of sea scallops still too small to interest the fishermen. Only one boat had fished in the study area since the first of the year and a sample of the landings showed that the fishermen had discarded almost all of this year class and retained only the relatively few larger, older scallops present.

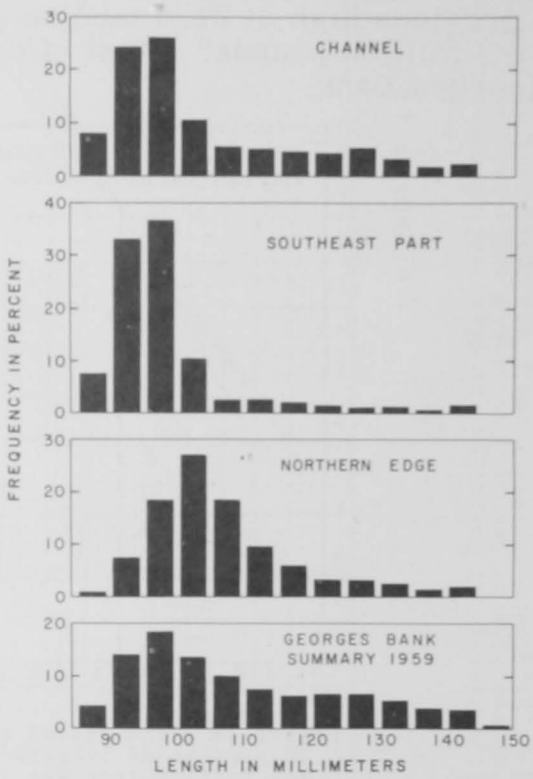


Figure 20.--Size composition of the sea scallops removed from the most heavily exploited areas on Georges Bank and a weighted summary of all size composition samples collected in 1959.

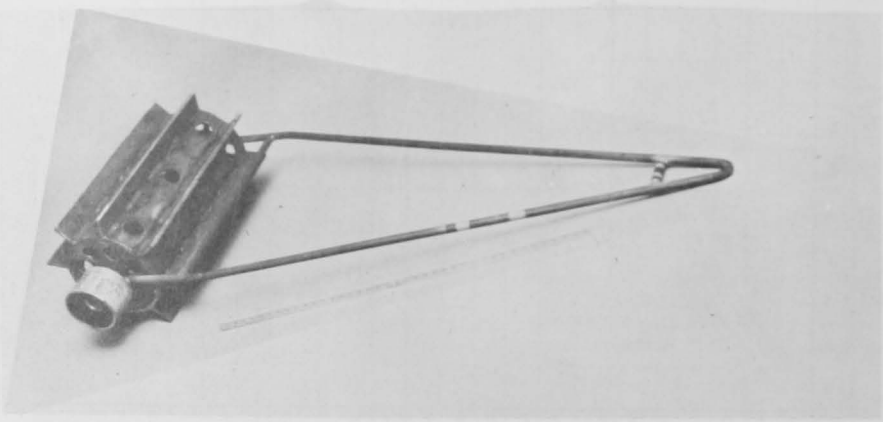


Figure 21.--Dredge odometer.

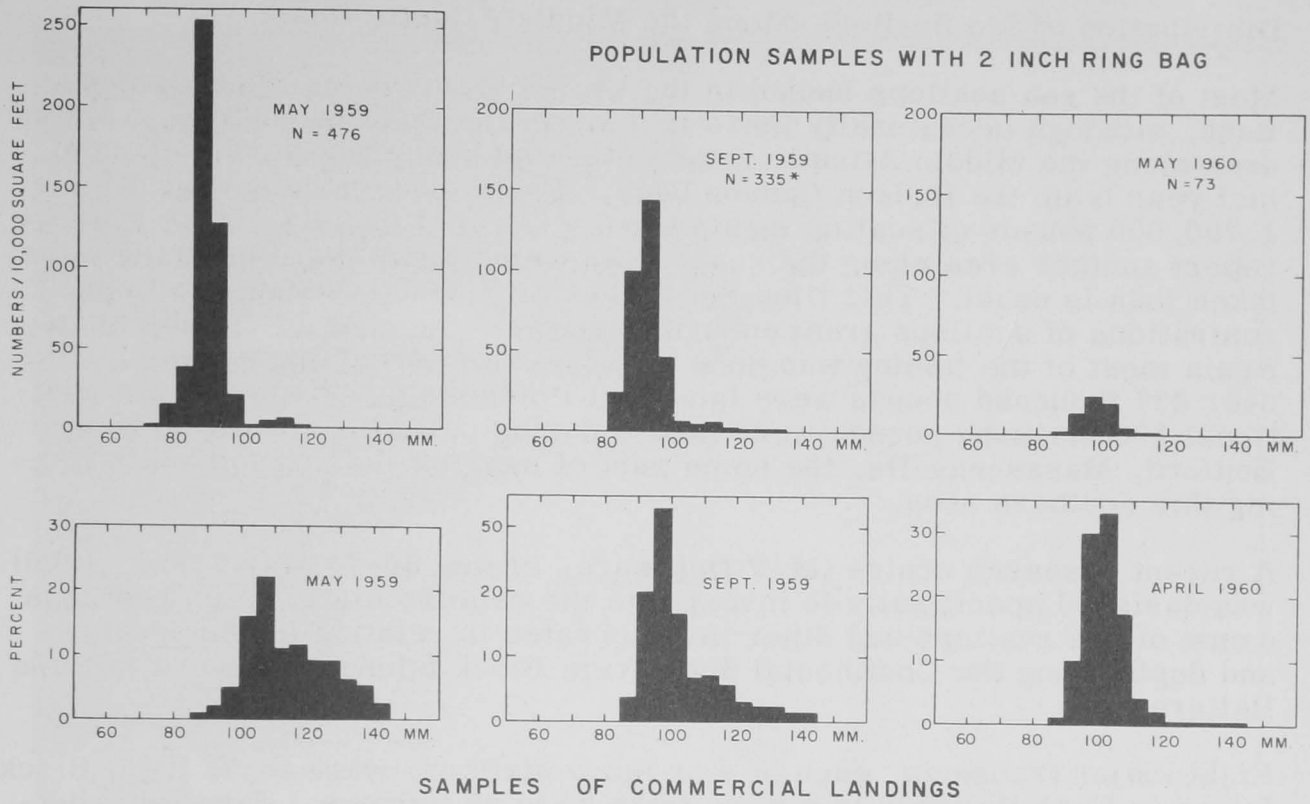


Figure 22.-- Quantitative samples of the population structure of a 16-square-mile study area on the Southeast Part of Georges Bank and the size composition of the scallops removed by the fleet (*estimated).

During the next few months, the scallops grew and the fishermen started to take the larger individuals of the incoming year class. The September sample was not quantitative but it shows the shift in the modal length. Fishing pressure soon became very heavy in the study area and by the time the smallest scallops in the year class were larger than the 85-mm. cull size, it was providing over 90 percent of the catch. No new year class was being recruited in this particular area in May 1960.

In one year, the apparent population of sea scallops in this area was reduced from 476 to 73 per 10,000 square feet; an annual total mortality rate of about 85 percent. From the ratio of clapper shells found to live scallops, it is estimated that about 8 percent can be ascribed to causes other than fishing. The 2.0 million pounds of meats that were removed from this area during the year represent about 54 million sea scallops.

Distribution of Sea Scallops Along the Middle Atlantic Coast

Most of the sea scallops landed in the United States come from Georges Bank, although occasionally there is a sharp increase in landings from an area along the Middle Atlantic coast. Such an occurrence was reported last year from the Hudson Canyon beds. From these beds a total of 1,260,000 pounds of scallop meats were taken in 6 months. This year we report another area along the coast from which many more scallops were taken than is usual. This time the waters off Chesapeake Bay had concentrations of scallops great enough to attract a number of scallop boats. Again most of the fishing was done in a 6-month period during which time over 837 thousand pounds were landed at Portsmouth, Virginia. An additional 300 thousand pounds were landed during periodic returns to New Bedford, Massachusetts, the home port of many of the scallop boats fishing this southern area.

A recent research cruise (M/V Delaware, cruise 60-7, May 11-21, 1960) was designed specifically to investigate the relative distribution and abundance of sea scallops and other invertebrates in relation to temperature and depth along the Continental Shelf from Block Island southward to Cape Hatteras.

Eight major transects, each of 4 or more stations, were made from Block Island to Cape Hatteras in waters from 20 to 80 fathoms. Fifty-six additional stations were occupied between the transects. In all, 153 tows at 93 stations were taken using either a 10-foot standard scallop dredge with 3-inch rings or a 30-inch Digby scallop dredge with a 1/2-inch liner.

The distribution of the sea scallops is shown in figure 23. Scallops were taken at 33 of the stations in depths ranging from 16 to 42 fathoms. Fifty percent of the scallops came from depths of 20 to 30 fathoms, 45 percent from depths of 30 to 40 fathoms, the remaining 5 percent from depths under 20 or over 40 fathoms. The average bottom temperature at the stations where sea scallops were found was as follows:

< 20 fathoms	- 50.8° C.	- 1 station
20 - 30 fathoms	- 42.2° C.	- 13 stations
30 - 40 fathoms	- 41.5° C.	- 15 stations
> 40 fathoms	- 40.5° C.	- 4 stations

As a result of this cruise we now have a clearer picture of the present distribution of sea scallops. Only 3 or 4 of the stations occupied had scallops in quantities that approach the density of some areas on Georges Bank where the scallop boats usually work. However, at 14 of these stations, scallops were obtained in sufficient quantities, as indicated by the solid circles and triangles of the figure, to warrant commercial fishing. No attempt was made to define the beds during this short cruise but most stations are within 20 miles of each other and this in itself describes the extent of most of the beds.

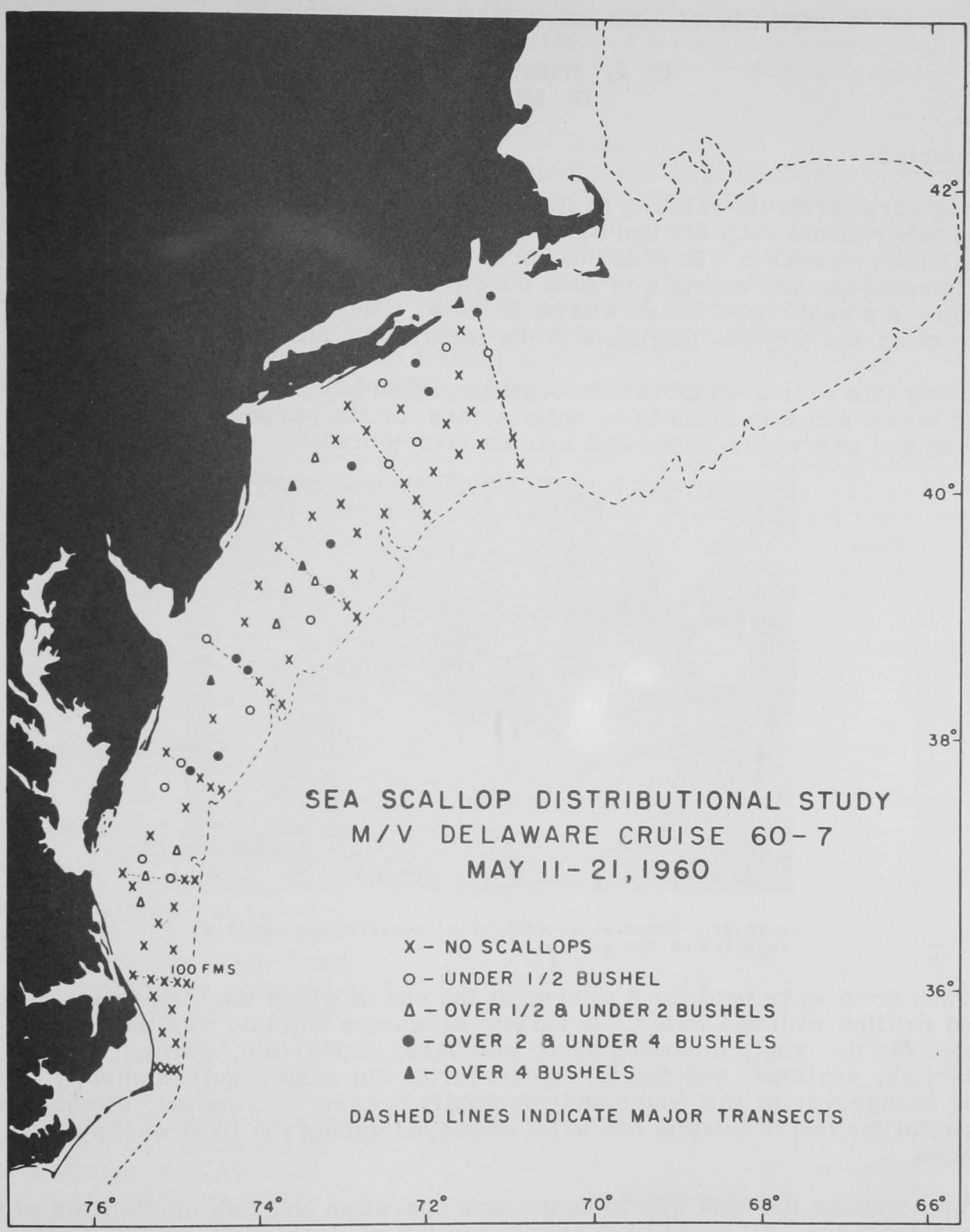


Figure 23.--Distribution of sea scallops along the Middle Atlantic Coast in May 1960. The quantities shown represent the catch of a 10-foot New Bedford type sea scallop dredge towed for 15 minutes.

AQUARIUM AND EXPERIMENTAL STUDIES

C. L. Wheeler, Chief
D. Miller

Aquarium

Long-term projects relating to fish behavior, physiology, tagging effects, and other allied subjects are becoming increasingly important in the field of fishery research. In order to carry on such work, a satisfactory means of keeping aquatic animals in good condition while experiments are in progress is a basic need which will be filled by a new aquarium now under construction and the tank facilities in the laboratory building.

During this year a temperature-controlled fish holding unit was assembled and tested and was found to be satisfactory for the purpose of keeping both fresh and salt water fishes and marine invertebrates.

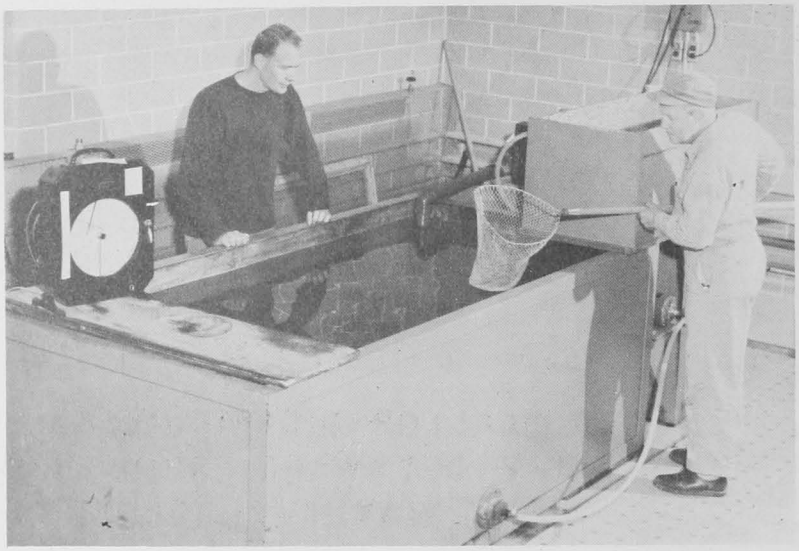


Figure 24.--Temperature-controlled aquarium unit with a capacity of 800 gallons.

Brook trout were held for 6 weeks, at the end of which the tank was drained and refilled with sea water. A variety of marine animals was then substituted for the trout, including scup, sea bass, rudderfish, whiting, filefish, starfish, scallops, and snails. A sea turtle was also acquired shortly after the changeover to salt water and eventually became acclimated, although a special method of feeding had to be employed during the first weeks of residence.

For 5 months the tank was in continuous operation and fish mortalities were extremely low, all being traceable to predation, lack of acceptable food, or poor condition when introduced. Tagged scup and whiting were under observation during the greater part of this period and it was noted that whiting, in contrast to all of the other species held in the tank, required living food for survival. Silversides and mummichogs were taken readily when actively swimming but chopped squid, sea scallops, and similar foods were consistently ignored.

Notes were kept on the behavior and characteristics of the various kinds of fish held in the tank during the test period and a complete description of the construction and operational details of the unit, including a cost analysis, was prepared.

The holding and display tanks to be installed in the new aquarium will have essentially the same specifications as the above with the principal exception of the plate glass fronts necessary for the 16 public exhibition tanks. Temperature control will be incorporated in 6 of these, in which such cold water species as cod, haddock, pollock, and others may be kept during the summer months when the available harbor water is too warm for their survival. The common bottom-living fishes which form the backbone of the commercial fisheries of New England are rarely seen in aquariums and thus unfamiliar to the general public.

Approximately 40 specimens of marine fish are normally resident in the Woods Hole area, either seasonally or throughout the year. Most of these will be available for both study and display and by soliciting the cooperation of commercial pound net operators a variety of exotic or unusual forms can be obtained. Local collections, using hand lines and haul seines, will constitute an important part of the program.

Experimental Studies

Rate of ascent of haddock eggs. --The fact that haddock eggs become buoyant when fertilized and subsequently rise to the surface layers from the ocean floor on which they are spawned, is well documented. However, there appears to be no information on the rate of this ascent. An experiment designed to determine this rate was conducted at the laboratory in April of this year and some interesting data were obtained.

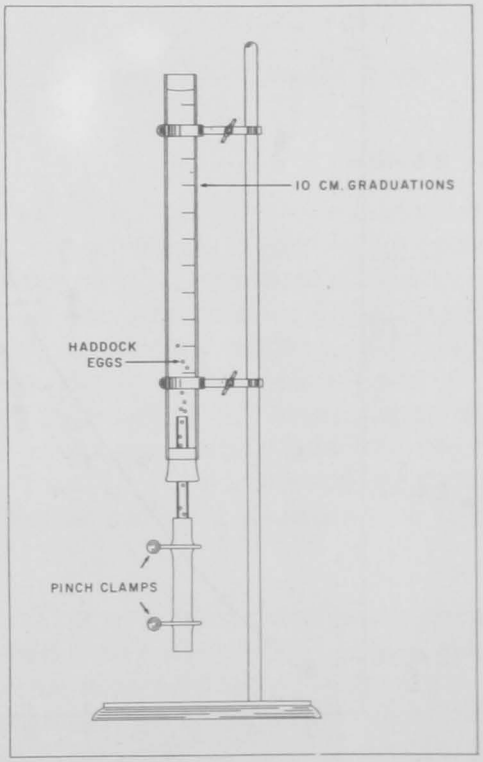


Figure 25.--Apparatus used for determining the ascent rate of haddock eggs.

The results indicated that, in sea water approximating the conditions of temperature and salinity prevailing on the major spawning areas of Georges Bank, the rate of rise is very close to 3 meters per hour. Since the mean depth in these areas is about 70 meters, haddock eggs would reach the surface layers about 24 hours after fertilization. The effects of turbulence would serve to increase the variability of this rate about the mean, but the experimentally determined value would be expected to represent the average condition.

Density of haddock eggs. --In conjunction with the work described above, determinations of the densities of haddock eggs were made. The results of this work show that the density of the eggs varies with the stage of development, the eggs becoming progressively less dense during the early development and more dense just prior to hatching. The value of these changes plotted against time are shown in figure 26.

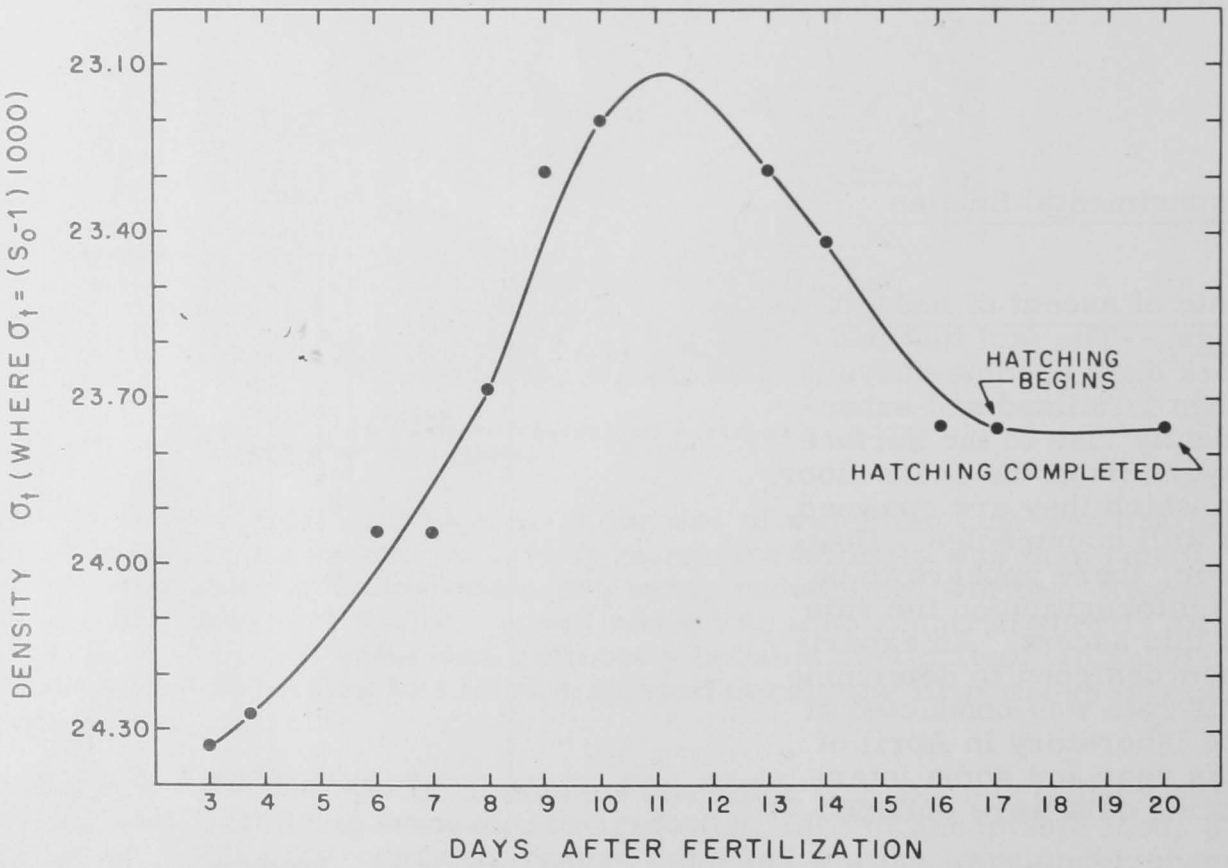


Figure 26.--Changes in haddock egg density during development.

Longhorn sculpin larva. --The early larval stages of the longhorn sculpin, Myoxocephalus octodecemspinosus, which were previously unrecognized, have been described and figured (fig. 27). Inasmuch as this species is a common inhabitant of our New England waters and the larvae occur in the plankton samples collected by biologists at this laboratory and other institutions, it was most desirable to be able to identify it.

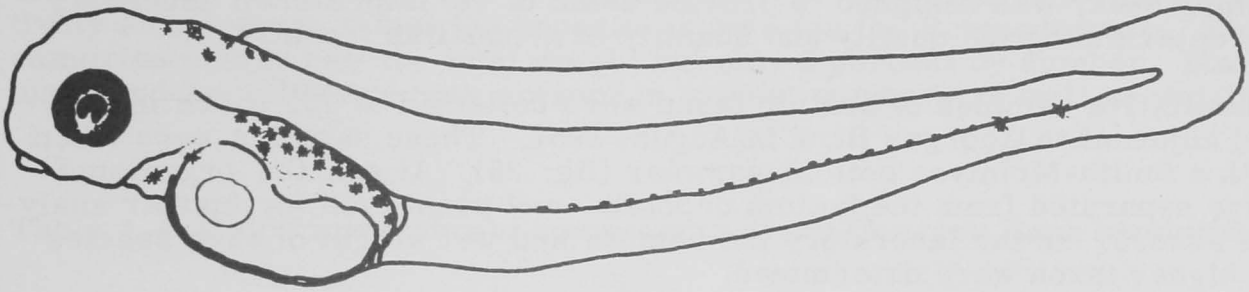


Figure 27.--Longhorn sculpin larva 24 hours after hatching. Total length 7 mm.

Eggs obtained from Vineyard Sound on January 27, 1960, were hatched in the laboratory and the larvae maintained for 32 days. Hatching commenced on February 28th. The eggs are demersal, commonly laid in clusters attached to shells, stones, or among the branches of the finger sponge (Chalina). The color of the egg clusters varies widely and may be orange, green, purple, brown, or a dirty white. The color is contained in the yolky substance of the egg, and this color is retained in the yolk sacs of the newly hatched larvae. The eggs examined had an average diameter of 2.1 mm., ranging from 1.9-2.3 mm. The chorion was thick and rather opaque. One or more oil globules of varying sizes were discernible within.

The larvae averaged 6.8 mm. at hatching. The eye was darkly pigmented. Several small chromatophores were scattered over the nape, and a single row of rather small indistinct chromotophores was arranged along the ventral midline of the tail. One or two larger chromatophores were often apparent just anterior to the tail tip. A large number of small stellate chromatophores covers the dorsal aspect of the gut. This basic pattern of melanophores remained unchanged during the first month of development under laboratory conditions. The most striking morphological change during this period was the development of the opercular spines, so characteristic of the adult. These first appeared at the end of the third week.

BENTHIC ECOLOGY INVESTIGATION

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

Many New England fishes of commercial importance depend heavily upon benthic (bottom-dwelling) organisms for their food. This is especially true of some of the most common species in this region, such as the cod, haddock, and several species of flounders. Since an adequate quantity of suitable food is a basic necessity for survival and maintenance of these stocks of fish, knowledge of the kinds and quantities of food on the various fishing grounds is necessary to understand migrations, growth rates, and geographic distributions of the different species and races of fish. An investigation of the benthic fauna on Georges Bank, the largest New England fishing bank, was designed to provide some of the information necessary for determining the quality and quantity of groundfish foods.

Quantitative samples of benthic fauna were collected at 161 localities on and adjacent to Georges Bank in August 1957. These samples were taken with a Smith-McIntyre bottom sampler (fig. 28). At sea the organisms were separated from the bottom deposits and preserved for further analysis ashore. In the laboratory the number and wet weight of each species or higher taxon were determined.

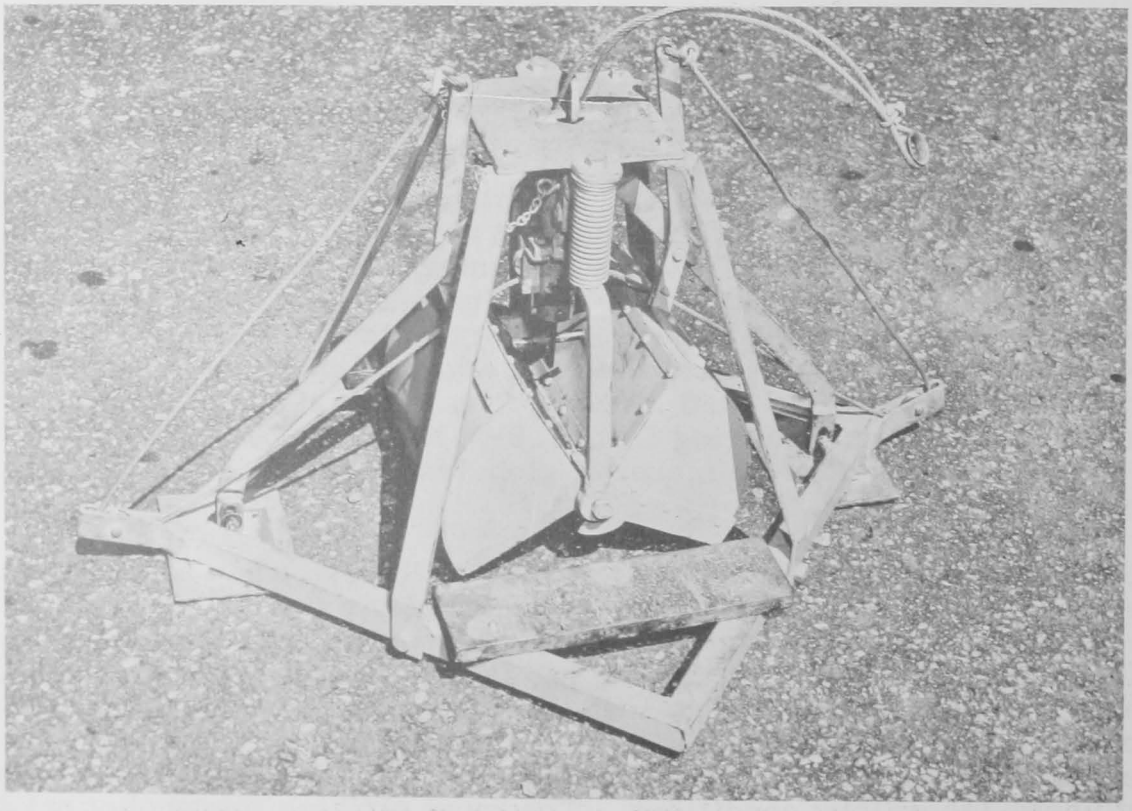


Figure 28.--Smith-McIntyre bottom sampler.

Haddock Food Resources

Inasmuch as haddock is the principal species of fish taken by the commercial fleet on Georges Bank, a special compilation of food resources available to this species has been computed. Since haddock in this region do not commonly prey upon organisms larger than 10 grams, these items have been omitted in compiling the data presented here.

Listed in table 4 are the main invertebrate categories of which the Georges Bank benthic fauna is composed. The four major groups are: Crustacea, Mollusca, Echinodermata, and Annelida. The weight and number (plus percentages) of each of these groups are included in the tabulation. The category Miscellaneous is made up of various groups which occurred in rather small quantities, such as coelenterates, ascidians, brachiopods, nemerteans, and others. It is apparent from this listing that Crustacea is by far the most numerous group, but in terms of weight it forms a relatively small share. Just the opposite is true for the Echinodermata. They comprise nearly half the total weight but only 3 percent by number. Mollusca and Annelida are both present in modest numbers as well as weights.

Table 4. --Major invertebrate components of the Georges Bank benthic fauna

Animal groups	Weight (grams)		Number	
	Per square meter	Percent	Per square meter	Percent
Crustacea	8	8	1,112	67
Mollusca	9	10	53	3
Echinodermata	47	50	47	3
Annelida	7	7	309	19
Miscellaneous	24	25	140	8
Total	95	100	1,667	100

Geographic distribution. --The quantitative geographic distribution of haddock foods has been studied in terms of numbers of organisms and also in terms of weight. In this discussion all species have been combined in order to give a comprehensive view of the results.

The number of organisms per meter of sea bottom is illustrated in figure 29. Three density categories, as defined in the figure legend, have been used. It will be noted that areas of high abundance were found along the southern portion of Georges Bank and smaller, scattered patches occurred on the eastern and western portions of the bank. In most instances, moderate densities occurred adjacent to the areas of high density. It should also be mentioned that large expanses of low density populations were found in the deep water northwest of Georges Bank and over much of the central and north-central parts of the banks.

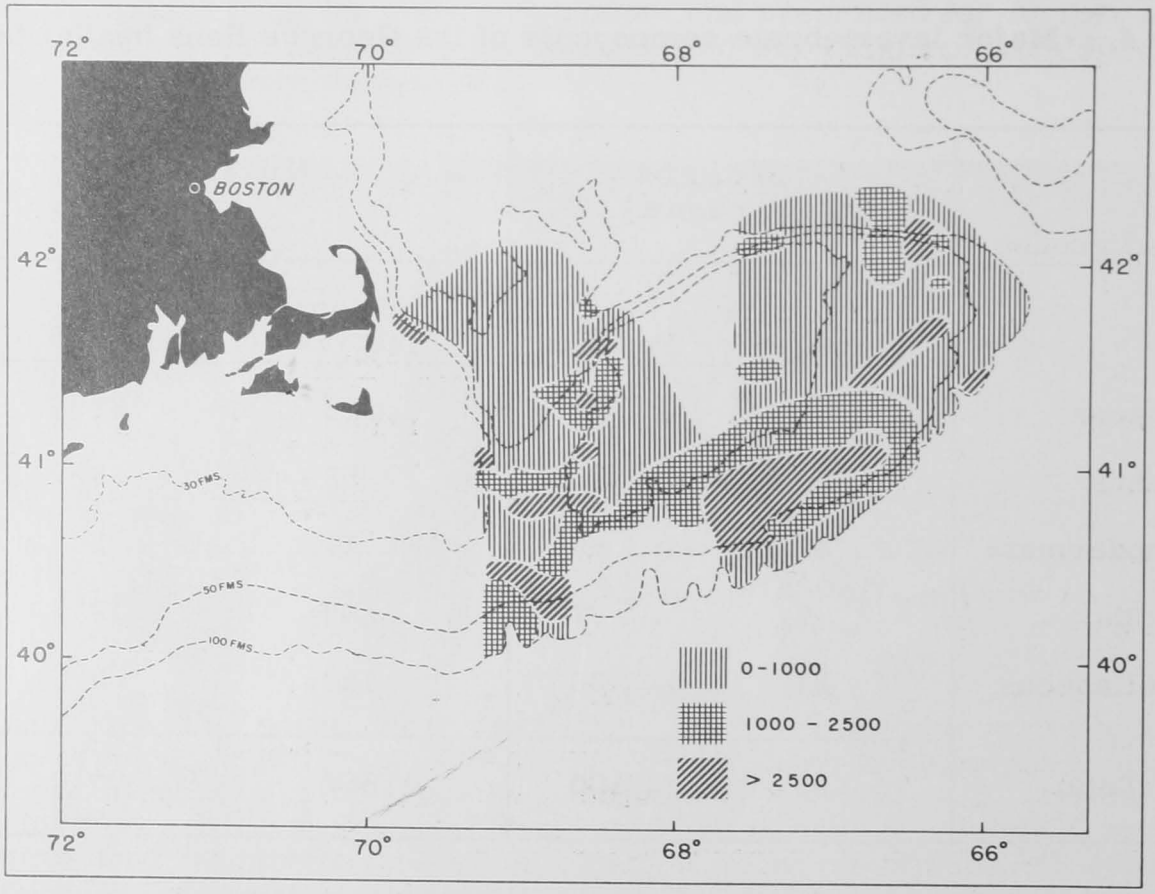


Figure 29.--Geographic distributuion of haddock foods, in numbers per square meter.

The geographic distribution of haddock foods in terms of weight (fig. 30) was basically similar to that described above for numbers. There were two large areas of high abundance, and five smaller areas. The two major areas were found on (1) the northern edge and (2) the south-central part of Georges Bank. Again, a significant aspect of these results is the disclosure that tremendously large portions of the bank and adjacent deep waters support relatively small quantities of haddock foods.

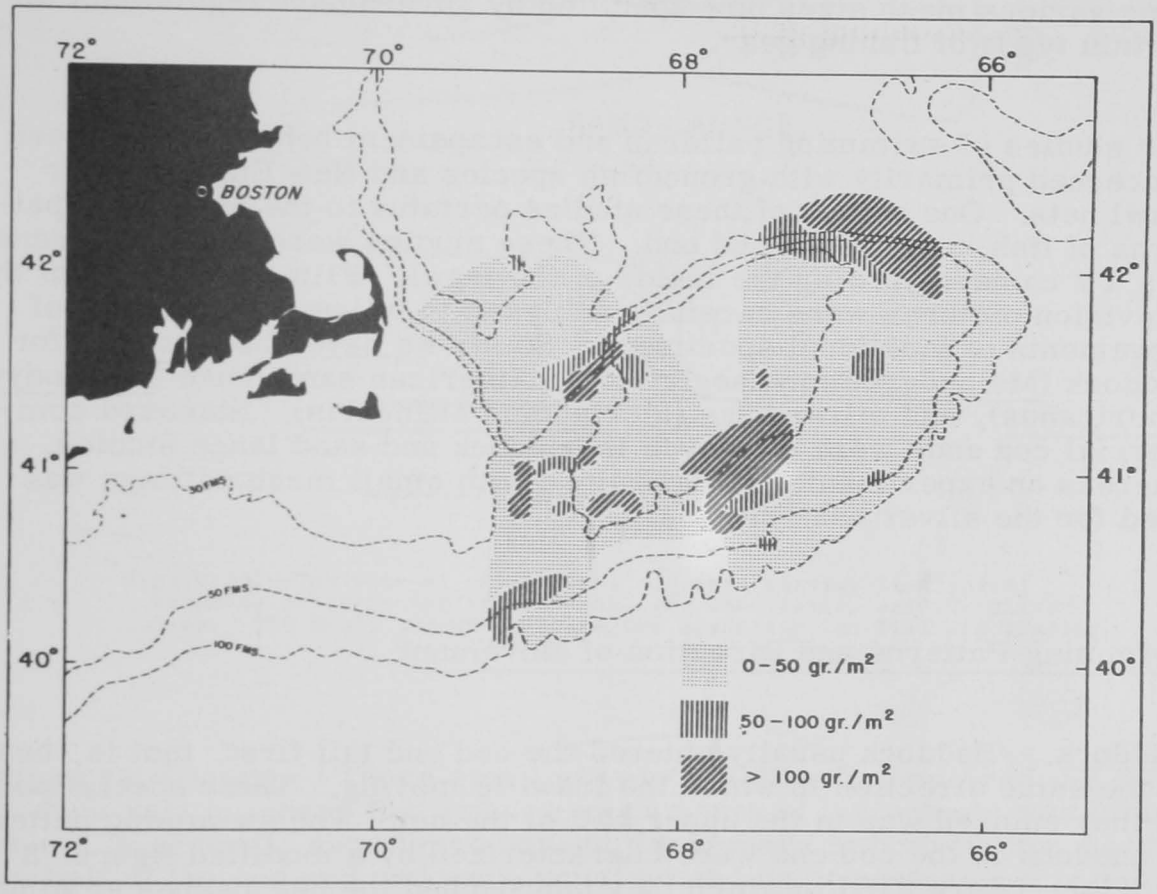


Figure 30.-Geographic distribution of haddock foods, in weight per square meter.

It is noteworthy that the principal areas where food organisms were abundant coincides with the areas where some of the major fisheries concentrate their efforts. For example, consistently heavy fishing for haddock takes place on the northern edge of Georges Bank. Also, concerted effort for yellowtail flounder is expended in the south-central part of the bank at this season of the year. Furthermore, large quantities of silver hake are landed from the northwestern part of the bank. Each of these areas was found to be rich in groundfish foods. This, in a general way, indicates that large aggregations of our New England groundfish occur in the same localities where benthic organisms are most plentiful.

FISH BEHAVIOR INVESTIGATION

R. Livingstone, Jr., Chief

The reactions of fish at the time they are being captured in commercial fishing nets varies in a multitude of ways. Some species are passive and quiescent, whereas others make violent attempts to escape. This escapement behavior is particularly important in the development of new fishing equipment and techniques, and is especially pertinent for evaluating various mesh sizes now specified by government regulations for certain types of fishing gear.

Our studies of swimming patterns and escapement behavior have been concerned primarily with groundfish species and New England otter trawl nets. One aspect of these studies pertains to the movement patterns of fish in the trawl cod end. These studies were made by means of a TV camera viewing the inside of the trawl. Film recordings of the television pictures were carefully analysed to follow the sequence of movements of individual specimens. So far we have observations for haddock (Melanogrammus aeglefinus), American sand lance (Ammodytes americanus), and silver hake (Merluccius bilinearis). Standard commercial cod ends were employed in haddock and sand lance studies, whereas an experimental cod end lined with small mesh nettings was used for the silver hake studies.

Swimming Patterns and Direction of Movement

Haddock. --Haddock usually entered the cod end tail first, that is, headed in the same direction in which the trawl is moving. Their special position as they entered was in the upper half of the net. The swimming patterns of haddock in the cod end were characterized by a modified figure "8" path (see figure 31A) in which they approached the net meshes at an angle of approximately 90 degrees. Generally after the first or second crossing haddock did not collide with the meshes. In fact they seemed to sense the barrier of netting and turned sharply before contact was made. Many haddock, after searching the cod end from side to side, turned and faced upstream, in the direction the trawl was moving. They appeared to adjust to the speed of the trawl and stayed in one location, either resting on the meshes at the bottom or swimming along in the middle zone of the net's interior. These fish appeared to be responding visually to the moving trawl, and by swimming with it were attempting to maintain the status quo.

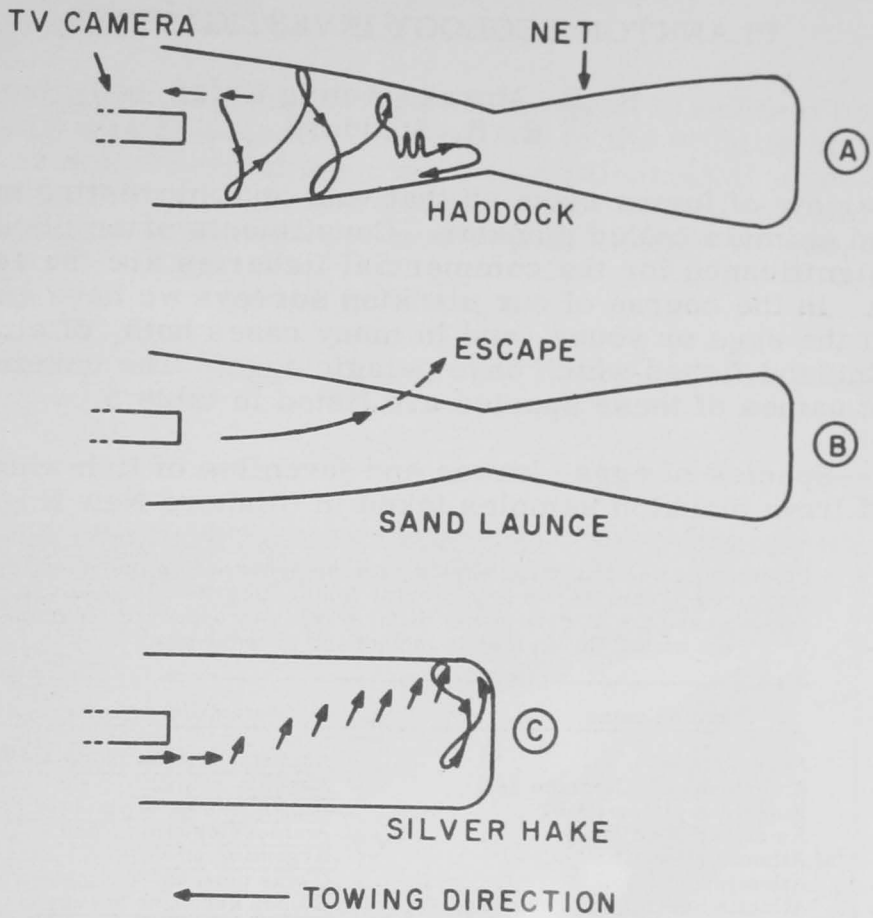


Figure 31.--Top view of otter trawl cod ends showing the typical swimming patterns for (A) haddock, (B) sand lance, and (C) silver hake. The small arrows indicate the direction the fish are heading.

American sand lance. --These small silvery eel-like fish entered the cod end in such vast numbers that tracing movements of individuals was often impossible. In general, sand lance passed the camera in both the top and bottom half of the cod end and were usually heading downstream into the net. Sand lance did not search or investigate the cod end in the manner noted for haddock. They quickly swam diagonally upward (see figure 31B), and the majority escaped through the net meshes in less than one second. However, they often hesitated momentarily before swimming through the mesh. They usually emerged through the top meshes where the cod end tapers.

Silver hake. --Silver hake reacted quite differently from the haddock and sand lance. Ordinarily silver hake entered the cod end on or near the net bottom, headed downstream into the net. They came singly and in groups, often side by side. Single fish usually turned at right angles from a downstream direction and drifted in this position into the cod end (see figure 31C). Groups of fish usually moved as a unit all facing downstream. The majority of silver hake reacted violently when they came in contact with other specimens or the net where the catch was accumulated.

PLANKTON ECOLOGY INVESTIGATIONS

R. R. Marak, Acting Chief
R. R. Stoddard

A wide variety of forms make up that vast and interesting assemblage of plants and animals called plankton. Constituents of the plankton which have special significance for the commercial fisheries are the eggs and larvae of fishes. In the course of our plankton surveys we have encountered and identified the eggs or young, and in many cases both, of almost all species of New England fishes which have pelagic eggs. The common names and scientific names of these species are listed in table 5.

Table 5. --Species of eggs, larvae and juveniles of fish which have been identified from plankton samples taken in offshore New England waters.

Common names are in agreement with the approved listing given in American Fisheries Society Special Publication No. 2, 1960. In cases where the Bureau name differs from the approved common name, the former is included in parentheses.

Common name	Scientific name
Alligatorfish	Aspidophoroides monopterygius
American eel (Common eel)	Anguilla rostrata
American plaice (Dab)	Hippoglossoides platessoides
American sand lance	Ammodytes americanus
Atlantic argentine	Argentina silus
Atlantic cod (Cod)	Gadus morhua
Atlantic herring (Sea herring)	Clupea harengus harengus
Atlantic mackerel (Boston mackerel)	Scomber scombrus
Atlantic menhaden (Menhaden)	Brevoortia tyrannus
Atlantic saury	Scomberesox saurus
Atlantic wolffish (Wolffish)	Anarhichas lupus
Banded rudderfish	Seriola zonata
Bluefish	Pomatomus saltatrix
Butterfish	Poronotus triacanthus
Cunner	Tautogolabrus adspersus
Cusk	Brosme brosme
Fawn cusk-eel	Lepophidium cervinum
Fourbeard rockling	Enchelyopus cimbrius
Goosefish (Anglerfish)	Lophius americanus
Haddock	Melanogrammus aeglefinus
Lanternfish	Myctophum affine
Longhorn sculpin	Myoxocephalus octodecemspinosus
Lumpfish	Cyclopterus lumpus
Northern searobin	Prionotus carolinus
Pollock	Pollachius virens
Redfish (Atlantic ocean perch)	Sebastes marinus
Rock gunnel	Pholis gunnellus
Rough scad	Trachurus lathami
Scup	Stenotomus chrysops
Silver hake (Whiting)	Merluccius bilinearis
Spotted hake	Urophycis regius
Squirrel hake (Red hake)	Urophycis chuss
Striped mullet	Mugil cephalus
Striped seasnail	Liparis liparis
Threespine stickleback	Gasterosteus aculeatus
Weakfish (Gray sea trout)	Cynoscion regalis
White hake	Urophycis tenuis
Windowpane	Scophthalmus aquosus
Winter flounder (Blackback, Lemonsole)	Pseudopleuronectes americanus
Witch flounder (Gray sole)	Glyptocephalus cynoglossus
Wrymouth	Cryptacanthodes maculatus
Yellowtail flounder (Yellowtail)	Limanda ferruginea

Fish Egg Mortality

A large concentration of dead and dying gadoid eggs (90 percent haddock and 10 percent cod) was detected in March 1960 in the vicinity of Browns Bank (fig. 32). These abnormal eggs were found floating at or near the surface over a wide area, calculated to be at least 1000 square miles in extent. The number of defective eggs was approximately 10,000,000 per square mile.

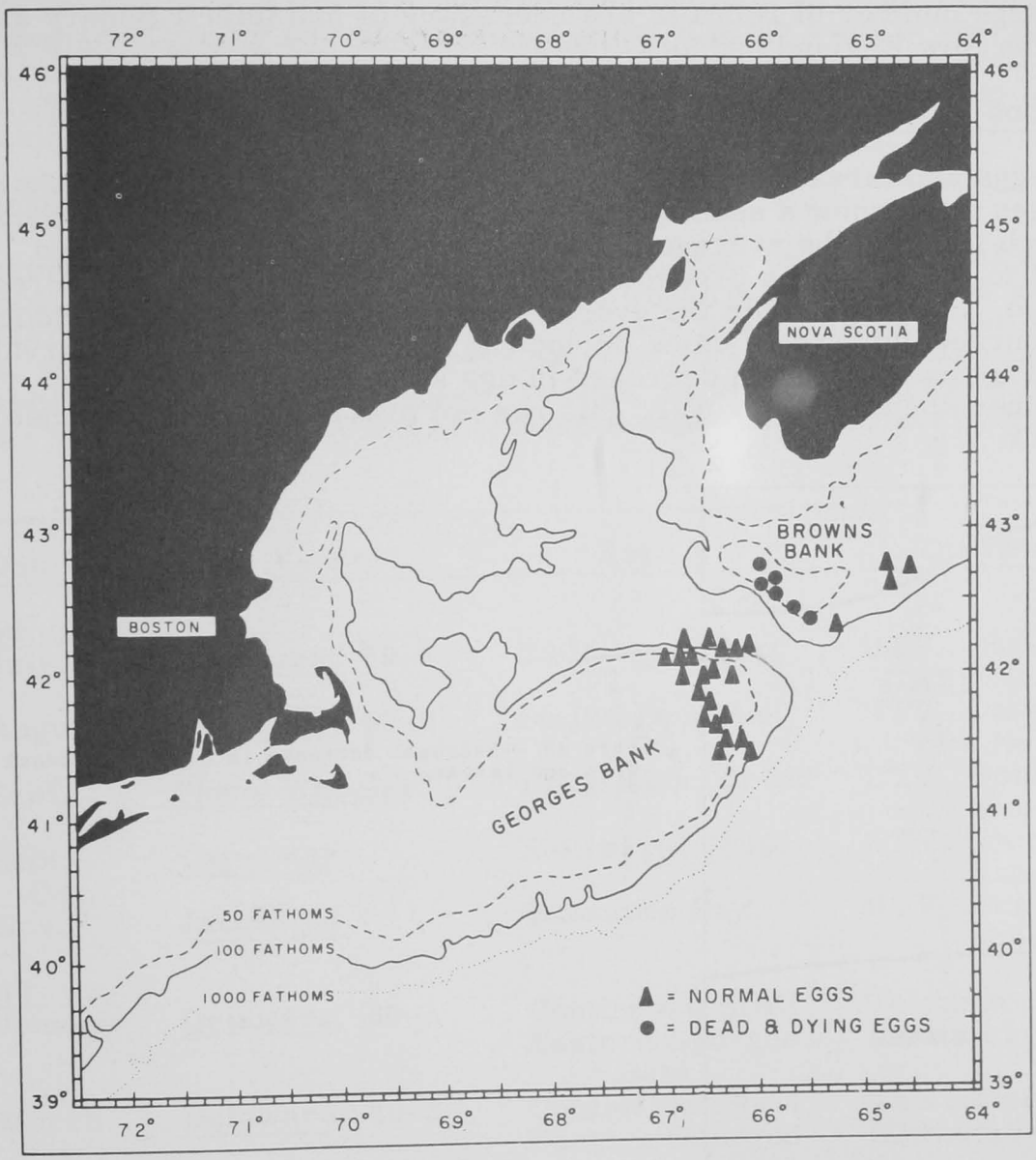


Figure 32.--Sampling stations for cod and haddock eggs, March 1960.

Samples of eggs collected from both Georges Bank and Browns Bank with 1-meter plankton nets were cultured for routine rearing and identification purposes. Not one of the abnormal eggs developed to the hatching stage, but all eggs from other species and a few gadoid eggs that were normal in appearance hatched into healthy larvae. Hatching experiments plus microscopic examination of the abnormal eggs revealed that the embryonic development was defective and soon arrested. These eggs were similar in appearance to aborted eggs; they may have been emitted prematurely.

A mass mortality of this nature has not been observed in surveys previously conducted in this area. The consequences of a mortality as extensive as this may be very serious. Obviously, a sufficient number of young are necessary for the continued existence of any given stock. Moreover, a large number of recruits are necessary to maintain a fishery as large as the New England haddock fishery.

Egg Size and Related Larval Size of Haddock

Haddock eggs and larvae taken in plankton samples from the Gulf of Maine and Georges Bank show a seasonal change in size. Over a 3-month period, from March to May, the average diameter of haddock eggs diminished from 1.54 to 1.45 mm., a 6-percent decrease. A corresponding decrease of 0.61 mm., 14 percent, in the average length of newly-hatched haddock larvae occurred during this same period (fig. 33). A reduction in larval size would logically follow a decrease in egg size, and this has been noted in other species. However, this has not previously been reported for haddock.

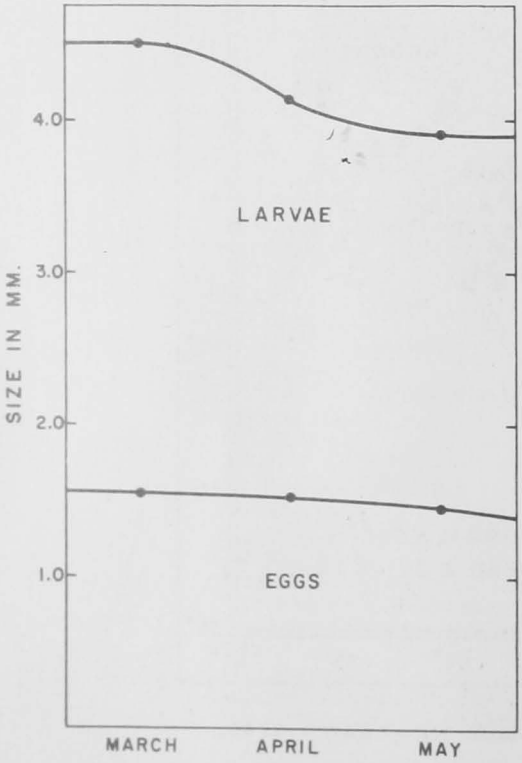


Figure 33.--Seasonal decrease in size of haddock eggs and larvae.

INSTRUMENTATION

James M. Crossen, Electronics Specialist

Instrumentation activities during the past year were scheduled between this laboratory and the Exploratory Fishing and Gear Research Base at Gloucester, Massachusetts. Underwater TV observations and kinescopic recordings of fish and fishing gear were the major projects.

A film, "Underwater Gear Studies," was prepared from recordings of underwater TV observations of a number 41 New England trawl. Special attention was given to the ground wire, first with rollers and then with chain gear throughout speeds of 1-1/2 to 4-1/2 knots. At speeds above 3-1/2 knots the net was well off the bottom and passing over several species of groundfish. Two other underwater television films were prepared: one documents the inshore dragging study in Buzzards Bay and the other illustrates an electrofishing operation aboard the Cape May. The latter is described in a later section of this report.

Underwater Television Observations

Observations have been carried out for the most part in coastal waters in depths ranging from 9 to 20 fathoms. Turbidity in the coastal areas of Buzzards Bay and Long Island Sound usually limit viewing from 3 to 10 feet, while on Stellwagen Bank visibility is 10 to 25 feet. The increased visibility on Stellwagen Bank can, in part, be attributed to the sandy bottom. The following is a list of cruises during the 1959 fiscal year.

Date	Vessel	Area	Operation
1959			
July	Delaware, 59-8	Stellwagen Bank	UTV. Observations of a No. 41 trawl
August	Delaware, 59-9	Stellwagen Bank	UTV. Observations of a No. 41 trawl
Sept.	Shang Wheeler	Long Island Sound	UTV. Bottom observations
Sept.-Oct.	Cape May	Stellwagen Bank	UTV. Electrical fishing
Nov.	Jacquelyn	Buzzards Bay	UTV. Dragging observations
1960			
January	Delaware, 60-1	Continental Shelf Eastern Georges Bank	Telemetering. Midwater trawl
March	Delaware, 60-3	Continental Shelf Eastern Georges Bank	Telemetering. Midwater trawl

Underwater Television Observations of Electrofishing

During September and October observations were made of an electrofishing operation aboard the Cape May on the southern part of Stellwagen Bank. A short film depicting the reaction of various species of fish to a comparatively high electric current was produced.

The television camera was suspended on a chain bridle from the belly of a modified number 41 trawl looking at the mouth of the net (fig. 34). The positive electrode was positioned about 10 feet in front of the ground wire, just off the bottom, and the negative electrode trailed 40 feet into the net. The electric apparatus generated 1700 peak volts at 80 amperes (136 kilowatts) through a heavy rubber-jacketed concentric cable to the V-shaped copper pipe electrodes. The system charges and discharges a large bank of capacitors through ignitrons (pulsing tube) at the desired pulse width and pulse repetition rate up to frequencies of approximately 50 cycles per second.

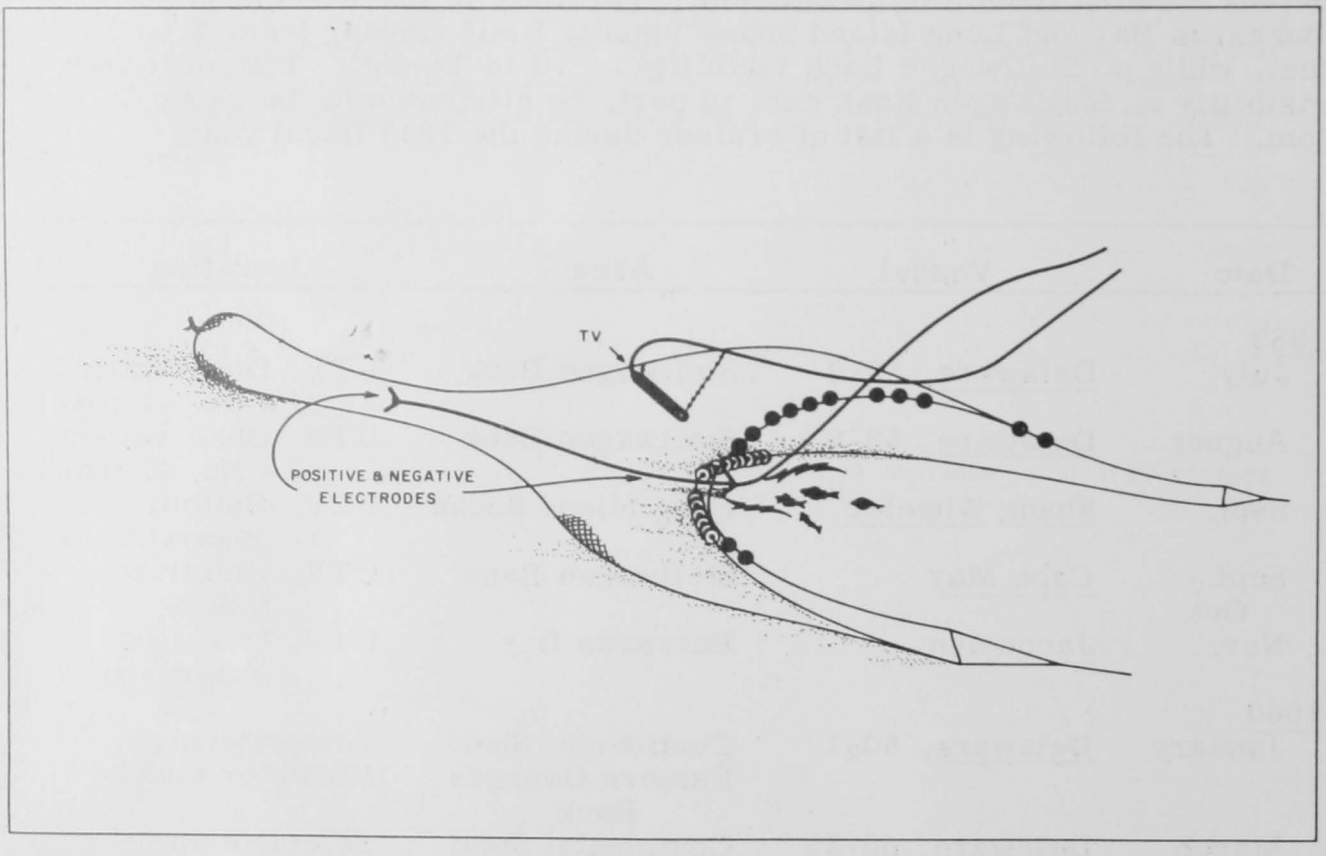


Figure 34.--Arrangement of apparatus used for underwater TV observations of electrofishing operations.

While fishing at standard trawling speeds in 11-15 fathoms, observations were made on the reaction of yellowtail flounder (Limanda ferruginea), skate (Raja sp.), spiny dogfish (Squalus acanthias), and silver hake, (Merluccius bilinearis) in the electric field. The cod end was left open during the lengthy (2 to 4 hours) tows. Therefore, no specimens were available for examination. All species were immediately stunned and none appeared to swim normally. Although no definite electronarcosis occurred, it seemed reasonable to assume that some of the shocked fish would probably be permanently affected. The yellowtail flounder and skate consistently curled up when they entered the electric field; flounders curled from head to tail, and skates curled from wing tip to wing tip. Dogfish were the only species that gave any indication of being in an electrotactic state.

Because of limitations on visibility (approximately 15 feet) due to inherent conditions of turbidity, we were unable to ascertain the maximum efficient range of the electric field. However, during periods when no fish were seen in front of the net, the electric apparatus was switched on and seconds later silver hake in an apparent state of electronarcosis were seen entering the net in an inverted position.

Radiological Monitoring

Radiological monitoring equipment has been distributed to the following stations: Boothbay Harbor, Gloucester, Woods Hole, Milford, New Bedford, Rockland, and the Delaware. Personnel have been instructed in the use of this equipment at the following stations: Woods Hole, Gloucester, Boothbay Harbor, and the Delaware.

Stations at Woods Hole and Gloucester actively participated in "Operation Alert" during May on the radiological level. The simulated exercise was designed to determine operational capabilities and limits of communications. A radiological report including a fallout contour chart was prepared.

PORT SAMPLERS POOL

L. H. Couture, Chief

R. C. Barnard, Rockland, Maine
C. F. Bocken, Gloucester, Mass.
P. F. Chase, Jr., New Bedford, Mass.
T. Gallagher, Pt. Judith, R. I.
J. R. Kallio, Gloucester, Mass.
J. C. Malone, Boston, Mass.
C. L. Philbrook, Rockland, Maine
L. R. Porter, Jr., Boston, Mass.
P. Swain, New Bedford, Mass.
A. F. Thibodeau, Portland, Maine

The Port Samplers Pool is composed of a group of fishery aids of which one or two are permanently stationed at each major fishing port in New England (see list above). During this past year they continued to supply information on the commercial landings and a large amount of biological data required by research investigations at this laboratory. This year the port samplers made 12,463 interviews with vessel captains; collected 1414 biological samples, 12,527 scales, and 8535 otoliths; and made 184,087 length-frequency or length-weight measurements.

In addition to their regular duties, the port samplers completed two surveys of the North Atlantic fishing fleet in cooperation with defense agencies. For the National Defense Agency, they obtained information pertaining to vessels over 65 feet in length, which fished areas greater than 50 miles from shore. Statistics collected included size, horsepower, electronic equipment, radio call-letters, and related items. For the Civil Defense Agency, approximately the same information was gathered, plus names and addresses of owners or operators, and dates of electronic gear installations, from owners of all fishing vessels based at New England ports.

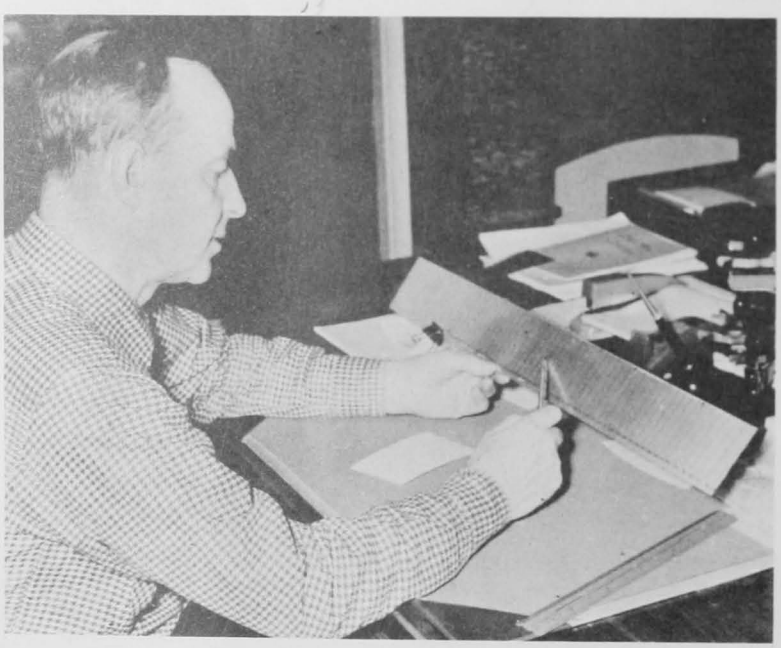


Figure 35.--Port agent obtaining length-frequency groups by means of a plastic overlay on an aluminum punch strip.

Figure 36.--Port agent recording tag information from a recaptured haddock.

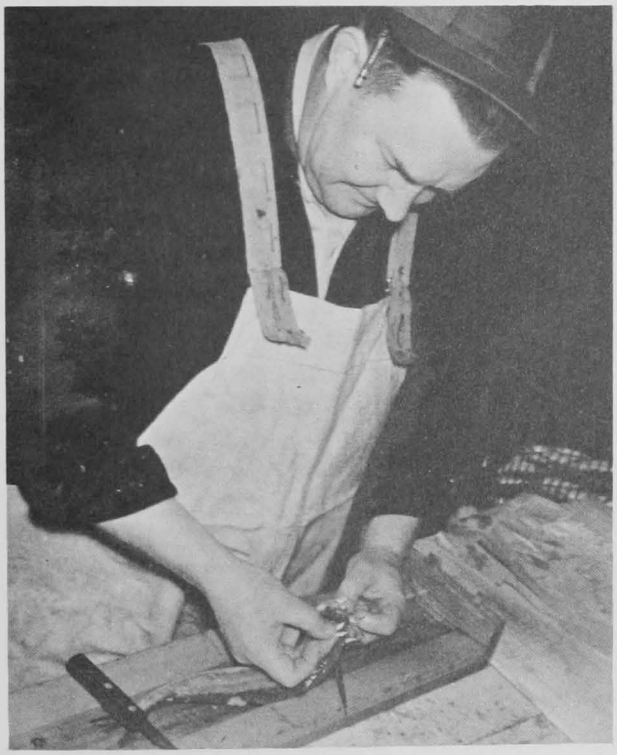


Figure 37.--Port agent removing otoliths from a silver hake.

Figure 38.--Port agent measuring scallop shells on a board especially designed for this purpose.

FISH TAGGING

S. L. Cogswell

This year the tagging unit has been expanded to include an intensive public relations program and to serve in a consulting capacity for other laboratories in the United States and Canada for problems related to tags and tagging. During the 4 years the tagging unit has been operating at this laboratory, 7 investigations have tagged 12 species of fish and shellfish, using a total of 56,000 tags. This year many inquiries have been received from Federal and state laboratories in the United States and from Canadian laboratories requesting information on new types of tags, supply sources of tags, tools, and equipment, as well as the application of these to specific tagging problems. Preliminary work has been started in compiling a purchasing guide from an accumulation of references and contacts.

A coordinated program of scup tagging is now in progress involving the U.S. Bureau of Commercial Fisheries and the conservation departments of New York and New Jersey. In connection with this program, new problems concerning tag-return data have emerged. By last September it became increasingly apparent that scup tags were not being discovered until the fish reached the retail stores, and, with the exception of returns by sport fishermen, no useful information was being received. One reason for this is the manner in which the fish are handled. Most of these fish are landed and distributed south of New England. They are not handled individually, but are iced (ungutted) in boxes and shipped to wholesalers and retailers.

Prior to the scup tagging program, all species tagged by this laboratory were mainly landed and processed in New England ports. Our port agents were in a position to pay cash rewards, and exchange with the fishermen and the plant workers tagging information for capture information. In a similar manner, the Canadian Government processes fish which are tagged in the U. S. and landed at Canadian ports.

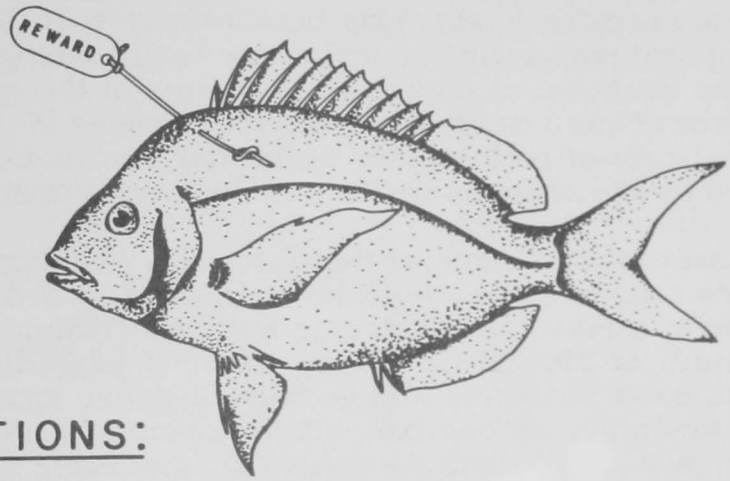
In order to obtain more complete information from the scup tagging program, a visit was made to Service personnel and fish dealers in the area from New York City to Norfolk, Virginia. In advance of the trip, announcements describing the tagging program were published in the Service Market News at New York City, Baltimore, and Hampton, Virginia. As a result of this survey, the following steps were taken to promote earlier discovery of tags and more complete information with returned tags: (1) Through the cooperation of state fishery laboratories, news releases dealing with the program were given to sport fishing publications and area newspapers. (2) Sixty large posters in brilliant day-glo coloring were posted at landing and distributing centers. A copy of this poster is illustrated in figure 39. (3) Smaller posters were distributed to vessel captains at all significant ports. (4) Colorful instruction cards were mailed (enclosed with their monthly billing) to retail stores by a few large distributors. These contacts with retailers were accomplished at no cost to the government and without intruding into confidential customer listings.

To date, this system has converted a majority of "blind" returns into returns supplying useful information.

REWARD $1.00

FOR TAGGED SCUP (PORGY)

(OR OTHER TAGGED FISH, AS - HADDOCK, COD, FLOUNDERS)



INSTRUCTIONS:

SEND TAG TO - U.S.F.W.S. WOODS HOLE, MASSACHUSETTS

WITH FOLLOWING INFORMATION

1. LOCATION CAUGHT
2. DATE
3. GEAR
4. DEPTH
5. NAME OF VESSEL
6. NAME & ADDRESS OF FINDER

NOTE: ANY INFORMATION WHICH WILL AID IN TRACING (AS THROUGH DEALERS) THE TIME & PLACE WHERE THE FISH WAS CAUGHT WILL BE HELPFUL.

Figure 39.--Reward poster used in the scup tagging program.

SHELLFISH LABORATORY

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

Oyster Biology

In the course of the preparation of a book on oyster (Crassostrea virginica) biology our research dealt primarily with the respiration and blood circulation in this species. Respiration is the most important function of a living organism. Consequently, the rate at which the oxygen is utilized under various environmental conditions determines the energy requirements of the organism and its need for food. The metabolic rate of the oyster is affected by the temperature, salinity, and other conditions of the environment and also by the seasonal changes in the tissues of the oyster. To summarize the effect of variations due to various causes it is necessary to study the oysters' rate of metabolism while they are in a "steady state," and are undisturbed by the changes in the outside environment.

According to the observations made at this laboratory adult oysters from New England waters consume oxygen at the mean rate of 5.8 milligrams per oyster per hour at a steady state during the prespawning conditions and at the temperature of 24°-25° C. In the majority of oysters the metabolic rates determined at the same temperature 2 weeks and 4 weeks after spawning showed a steady decline. These oysters were artificially stimulated to spawn and all of them discarded considerable quantities of gonad material. Besides the lower metabolic rate the after-spawning period in the life of the oyster is characterized by a lower rate of water transport, increased periods of shell closure, increased water content in the tissues, and generally poor condition. A lower rate of oxygen consumption persists throughout the winter but increases with the onset of warm water. For studies during the winter the oysters were removed from their natural environment and the water temperature was gradually raised to 24°-25° C. From the analysis of numerous data it became obvious that single observations are meaningless if they are not accompanied by the records of shell movements and by observations on water transport by the gills. The data on oxygen consumption by the oyster provide a key for determining the amount of food required by the mollusks for vital functions.

For a study of blood circulation of the oyster, a highly satisfactory method of injecting the blood vessels was developed. A water soluble dye was introduced into the heart and blood vessels through an exceedingly fine hypodermic needle and the preparation was immediately placed in 95-percent ethyl alcohol, which caused the precipitation of the dye inside the vessels. The precipitate was not washed away and was not diffused during the following processing.

The interesting detail revealed by the study of circulation is the apparent independence of the two accessory hearts from the main circulatory system. The accessory heart is not a tubular vessel, as previously described but is a Y-shaped structure located on the inner surface of the mantle (fig. 40). It contracts independently of the principal heart and at a much slower rate of about 7-8 contractions per minute at room temperature as compared to 16-18 contractions of the heart. Two distinct waves of contraction originate in each accessory heart; one wave forces the blood toward the visceral mass, while the opposing wave moves it ventrally into the pallial artery against the blood pressure caused by the contraction of the ventricle. There is a direct capillary connection between the small vessels of the accessory heart and the blood vessel of the gill. The function of the accessory heart is to oscillate the blood inside the mantle. These observations corroborate the conclusion that the mantle plays a significant role in the respiration of the oyster.

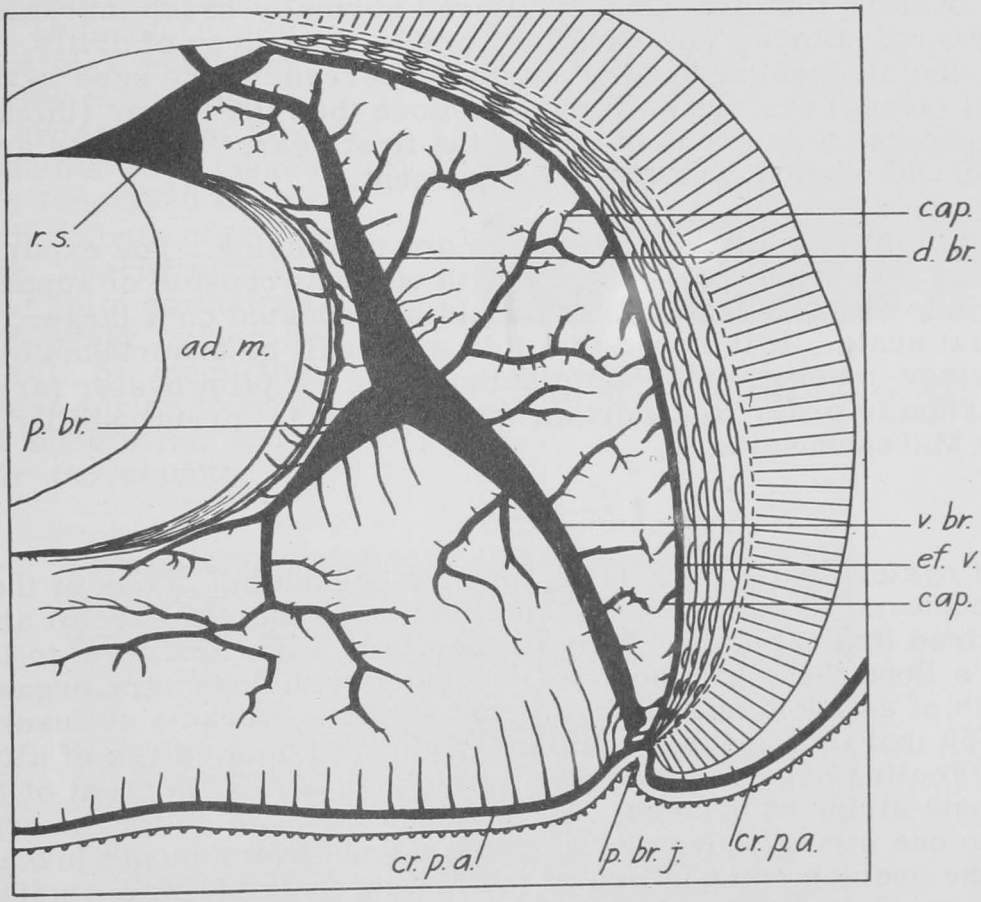


Figure 40.--Drawing of the injected accessory heart.

(ad. m. --adductor muscle; cap. --capillaries; cr. p. a. --circumpallial artery; d. br. --dorsal branch of accessory heart; ef. v. --efferent vein; p. br. --posterior branch of accessory heart; p. br. j. --palliobranchial junction; v. br. --ventral branch of accessory heart; r. s. --renal sinuses.)

Raft Culture

Since 1957 a set of oysters has been under observation in Cape Cod waters for the purpose of determining to what extent their rate of growth may be increased by using raft culture methods. In November 1959 the first phase of this project was completed when a Chatham, Massachusetts, oyster grower, who cooperated with the Bureau of Commercial Fisheries, marketed 25 bushels of 2-year-old-raft-grown oysters at a fair price. In this way it was demonstrated that it is possible to raise oysters to market size in local waters in 2 years. We found that it is advisable to keep the oysters suspended from the raft the first year, but the second year they should be planted on the sea bed to facilitate the thickening and hardening of their shells. Oysters produced by this method were legal size, averaging 3-1/2 inches in height and 2-1/4 inches in width. Their flavor was reported to be excellent and their content of solids was about 16 percent. Local oystermen considered them to be of good quality and suitable for the half-shell trade.

Cape Cod oysters that are not raft cultured normally reach marketable size in 4 to 5 years. During this time they are at the mercy of drills, whelks, and other enemies which destroy nearly 90 percent of the seed oysters. Since seed (young) oysters suffer much more than the larger (thick-shelled) ones, the mortality is greatest during the first year. Mortality among raft-suspended oysters was only 17.4 percent.

Results from these preliminary studies are promising. The experiment so far was carried out on a small scale with one raft capable of supporting 25-30 bushels of adult oysters. It should be repeated on a larger, semi-commercial scale. It is hoped that this work will be undertaken either by private oyster growers or by state authorities. A pilot oyster farm could be established in order to ascertain the commercial practicability of raft culture in Massachusetts.

Fouling

Fouling of oyster shells (fig. 41) by marine organisms is one of the problems encountered in culturing this mollusk that requires careful attention. It was noticed that soon after being transferred from mud flats to the raft in Taylor's Pond the shells became encrusted with sedentary organisms. The growth of an ascidian, *Molgula manhattensis*, became so luxuriant in August 1959 that this species completely covered both valves of all the oysters. Fouling organisms at this time comprised 33 percent of the total weight of one string of oysters. Since August, the weight of the organisms attached to one string of oysters was determined every month (except January) and the species composition of the fouling material was studied. A total of 26 species was found growing on the shells, but only 4 were abundant. In different months these 4 species comprised from 22 to 47 percent of the total weight of fouling organisms. The principal forms were the compound ascidian *Botryllus schlosseri*, a simple ascidian *Molgula manhattensis*, the annelid worm *Amphitrite ornata*, and the barnacle *Balanus balanoides*. The relative abundance of these animals varied seasonally. *Molgula* was dominant during the fall whereas *Botryllus* prevailed in winter. *Amphitrite* and *Balanus* became dominant from November to March.

Whelks

Investigations conducted in Oyster Pond River, Chatham, Massachusetts, in 1957-1958 have shown that many channeled whelks (Busycon canaliculatum) can be caught in traps. Since the population of whelks was not eradicated by trapping and equal numbers of them were captured each year, it appears probable that whelks which inhabit this area are not a local population with a restricted range. These specimens which invade the oyster beds of Oyster Pond River may originate in areas several miles away. In order to test this idea 100 whelks were tagged (fig. 42) in June 1960 and released at the mouth of Oyster Pond River, approximately one-quarter mile downstream from the nearest oyster bed. Attempts will be made this fall and next spring to locate the tagged specimens and to trace their movements.

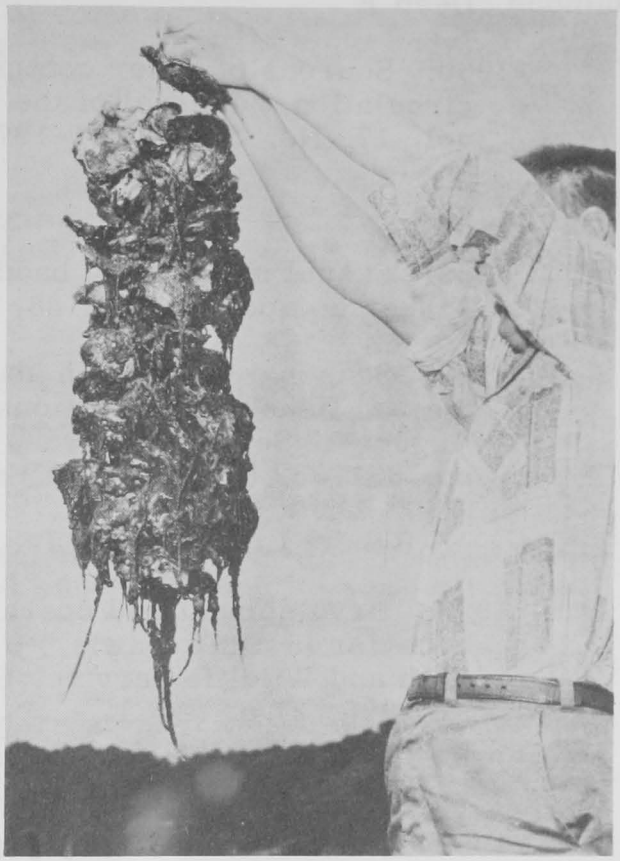


Figure 41.--Fouled oyster string which had been suspended from a raft in Taylor's Pond, Chatham, Mass.

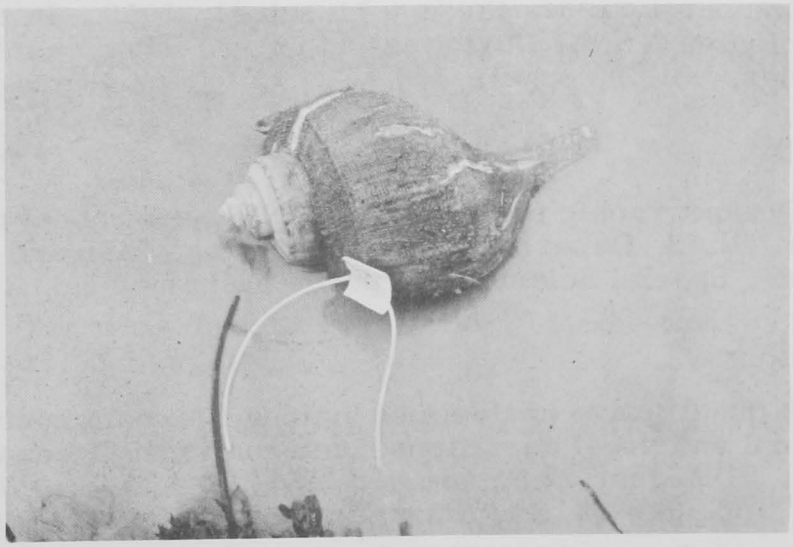


Figure 42.--Tagged channeled whelk.

PUBLICATIONS

Bumpus, Dean F.

1960. Sources of water contributed to the Bay of Fundy by surface circulation. Journal of the Fisheries Research Board of Canada, vol. 17, No. 2, pp. 181-197.

Clark, John R.

1959. Sexual maturity of haddock. Transactions of the American Fisheries Society, vol. 88, No. 3, pp. 212-213.

1959. Seasonal changes in abundance within a community of demersal fishes. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., pp. 331-332 (summary in English, abstract in Russian).

----------, Robert Livingstone, Jr., and James M. Crossen

1959. Development and operation of television for studying fish behavior in otter trawls. U. S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report--Fisheries No. 320, 21 pp.

---------- and Vadim D. Vladykov

1960. Definition of haddock stocks of the northwestern Atlantic. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Bulletin 169, vol. 60, pp. 283-296.

Couture, Lawrence H.

1959. ICNAF mesh regulations, operation of 10% annual exemption October 1, 1957, through March 31, 1959. International Commission for the Northwest Atlantic Fisheries, Annual Proceedings, vol. 9, pp. 98-100.

Day, C. Godfrey

1959. Oceanographic observations, 1958, east coast of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report--Fisheries No. 318, 119 pp.

Edwards, Robert L.

1959. A quantitative analysis of marine fish communities and their seasonal and areal variations. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., pp. 340-341 (summary in English, abstract in Russian).

Edwards, Robert L.

1960. Interspecific relations of some marine fishes. Proceedings, Northeast Wildlife Conference, Providence, Rhode Island, January 10-13, 1960 (abstract).

Fritz, Raymond L.

1959. A summary of hake tagging in Europe and the United States, 1931-1958. Journal du Conseil, vol. 24, No. 3, pp. 480-485.

Galtsoff, Paul S.

1959. Ecological evaluation of the usable productivity of bottom communities. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., pp. 233-234 (summary in English, abstract in Russian).

1960. Sponges. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Leaflet 490, 17 pp.

---------- and D. E. Philpott

1960. Ultrastructure of the spermatozoon of the oyster, Crassostrea virginica. Journal of Ultrastructure Research, vol. 3, pp. 241-253.

Graham, Herbert W.

1959. XI. United States Research Report, 1958. International Commission for the Northwest Atlantic Fisheries, Annual Proceedings, vol. 9, pp. 87-91.

Holt, S. J., J. A. Gulland, C. Taylor, and S. Kurita

1959. Terminology and notation for fishery dynamics. Journal du Conseil, vol. 24, pp. 239-242.

Jensen, Albert C.

1959. Cape Cod forests. American Forests, vol. 65, No. 8, pp. 28-29 and pp. 47-49.

1960. Tracking down the spiny dog. Maine Coast Fisherman, vol. 14, No. 6, p. 16.

1960. Sinai village and the Erie Canal. The New York State Conservationist, vol. 14, No. 3, pp. 30-31.

1960. Haddock. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Leaflet 489, 10 pp.

Jensen, A. C.

1960. Cape Cod's cod. The New York Times, vol. 109, (37, 36[illegible] p. XX9.

---------- and Raymond L. Fritz

1960. Observations on the stomach contents of the silver hake. Transactions of the American Fisheries Society, vol. 89, No. [illegible] pp. 239-240.

Kelly, George F., Allan M. Barker, and George M. Clarke

1960. United States--1958. Length-frequencies--redfish. International Commission for the Northwest Atlantic Fisheries, Sampling Yearbook, vol. 3, pp. 151-164.

---------- and Robert S. Wolf

1959. The age and growth of redfish, Sebastes marinus (Linnaeus) in the Gulf of Maine. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Bulletin 156, vol. 60, pp. 1-31.

Livingstone, Robert, Jr.

1959. The use of underwater television for studying the behavior of marine fish in trawl nets. Anatomical Record, vol. 134, No. 3, pp. 601-602 (abstract).
Also in: Bulletin Ecological Society of America, vol. 40, No. [illegible] p. 94.

1959. Television observations of the behavior of marine fish in a trawl net. Anatomical Record, vol. 134, No. 3, p. 602 (abstract).
Also in: Bulletin Ecological Society of America, vol. 40, No. [illegible] p. 86.

Lux, Fred E.

1959. Age determination of fishes. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Leaflet 488, 10 pp.

1959. A case of partial albinism in the four-spotted flounder, Hippoglossina oblonga. Copeia, 1959, No. 2, p. 253.

1960. Notes on first-year growth of several species of Minnesota fish. U. S. Department of the Interior, Fish and Wildlife Service, The Progressive Fish-Culturist, vol. 22, No. 2, pp. 81-82.

---------- and Lloyd L. Smith, Jr.

1960. Some factors influencing seasonal changes in angler catch in a Minnesota lake. Transactions of the American Fisheries Society, vol. 89, No. 1, pp. 67-79.

Marak, Robert R.

1960. Food habits of larval cod, haddock, and coalfish in the Gulf of Maine and Georges Bank area. Journal du Conseil, vol. 25, No. 2, pp. 147-157.

Merrill, Arthur S.

1959. A comparison of Cyclopecten nanus Verrill and Bush and Placopecten magellanicus (Gmelin). Occasional Papers on Mollusks, Museum of Comparative Zoology, vol. 2, No. 25, pp. 209-228.

1959. An unusual occurrence of Mya arenaria L. and notes on other marine mollusks. The Nautilus, vol. 73, No. 2, pp. 29-43.

1960. Living inclusions in the shell of the sea scallop Placopecten magellanicus. Ecology, vol. 41, No. 2, pp. 385-386.

Miller, David

1959. A pelagic record of the snipefish, Macrorhamphosus scolopax (L.), in the Gulf of Maine. Copeia, 1959, No. 2, p. 160.

---------- and Robert R. Marak

1959. The early larval stages of the red hake, Urophycis chuss. Copeia, 1959, No. 2, pp. 248-250.

Posgay, Julius A.

1959. Underwater camera as a tool for studying benthic communities. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., p. 483 (abstract).

Taylor, Clyde C.

1959. Temperature and growth--the Pacific razor clam. Journal du Conseil, vol. 25, No. 1, pp. 93-101.

1959. The axiom of stable environment in fishery science. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., pp. 352-355 (summary in English, abstract in Russian).

Jensen, A. C.

1960. Cape Cod's cod. The New York Times, vol. 109, (37, 367), p. XX9.

---------- and Raymond L. Fritz

1960. Observations on the stomach contents of the silver hake. Transactions of the American Fisheries Society, vol. 89, No. 2, pp. 239-240.

Kelly, George F., Allan M. Barker, and George M. Clarke

1960. United States--1958. Length-frequencies--redfish. International Commission for the Northwest Atlantic Fisheries, Sampling Yearbook, vol. 3, pp. 151-164.

---------- and Robert S. Wolf

1959. The age and growth of redfish, Sebastes marinus (Linnaeus) in the Gulf of Maine. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Bulletin 156, vol. 60, pp. 1-31.

Livingstone, Robert, Jr.

1959. The use of underwater television for studying the behavior of marine fish in trawl nets. Anatomical Record, vol. 134, No. 3, pp. 601-602 (abstract).
Also in: Bulletin Ecological Society of America, vol. 40, No. 3, p. 94.

1959. Television observations of the behavior of marine fish in a trawl net. Anatomical Record, vol. 134, No. 3, p. 602 (abstract).
Also in: Bulletin Ecological Society of America, vol. 40, No. 3, p. 86.

Lux, Fred E.

1959. Age determination of fishes. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Leaflet 488, 10 pp.

1959. A case of partial albinism in the four-spotted flounder, Hippoglossina oblonga. Copeia, 1959, No. 2, p. 253.

1960. Notes on first-year growth of several species of Minnesota fish. U. S. Department of the Interior, Fish and Wildlife Service, The Progressive Fish-Culturist, vol. 22, No. 2, pp. 81-82.

---------- and Lloyd L. Smith, Jr.

1960. Some factors influencing seasonal changes in angler catch in a Minnesota lake. Transactions of the American Fisheries Society, vol. 89, No. 1, pp. 67-79.

Marak, Robert R.

1960. Food habits of larval cod, haddock, and coalfish in the Gulf of Maine and Georges Bank area. Journal du Conseil, vol. 25, No. 2, pp. 147-157.

Merrill, Arthur S.

1959. A comparison of Cyclopecten nanus Verrill and Bush and Placopecten magellanicus (Gmelin). Occasional Papers on Mollusks, Museum of Comparative Zoology, vol. 2, No. 25, pp. 209-228.

1959. An unusual occurrence of Mya arenaria L. and notes on other marine mollusks. The Nautilus, vol. 73, No. 2, pp. 29-43.

1960. Living inclusions in the shell of the sea scallop Placopecten magellanicus. Ecology, vol. 41, No. 2, pp. 385-386.

Miller, David

1959. A pelagic record of the snipefish, Macrorhamphosus scolopax (L.), in the Gulf of Maine. Copeia, 1959, No. 2, p. 160.

---------- and Robert R. Marak

1959. The early larval stages of the red hake, Urophycis chuss. Copeia, 1959, No. 2, pp. 248-250.

Posgay, Julius A.

1959. Underwater camera as a tool for studying benthic communities. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., p. 483 (abstract).

Taylor, Clyde C.

1959. Temperature and growth--the Pacific razor clam. Journal du Conseil, vol. 25, No. 1, pp. 93-101.

1959. The axiom of stable environment in fishery science. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., pp. 352-355 (summary in English, abstract in Russian).

Wigley, Roland L.

1959. Life history of the sea lamprey of Cayuga Lake, New York. U. S. Department of the Interior, Fish and Wildlife Service, Fishery Bulletin 154, vol. 59, pp. 561-617.

1959. Organic content of Georges Bank bottom sediments. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., pp. 587-589 (summary in English, abstract in Russian).

Wise, John P.

1959. Emigration of cod, Gadus morhua L. International Oceanographic Congress, 31 August-12 September 1959, A. A. A. S., Washington, D. C., pp. 358-359 (summary in English, abstract in Russian).

1960. A synopsis of biological data on cod, Gadus morhua L. Issued as a separate by the Food and Agriculture Organization of the United Nations, ii + 44 pp.

1960. Cod, haddock, and temperature. Proceedings, Northeast Wildlife Conference, Providence, Rhode Island, January 10-13, 1960 (abstract).

---------- and Frank A. Dreyer

1960. United States--1958/59. Length frequencies--haddock. International Commission for the Northwest Atlantic Fisheries, Sampling Yearbook, vol. 3, pp. 130-132.

1960. United States/Canada cooperative programme--1958/59. Length frequencies--haddock. International Commission for the Northwest Atlantic Fisheries, Sampling Yearbook, vol. 3, pp. 127-129.

---------- and Albert C. Jensen

1959. Movements of tagged halibut off New England. Transactions of the American Fisheries Society, vol. 88, No. 4, pp. 357-358.

---------- and Harriett E. Murray

1960. United States--1958. Length frequencies--cod. International Commission for the Northwest Atlantic Fisheries, Sampling Yearbook, vol. 3, pp. 70-71.