1961

ANNUAL REPORT

BUREAU OF COMMERCIAL FISHERIES
BIOLOGICAL LABORATORY
WOODS HOLE MASSACHUSETTS

CIRCULAR 137

United States Department of the Interior, Stewart L. Udall, Secretary
Fish and Wildlife Service, Clarence F. Pautzke, Commissioner
Bureau of Commercial Fisheries, Donald L. McKernan, Director

ANNUAL REPORT

BIOLOGICAL LABORATORY

Woods Hole, Massachusetts

for the year ending June 30, 1961

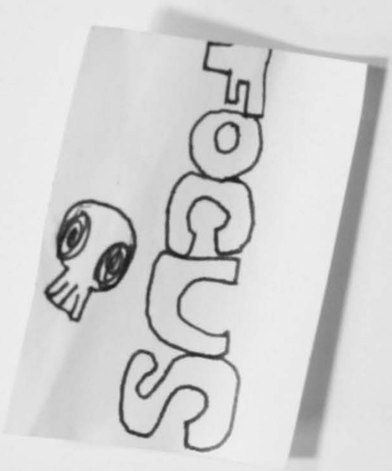
Herbert W. Graham, Laboratory Director

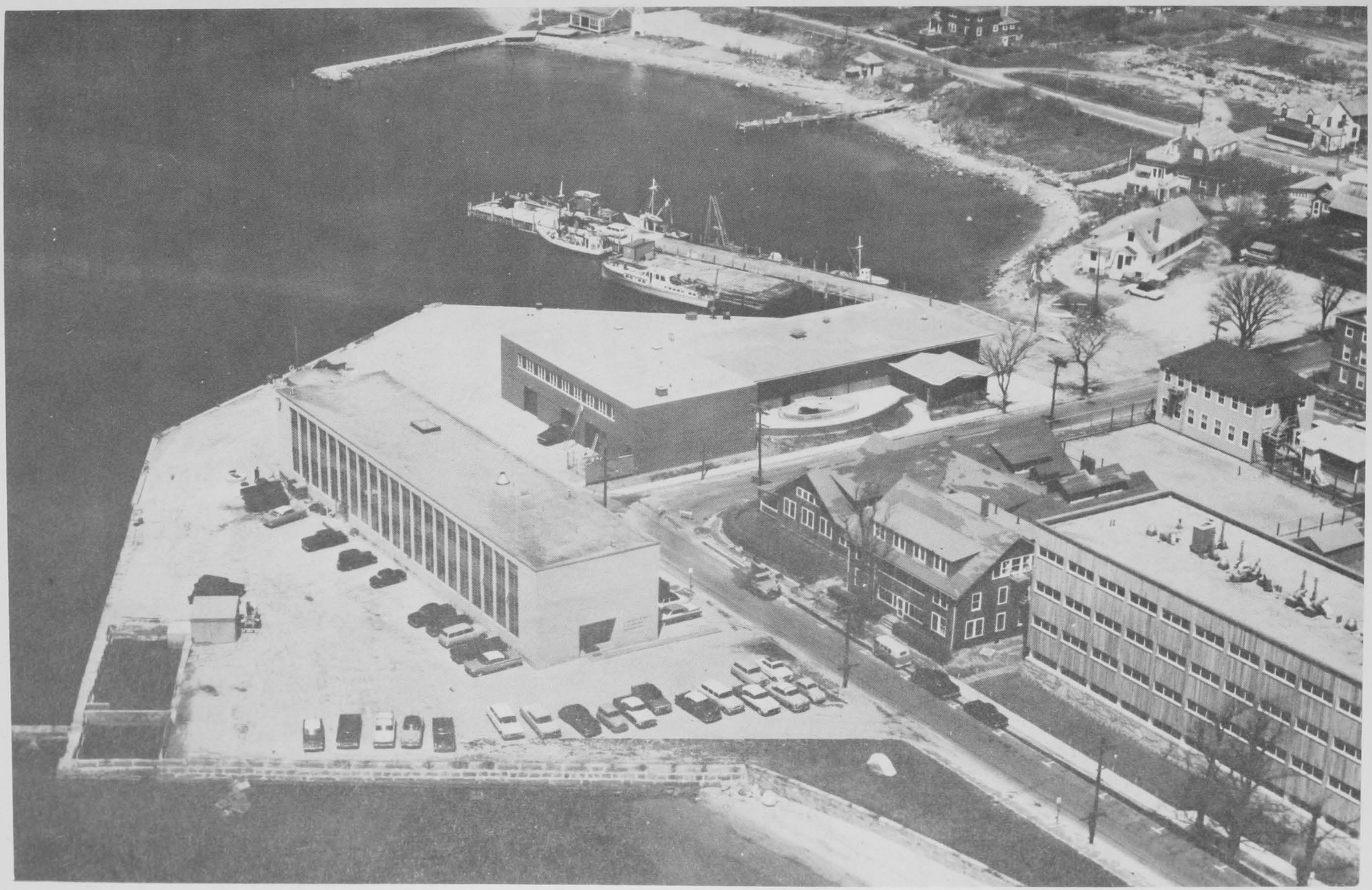
Circular 137

Washington, D. C.
February 1, 1962

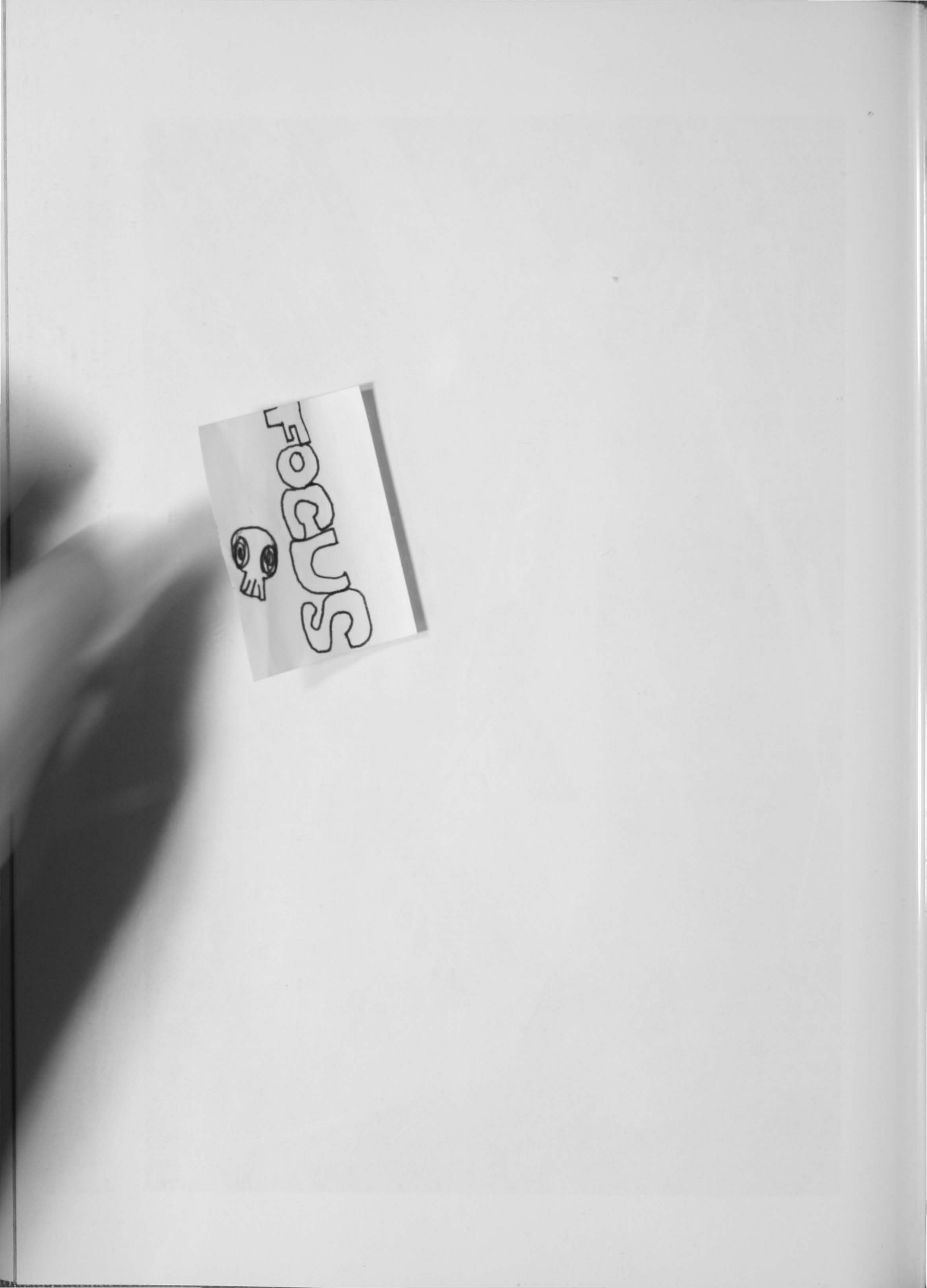

FOCUS

TABLE OF CONTENTS


FOCUS



An aerial view, looking northwest, of the new Woods Hole Biological Laboratory (center) and Aquarium (center left) of the Bureau of Commercial Fisheries. The new Marine Biological Laboratory building is at the lower left. Taken in May 1961, by R. K. Brigham.


FOCUS

REPORT OF THE LABORATORY DIRECTOR

Herbert W. Graham

Introduction

The research program of the Bureau of Commercial Fisheries Biological Laboratory at Woods Hole, is concerned with fishery and oceanographic research in that part of the ocean which supports the fisheries of the New England States. Georges Bank and the Gulf of Maine are the principal areas of interest but, for purposes of our studies, we must concern ourselves with the entire Continental Shelf from Nova Scotia to Hudson Canyon. When laid out on a map of the world oceans this area is minute indeed. However, this little dot in the world oceans covers more than 72 thousand square miles which, when viewed from the standpoint of logistics, is almost too large an area to be covered adequately with the facilities available for survey.

Fortunately the fishermen's catches are available for study so that much of the information which the biologist needs is provided by sampling the landings. Through the cooperation of the fisherman, samples of the catches and information on area fished and effort expended are obtained. From these data much of the required information on abundance and population structure is secured for the chief fishing grounds and important commercial species of fish.

To understand the life history of fishes, and causes of fluctuations in abundance which are so characteristic of fish populations, it is necessary to relate the fish to its environment. This requires, even for bottomfish, sampling of the entire water column for eggs, larvae, and immature stages as well as regular oceanographic surveys to record the environmental conditions throughout the year, and especially at those times which may be critical in the lives of particular species.

The long-range program of the Laboratory includes surveys of fish distribution and abundance and hydrographic conditions in such a manner as to provide the kind of information required to develop answers to the problem of fluctuating fish populations. At the present time the program is not completely implemented due, in part, to inadequate vessel facilities which will be corrected in the near future. Some parts of the requisite program presently are being carried out on a full scale. For example, the commercial landings are being sampled adequately for most species, but improvements will be made in this program from time to time.

Sampling and observing at sea, of course, is a more time consuming and expensive operation than sampling ashore. Our present program of fishery and oceanographic surveys must be more than doubled to provide the coverage required. This year, utilizing the Delaware for survey work, about 75 days were spent at sea on seven cruises. When our new research vessel is received next year, we expect to increase sampling to 220 days. Even this effort, however, cannot provide the amount of coverage which is desirable.

Since research vessels are so expensive to operate, oceanographers have been attempting to set up automatic recording instruments at strategic stations at sea that would obtain continuous records of temperature, currents, and other oceanographic conditions. Such instruments will either transmit the information to a shore station or store it until visited by a vessel for servicing.

As a start toward setting up a network of observation stations on the Continental Shelf, the Woods Hole Oceanographic Institution, under contract with the Bureau of Commercial Fisheries, has established oceanographic observation posts on all the lightships along the Atlantic Coast. These are now providing valuable, continuous information on temperature and salinity conditions along the inner part of the Shelf. Continuous records of this nature become more valuable as the years pass. These stations will become an integral part of a more widespread network of observation posts when anchored buoys are established and the vessel surveys extended.

International Commission for the Northwest Atlantic Fisheries

This Laboratory's research is intimately associated with the work of the International Commission for the Northwest Atlantic Fisheries (ICNAF). Management of the groundfish in the Northwest Atlantic is carried out through this commission, and the biological research required as a basis for this management is conducted by member countries. Population studies are conducted by the Woods Hole staff on haddock, cod, redfish, silver hake, flounder, and sea scallops.

At the 1961 Annual Meeting of ICNAF, actions affecting the entire convention area in the North Atlantic from Greenland to Rhode Island were taken. Cod and haddock are already under regulation in three of the five subareas of the Convention Area, but recommendations made at the last meeting look toward regulating all groundfish in the entire Convention Area, as well as sea scallops, and harp and hood seals.

Recommendations for a number of otter trawl mesh-size regulations resulted from the Commission which received a report of a special International Committee on assessment of the effects of increasing mesh size in the Convention Area. The committee, which was appointed 2 years ago, outlined the immediate and long-term effects of different mesh sizes for most of the stocks of the important groundfish species in the Northwest Atlantic. The United States was represented on the committee by Ralph Silliman and Richard Hennemuth.

The following recommendations limiting the size of mesh of nets in the various subareas were made by the Commission to member countries:

1. In Subarea 1 (west coast of Greenland) and Subarea 2 (Labrador Coast), a minimum mesh size of 4-1/2 inches for all species of groundfish including ocean perch or redfish. To date these subareas have been unregulated.

2. In subarea 3 (Grand Bank of Newfoundland), a minimum mesh size of 4-1/2 inches for all groundfish in the entire subarea, except for redfish in the southern part of the subarea, where redfish are smaller. The present regulation in this subarea calls for a minimum mesh of 4 inches for cod and haddock only.

3. In Subarea 4 (Nova Scotian Banks), a minimum mesh size of 4-1/2 inches for cod, haddock, and flatfishes. The present regulation which specifies a minimum of 4-1/2 inches applies only to cod and haddock.

4. In Subarea 5, the 4-1/2 inch minimum for cod and haddock was left unchanged.

When the recommendations are implemented, there will be a uniform minimum mesh size of 4-1/2 inches throughout the Convention Area for nets used in fishing for cod and haddock. Flatfishes will be under a 4-1/2-inch minimum mesh size from Greenland to the southern end of Nova Scotia; redfish will be under the same minimum size on all grounds north of the southern part of the Grand Bank.

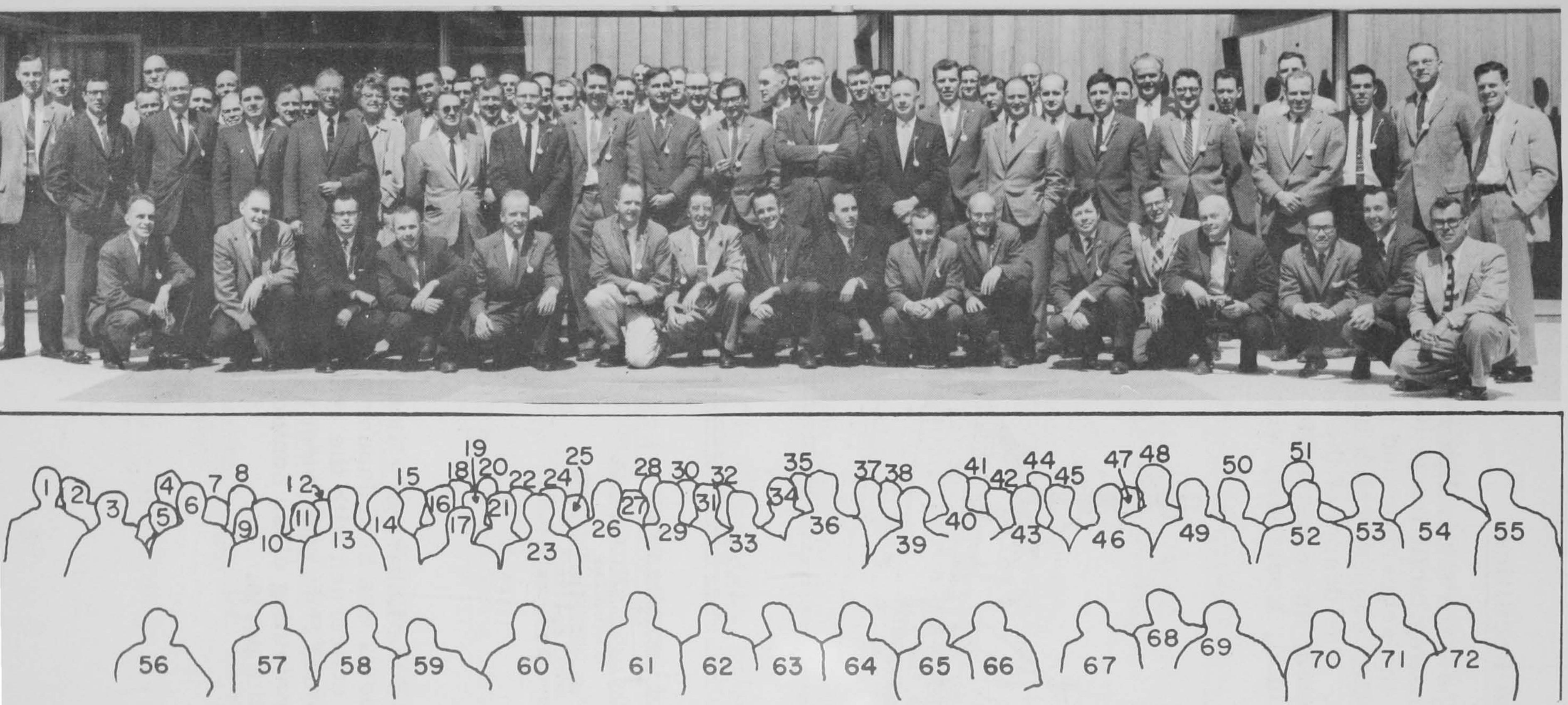
Fishing effort in the Northwest Atlantic has increased in recent years, and the pressure is expected to mount even higher. There was general agreement in the Commission that, under these circumstances, increasing mesh size for all groundfish in the Convention Area would be beneficial. The Commission expressed the opinion that redfish of the southern part of the Convention Area, as well as silver hake (whiting) and flatfishes in Subarea 5, should be brought under mesh regulation as soon as possible. There was also considerable interest in increasing the mesh size above 4-1/2 inches for cod, haddock, and flounders.

The conservation of sea scallops was given considerable attention by the Commission. Evidence was presented indicating that the present ring size of scallop dredges is too small to maintain maximum sustained yield at present fishing levels. The Commission would welcome a proposal for increasing ring size at its next annual meeting. Canadian and United States scientists agreed to work cooperatively in determining the optimum size of ring and in developing a specific proposal for regulation.

During the week preceding the Washington meeting, the Commission's Committee on Research and Statistics met in Woods Hole. The scientists reviewed the research and statistical reports of the member countries from which they prepared special reports for the consideration of the Commissioners in Washington.

The scientific groups reviewed a report of a special international committee on environmental symposium studies in 1963. The International Council for the Exploration of the Sea (ICES) will be asked to co-sponsor this symposium. Another result of this committee's work is a plan for joint action research of countries interested in Subarea 1 (west coast of Greenland). A multi-ship survey of the area is planned for 1963 to learn more about the oceanographic conditions in the area in relation to the drift of plankton and fish larvae.

Preceding the meetings of the Committee on Research and Statistics, a 4-day symposium on fish marking was held in Woods Hole. Over 60 contributions were submitted to the symposium with the main topics being (1) methods and effectiveness of tagging and tag recovery, and (2) analysis of tag returns. From the symposium were developed many new ideas which will be valuable in planning tagging programs in the ICNAF area. These include new methods of tagging, new techniques for measuring the efficiency of tag recoveries, and new methods for estimating population size and mortality rates.



The participants of the I.C.N.A.F. Tagging Symposium at Woods Hole, May 1961. Photographed by R. K. Brigham. 1. F. E. Lux, 2. E. G. Karvelis, 3. J. R. Clark, 4. W. R. Crowe, 5. L. S. Joeris, 6. S. D. Gerking, 7. R. R. Marak, 8. J. A. Posgay, 9. J. W. Moffett, 10. M. L. Hayes, 11. F. D. McCracken, 12. S. R. Nickerson, 13. F. J. Mather, III, 14. M. Watson, 15. R. C. Hennemuth, 16. J. B. Skerry, 17. R. Hile, 18. A. C. Jensen, 19. R. L. Fritz, 20. F. C. Cleaver, 21. R. K. Allen, 22. G. J. Paulik, 23. H. W. Graham, 24. E. Cadima, 25. A. M. Barker, 26. R. J. H. Beverton, 27. S. J. Holt, 28. M. McLean, 29. E. D. LeCren, 30. C. O'Connell, 31. W. Templeman, 32. J. A. Gulland, 33. G. Krefft, 34. F. M. Smith, 35. N. S. Baldwin, 36. D. R. Franklin, 37. R. L. Edwards, 38. P. H. Chase, Jr., 39. P. Zimmer, 40. B. E. Skud, 41. R. N. Hersey, 42. P. S. Robson, 43. G. Cannone, 44. W. R. Beckman, 45. F. R. Thomas, 46. G. H. Lawler, 47. O. R. Martin, 48. Sv. Aa. Horsted, 49. V. M. Hodder 50. E. Bertelsen, 51. R. L. Wigley, 52. G. W. Warner, 53. B. D. Fink, 54. P. E. Hamer, 55. M. D. Grosslein, 56. J. E. Watson, 57. V. A. Mackesy, 58. J. A. McCann, 59. H. H. Eckles, 60. G. F. Kelly, 61. R. Livingstone, Jr., 62., T. J. Costello, 63. A. C. Hartt, 64. W. Jurasz, 65. A. Marcotte, 66. R. J. Myhre, 67. J. Jonsson, 68. L. M. Dickie, 69. P. M. Hansen, 70. H. Kasahara, 71. P. A. Larkin, 72. J. P. McDermott.

Rehabilitation of Physical Facilities

Two more important steps were taken this year in the complete replacement of shoreside and floating facilities at the Laboratory. The second building unit comprising the acquarium and maintenance shops was completed, as was the saltwater system which supplies both the aquarium and laboratory buildings. The design of the new vessel to replace the Albatross III was completed, and construction is now underway by Southern Shipbuilding Co., Slidell, Louisiana, with completion scheduled for October 1962.

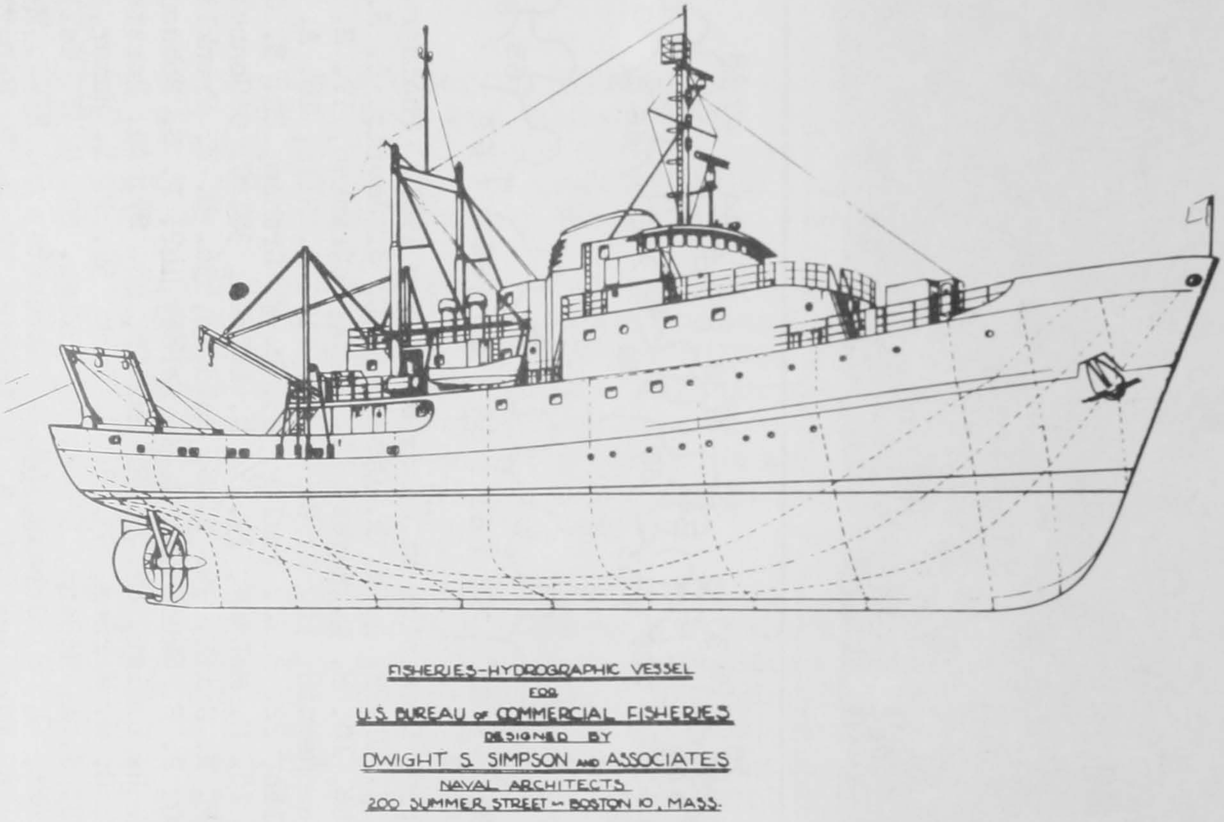


Figure 2.

Annual Conference

The Annual Conference of the Laboratory biologists and the personnel stationed in the fishing ports was held January 10-11, 1961. At these conferences all persons concerned with the collection of samples and statistics used by the Woods Hole staff meet in Woods Hole. Such meetings are essential to maintaining close contact between the biologists and those collecting data in the ports.

Seminar Program

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

Seasonal changes in the internal anatomy of haddock, John P. McDermott

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

Estimates of the fish populations of Clear Lake, Iowa, James A. McCann

Sink Gill-net Fishing - New England, Warren F. Rathjen, Bureau of Commercial Fisheries Exploratory Fishing and Gear Research Base, Gloucester

Research problems in animal reproduction, Dr. Thaddeus Mann and Dr. Cecilia Lutwak-Mann, University of Cambridge

Statistical analysis of periodic biological phenomena, Dr. Chester L. Bliss, Connecticut Agriculture Experiment Station and Yale University

Physiology of reproduction in mollusks, Dr. Paul S. Galtsoff

Plankton biology at the Woods Hole Oceanographic Institution, C. Yentsch and G. Grice, Woods Hole Oceanographic Institution

The Limnological Congress in Vienna, Dr. William Burbanck, Emory University

The biological effects of high frequency sound, Margaret Watson, Woods Hole Oceanographic Institution

The proteins of skeletal and cardiac muscle, Prof. William R. Amberson, Marine Biological Laboratory

Experimental stimulation of gametogenesis, Harry Turner, Woods Hole Oceanographic Institution

The breeding biology of the alewife, Richard Cooper, University of Rhode Island

Sampling problems for the industrial fishery, Joel O'Conner, University of Rhode Island

Animals, sediments and feeding types, Dr. Howard L. Sanders, Woods Hole Oceanographic Institution

Redfish tagging studies at Eastport, George F. Kelly

The distribution of Western North Atlantic Bluefin Tuna, Frank J. Mather, III, Woods Hole Oceanographic Institution

Using material collected from navigation buoys, Arthur S. Merrill

Sediments as environmental indications, Dr. John M. Zeigler, Woods Hole Oceanographic Institution

Seasonal trends in the food habits of haddock, Dr. Roland L. Wigley

Age and growth of yellowtail flounder, Fred E. Lux

Problems of economic research in fisheries, Dr. Harlan Lampe, University of Rhode Island

Comparative functional morphology of the boring mechanism of boring gastropods, Dr. Melbourne Romaine Carriker, Bureau of Commercial Fisheries Biological Laboratory, Oxford, Maryland

STAFF

Woods Hole Biological Laboratory

Herbert W. Graham, Laboratory Director
Robert L. Edwards, Assistant Laboratory Director

Fishery Research Biologists

Allan M. Barker
Lawrence H. Couture (Reassigned October 1, 1960, to Office of Statistical Services, Gloucester, Mass.)
Kenneth B. Cumming (Appointed June 7, 1961.)
Raymond L. Fritz
Marvin D. Grosslein (Appointed May 8, 1961.)
Evan B. Haynes (Appointed June 19, 1961.)
Richard C. Hennemuth (Transferred from San Diego, Calif., January 15, 1961.)
Albert C. Jensen
George F. Kelly
Robert Livingstone, Jr.
Fred E. Lux
Robert R. Marak
James A. McCann
John P. McDermott
Arthur S. Merrill
David Miller
Fred E. Nichyparowich
Marian H. Pettibone (Temporary WAE Appointment July 19 to September 16, 1960.)
Julius A. Posgay
John B. Skerry (Transferred to Branch of Resource Management, Gloucester, Mass., March 7, 1961.)
Charles L. Wheeler
Roland L. Wigley
John P. Wise (Transferred to FAO, South America, November 26, 1960.)

Fishery Aids and Technicians

Philip H. Chase, Jr. (Transferred from New Bedford, Mass., October 1, 1960.)
John R. Donovan
Lewis M. Lawday
Harriet E. Murray (Reassigned from Statistical Clerk, March 5, 1961.)
Llewellyn R. Porter, Jr. (Transferred from Boston, Mass., September 2, 1960.)
Ruth R. Stoddard (Reassigned from Statistical Clerk, December 15, 1960.)
Roger B. Theroux

Fishery Aids and Technicians (continued)

Richard C. Barnard) Claude F. Bocken) George M. Clarke) Theodore Gallagher) John R. Kallio) John C. Malone) Charles L. Philbrook) Paul Swain) Albert F. Thibodeau)	Reorganized under Office of Statistical Services, Gloucester, Mass., October 1, 1960.

Statistical Staff

William H. Callahan
Frank A. Dreyer
Robert N. Hersey
Henry W. Jensen
Harriett E. Murray (Reassigned to Fishery Aid, March 5, 1961.)
Ruth R. Stoddard (Reassigned to Fishery Aid, December 15, 1960.)

Administrative and Maintenance

August F. Almeida, Maintenanceman
Kathleen J. Blair, Clerk-Stenographer (Resigned August 5, 1960.)
Alice M. Cairns, Personnel Clerk
Gilbert J. Costa, Foreman I-Building Repairman
Jean A. Hilton, Clerk-Typist (Appointed August 8, 1960.)
Dorothy C. Johnson, Clerk-Stenographer
Sally H. Jones, Secretary (Steno.)
Helen I. Kiernan, Purchasing Agent
Warren L. Loring, Building Repairman
Franklin A. Macaulay, Buildings and Grounds Manager (Appointed June 14, 1961.)
Vincent A. Mackesy, Administrative Assistant
Harold M. Neal, Maintenanceman
Robert E. Polley, Janitor
Ruth M. (Young) Porter, Clerk-Stenographer
Harold W. Ruschky, Maintenanceman, (Temporary Appointment March 6, 1961.)
Mary C. Thompson, Clerk (Typing)

Technical Assistants

Herbert A. Ashmore, Statistical Draftsman (Appointed January 16, 1961.)
Frank A. Bailey, Scientific Illustrator (Statistical Draftsman)
Robert K. Brigham, Photographer
Sterling L. Cogswell, Fishery Methods and Equipment Specialist
James M. Crossen, Electronics Technician (General)
Elizabeth B. Leonard, Librarian
Samuel R. Nickerson, Fishery Methods and Equipment Specialist

Student Assistants (Fishery Aids)

William H. Evoy (June 17 to September 1, 1960)
Ruth K. Henderson (June 17 to October 7, 1960)
Joel S. O'Connor (June 16 to October 14, 1960)

Shellfish Laboratory

Paul S. Galtsoff, Chief
William N. Shaw, Fishery Research Biologist (Transferred to Oxford, Maryland, November 27, 1960.)
Patricia A. Philpott, Clerk-Typist
Ruth L. Von Arx, Scientific Illustrator (Temporary Appointment-WAE.)

Vessel Operation

Seven cruises were made on the M/V Delaware by the Woods Hole Biological Laboratory during the fiscal year. The Delaware is operated by the Bureau of Commercial Fisheries Exploratory Fishing and Gear Research Base, Gloucester, Massachusetts. The cruises were as follows:

Cruise no.	Date	Operation
60-10	July 5-9	Investigation of the haddock inshore nursery grounds.
60-12	Nov. 1-23	Survey of the distribution and abundance of young-of-the-year haddock and other fishes in the Gulf of Maine.
61-4	Mar. 16-27	Investigation of the vertical movements of the silver hake and American hake.
61-5	Mar. 30 to Apr. 7	Fluke tagging.
61-7	May 2-11	Sea scallop survey; quantitative sampling.
61-9	June 12-16	Survey of the distribution and abundance of groundfish on the inshore fishing grounds.
61-10	June 20-30	Sampling of bottom sediments and benthic fauna in the central and northern parts of the Gulf of Maine.

Two cruises were made aboard the M/V Captain Bill III, chartered for the purpose as follows:

Cruise no.	Date	Operation
2	Aug. 22-26	Survey of the distribution of groundfish on the inshore fishing grounds, second in a series of three cruises for this purpose
3	Sept. 19-24	As above, third in the series

Three cruises were made aboard the M/V Noah A by personnel of the Scallop Research Program for the purpose as follows:

Cruise no.	Date	Operation
1	Sept. 30	To census a scallop population and take samples of this material to the Laboratory for further study.

Cruise no.	Date	Operation (continued)
2	Oct. 9	To check spawning and bring back unspawned scallops to Laboratory for experiments, and to make underwater observations on the efficiency of scallop gear.
3	Oct. 23	Twofold: To check sea scallop spawning. To take and observe underwater motion pictures of the operation of sea scallop gear.

HADDOCK PROGRAM

M. D. Grosslein, Chief,[1]
J. P. McDermott and R. N. Hersey

Routine inventory of commercial landings continues and a beginning was made on a study of refining short-term predictions of yield. The results of these efforts are incorporated into a review of the present status of the U. S. haddock fishery. First, however, a brief summary of the world distribution and harvest of haddock is presented for background to the ultimate problem of haddock management on an ocean-wide basis. Recent build-up of new fishing fleets in the Northwest Atlantic have raised urgent questions about future sharing of the haddock harvest from that area.

World Distribution and Harvest of Haddock

The haddock, which is found only in the North Atlantic, has long been one of the most heavily exploited Atlantic fishes and for many years has been the most valuable food fish of the New England fisheries. In the Northwest Atlantic, haddock occur in commercial quantities on shelf areas from Cape Cod to Newfoundland and on the west coast of Greenland. The fisheries in these areas are managed through the International Commission for the Northwest Atlantic Fisheries (ICNAF). In the Northeast Atlantic, haddock are found around Iceland, on the Faroe Plateau, and from the southern North Sea to the warmer parts of the Barents Sea. The statistics for these areas are published by the International Council for Exploration of the Sea (ICES).

Fairly complete statistics on most haddock landings have been kept on both sides of the Atlantic since the turn of the century. Landings from the whole North Atlantic have fluctuated but there has been no trend over the last 60 years. Lows of about 2.4 million metric tons occurred during the period 1910-19, and during the 1940's as a result of the two World Wars (fig. 3). It is noteworthy that the last decade[2] has yielded the greatest production, over 4 million metric tons.

The relative contribution of the Northwest Atlantic Fisheries (by members of ICNAF) to the world landings of haddock ranged from less than 20 percent in 1900-09, to more than 40 percent in the 1940's. In the last decade, and for the past 60 years, ICNAF countries landed approximately one-third of the world harvest of haddock. Except for a slight drop in the 1940's, there has been a steady increase in landings from the ICNAF area.

1/ J. P. Wise was in charge until November 1960.

2/ The 1959 landings are not yet available.

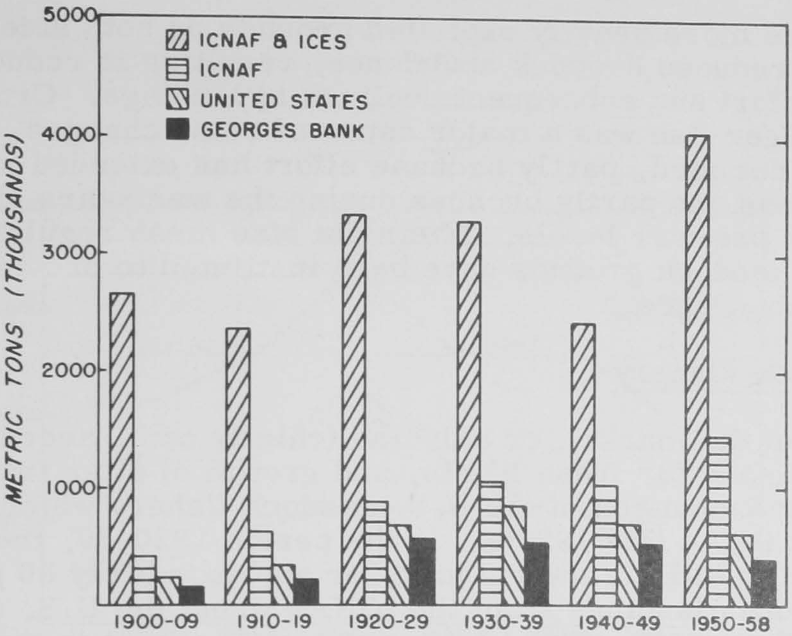
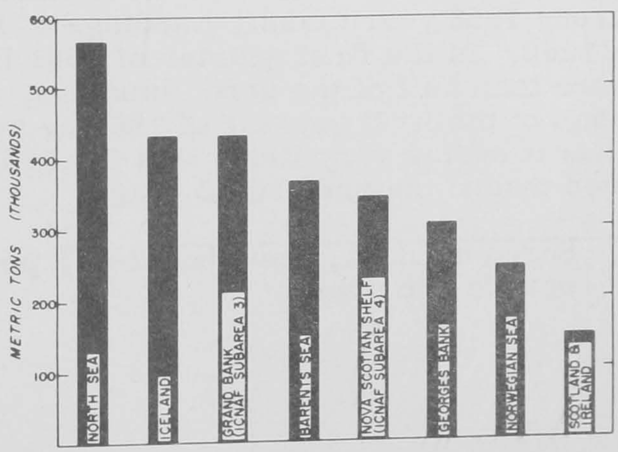


Figure 3.--Comparison of haddock landings from Georges Bank with total U.S. landings and total landings for the two sides of the Atlantic.

In recent years the landings from Canada (including Newfoundland), Spain, and the United States have accounted for more than 95 percent of the haddock landings by ICNAF countries. England, Germany, Iceland, Norway, and Scotland land the bulk of the haddock taken by ICES countries (over 80 percent in 1956, 1957, and 1958).

Among major haddock fishing grounds in recent years, the North Sea ranked first in haddock landings and Iceland and the Grand Bank (Newfoundland) ranked second and third respectively (fig. 4). Georges Bank, the major haddock ground of the U.S. fishery, ranked sixth. It should be noted that this ranking does not represent a comparison of the relative productivity of the various grounds because it does not account for the size of the areas.

Figure 4.-- Haddock landings from various areas in the North Atlantic during the years 1950-58.



Fishing on the more heavily exploited grounds on both sides of the Atlantic has reduced haddock abundance, resulting in reduced catch per unit of effort and subsequent declines in landings. Cropping the older and larger fish was a major cause of these changes. Total harvest has not declined, partly because effort has extended to less heavily fished areas and partly because during the war years stocks increased over pre-war levels. Minimum size mesh regulations on some major haddock grounds have been instituted to prevent further declines in abundance.

U. S. Haddock Fishery

The decline of the market for salt fish (chiefly cod), accompanied by increased demand for fresh fillets, and growth of otter trawling all contributed to expansion of the U.S. haddock fishery which yielded a peak harvest in the late 1920's. In the period 1920-39, the U.S. fleet landed over 1.5 million metric tons, or approximately 80 percent of the total haddock landings from the ICNAF area; the U.S. contribution dropped to 68 percent in the 1940's and to 43 percent in the period 1950-58. Georges Bank has supplied about two-thirds of total U.S. haddock landings since 1900 (fig. 3). The maximum contribution of Georges Bank was in the 1920's and the 1940's when more than three-fourths of the total U.S. landings came from this productive ground.

In the last 5 years, average abundance of haddock on Georges Bank appears to have been the lowest since 1931; but there is no conclusive evidence of a long-term downward trend in total abundance on a weight basis (fig. 5). However, since 1940 there has been a decrease in abundance of large haddock and since 1950 the catch per day of scrod usually has exceeded that of large haddock[3/]. As a result of poor survival of broods in 1955, 1956, and 1957, the catches per day (scrod and large combined) in 1958 and 1959 were the lowest in the entire period 1931-60.

Abundance increased in 1960, and total U.S. haddock landings in that year were about 15 percent greater than landings in 1958 and 1959, primarily due to increased scrod landings from recruitment of the strong 1958 year class. Landings of large haddock remained steady in 1960. In the first quarter of 1961 the 1958 year class contributed more than half of the scrod landings, and total landings have exceeded those of the first quarter of 1960 by more than 8 million pounds. Thus it seems very likely that the 1961 Georges Bank harvest will exceed that of the previous 2 years.

3/ Scrod haddock, less than 2-1/2 pounds; large haddock, 2-1/2 pounds and over.

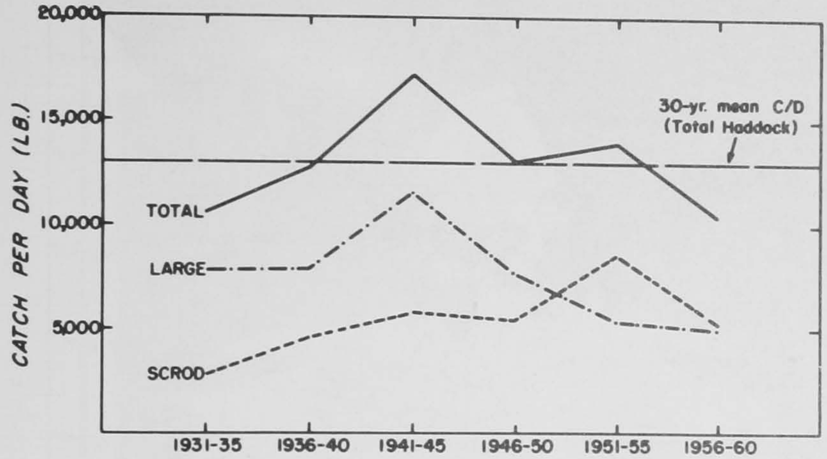


Figure 5.--Abundance of haddock on Georges Bank; five-year means for the period 1931-60. Indices for the market categories "large" and "scrod" and the total of the two are shown separately.

Landings of haddock from Georges Bank in the years immediately ahead probably will decline. Survey cruises for young-of-the-year haddock suggest that the 1959 brood may have been weaker than that of 1958 because there were fewer areas of heavy concentration of young haddock in 1959 (fig. 6). Further evidence of this difference is the fact that landings of the 1959 year class in the first quarter of 1961 were only about one-third the landings of the 1958 year class in the corresponding quarter of 1960. The 1960 survey cruise found no areas of heavy concentration of young haddock suggesting that the 1960 year class was relatively weak.

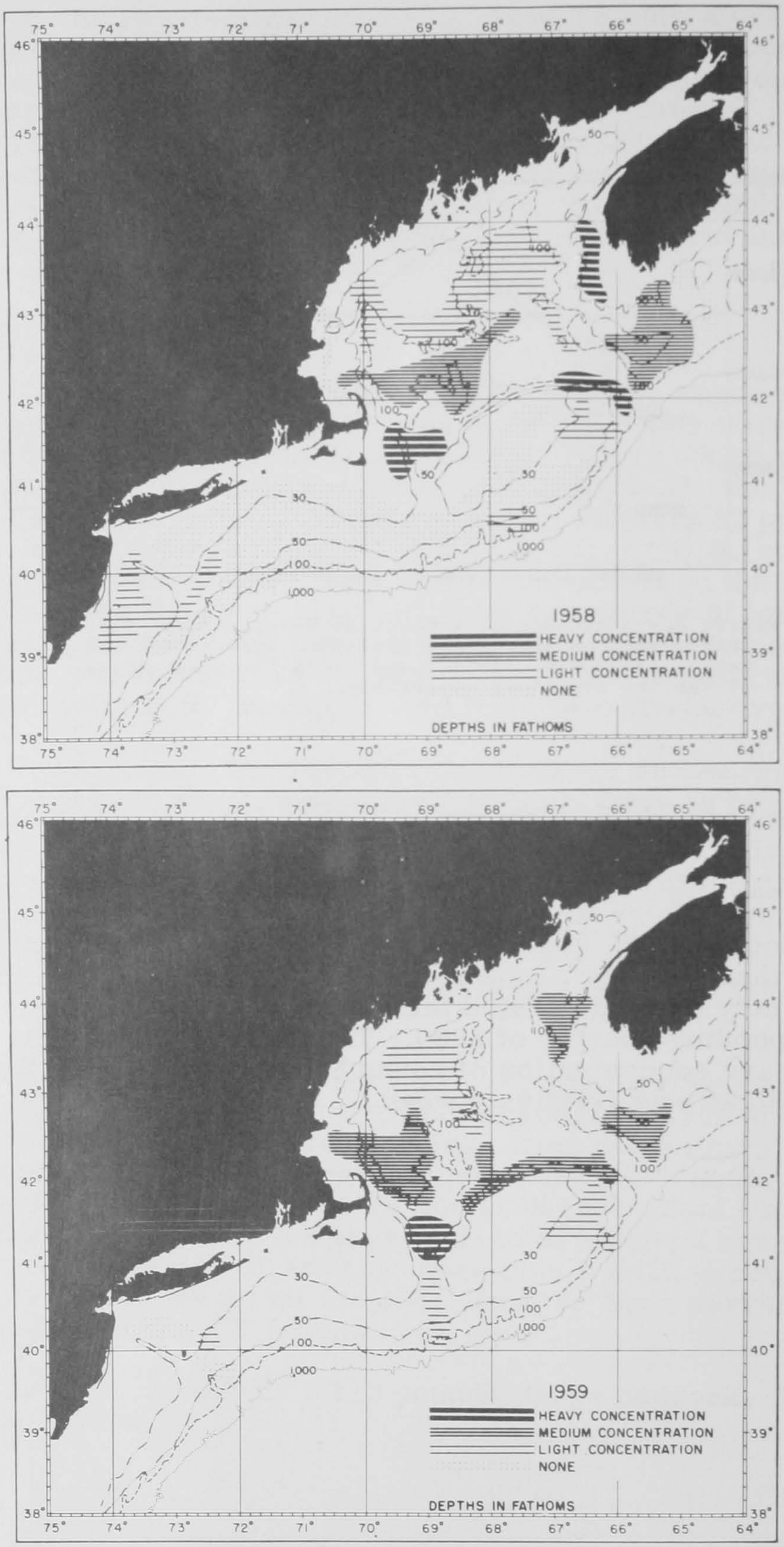


Figure 6a.--Distribution of young-of-the year haddock in fall groundfish surveys in 1958 and 1959.

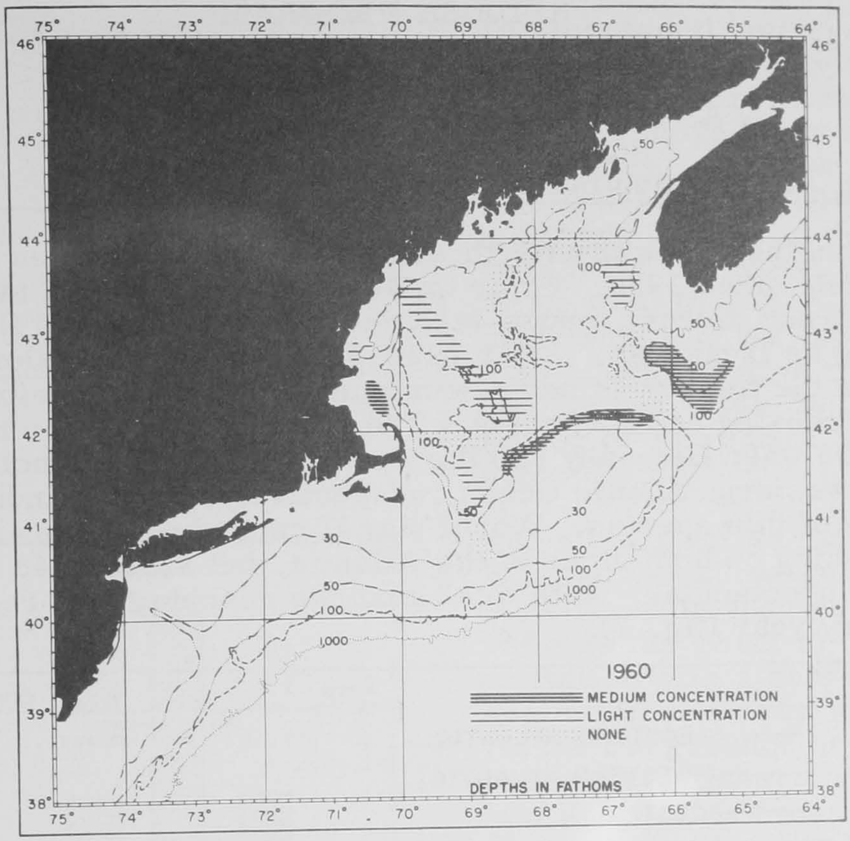


Figure 6b.--Distribution of young-of-the-year haddock in 1960 fall groundfish survey.

REDFISH PROGRAM

G. F. Kelly, Chief,
A. M. Barker, and P. H. Chase, Jr.

The North Atlantic Redfish Fishery

Redfish landings from the North Atlantic Ocean have risen almost continuously since 1920. Prior to World War I, several million pounds of redfish were landed each year by Germany and Norway for marketing as fresh fish. After 1920, this market rose slowly until 1935 when the fishery gained new momentum from technological progress in freezing and packaging. The modern fishery for redfish began in 1935 when Germany and the United States, in the northeastern and northwestern Atlantic Ocean, respectively, began landing large quantities of this species. World War II caused a temporary reduction in fishing on both sides of the Atlantic, but since 1946 the fishery has risen spectacularly with total landings reaching new records almost every year (fig. 7).

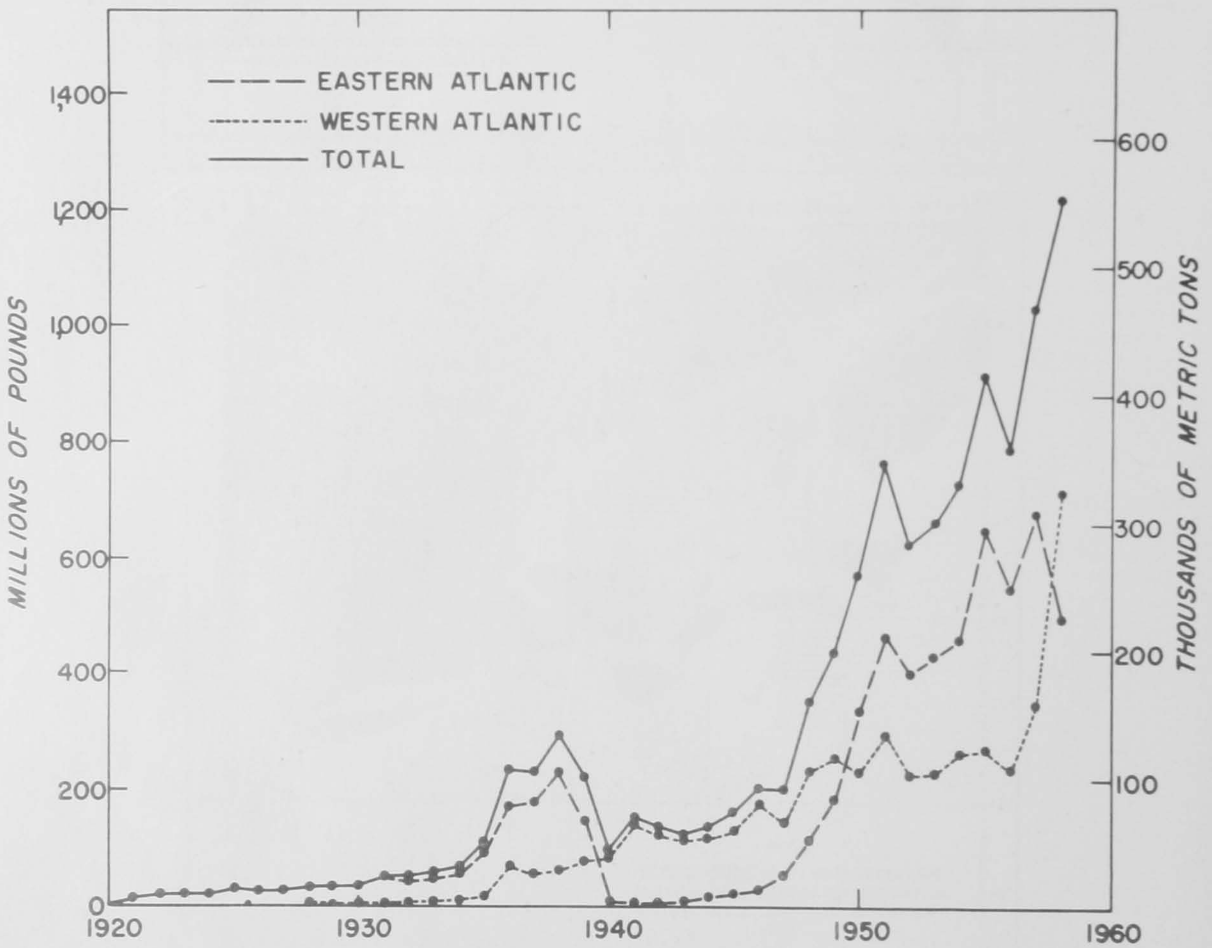


Figure 7.--Redfish landings from the North Atlantic Ocean, 1920-60. (Division between Eastern and Western Atlantic at the southern tip of Greenland, Longitude 44° West).

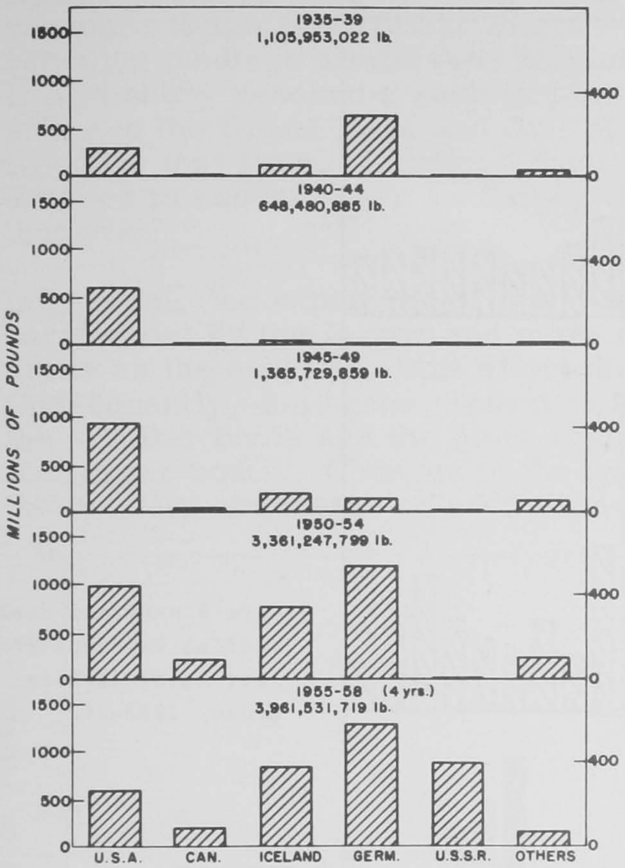


Figure 8.--North Atlantic redfish landings by country, for 5-year periods, 1935-58.

The increased landings were the result of annually increasing fishing effort as more countries and more boats entered the fishery. The post-World War II surge was led by Germany and Iceland in the east and the United States and Canada in the west (fig. 8). Russia became active in the fishery in 1955 with a large fleet of trawlers and factory ships, and in 1958 landed more redfish than any other country.

The history of the fisheries on local stocks shows that this slow-growing species quickly reflects the effect of heavy exploitation with a corresponding decline in catch per unit effort. As the old grounds became less productive, fishermen moved to new areas where unexploited stocks existed. The steady expansion of the fishery in recent years is the result of heavy fishing effort on virgin stocks of redfish found on the distant banks of Labrador, Greenland, and the northern Grand Bank.

It is not realistic to believe that the future fishery can continue to expand at its past rate. The presently known redfish stocks cannot withstand the present fishing rate for more than a few years without showing a marked reduction in abundance. Nor is it probable that many unexploited stocks of redfish still exist in the North Atlantic. It is to be expected that the total North Atlantic landings of redfish soon will begin to decline.

The history of the United States redfish fishery from 1935 to the present time illustrates the rise and decline of redfish harvest from a series of fishing grounds. The relationship between fishing effort, landings, and catch per unit effort recorded in these instances serves as the pattern for the future of fisheries recently established on previously unexploited redfish stocks. Annual landings of U.S. vessels from the four major redfish areas are summarized in figure 9. In each area U.S. landings rose for a few years to a peak and then de-

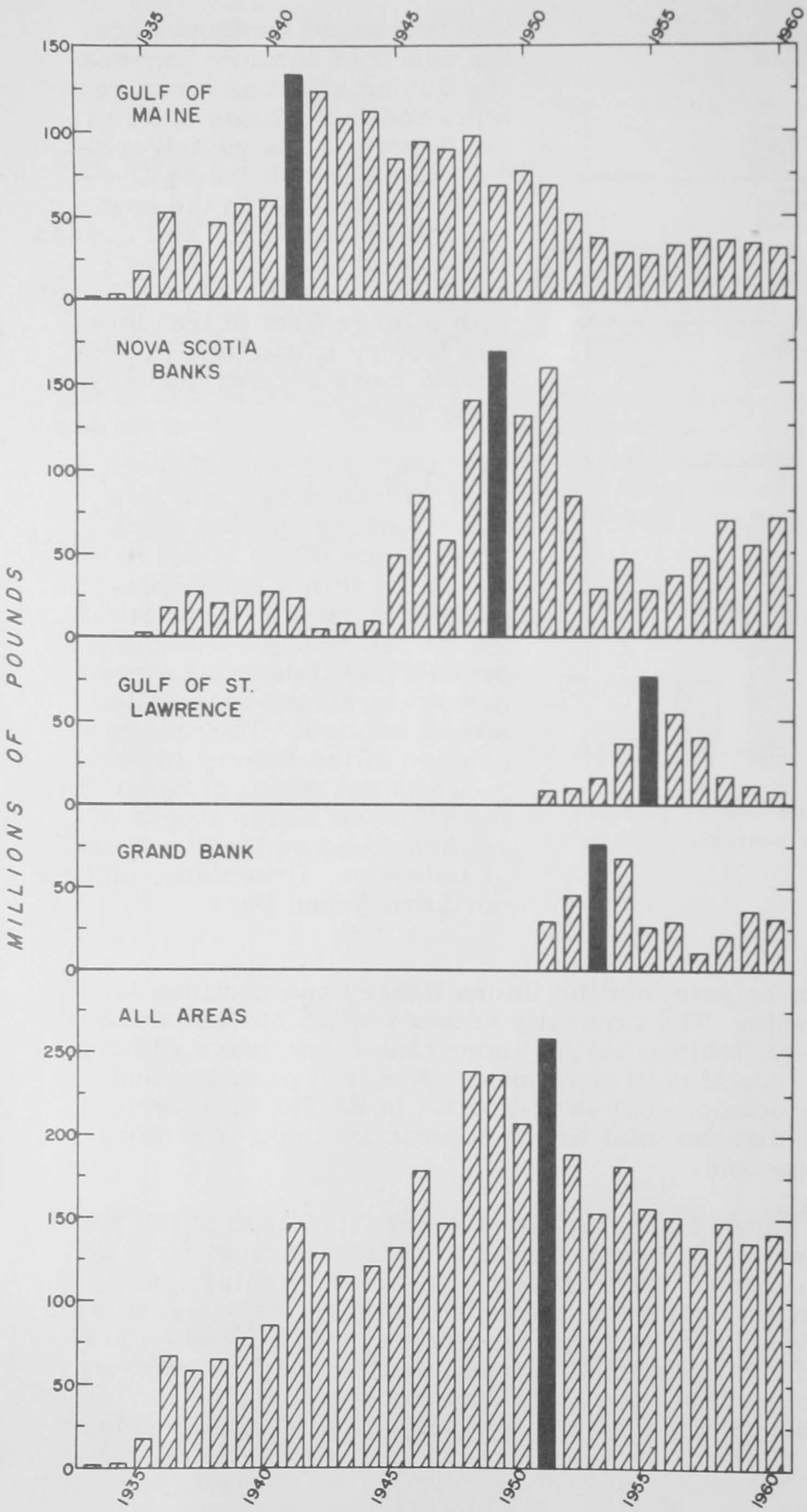


Figure 9.--United States redfish landings from four major fishing areas, 1933-60.

clined. Fishing began in the Gulf of Maine in 1935, then moved in sequence to the Nova Scotia banks, Grand Bank, and Gulf of St. Lawrence as landings diminished from the earlier fished areas. The U.S. fishery reached a peak in 1951 and, despite the shift of fishing effort to the Grand Bank and Gulf of St. Lawrence, has declined steadily since that time. Landings from the Nova Scotia banks have increased in recent years as fishing effort has once again increased in that area.

In general, the expansion of the U.S. fishery to new grounds was carried out by the larger and more efficient boats that explored new areas as the catch per unit effort diminished in the older areas. Consequently, the areas closest to New England have been fished by the smaller boats and the more distant grounds have been fished by the larger boats. Changes in the annual average catch per day reflect the relative abundance of redfish in the four fishing areas (fig. 10).

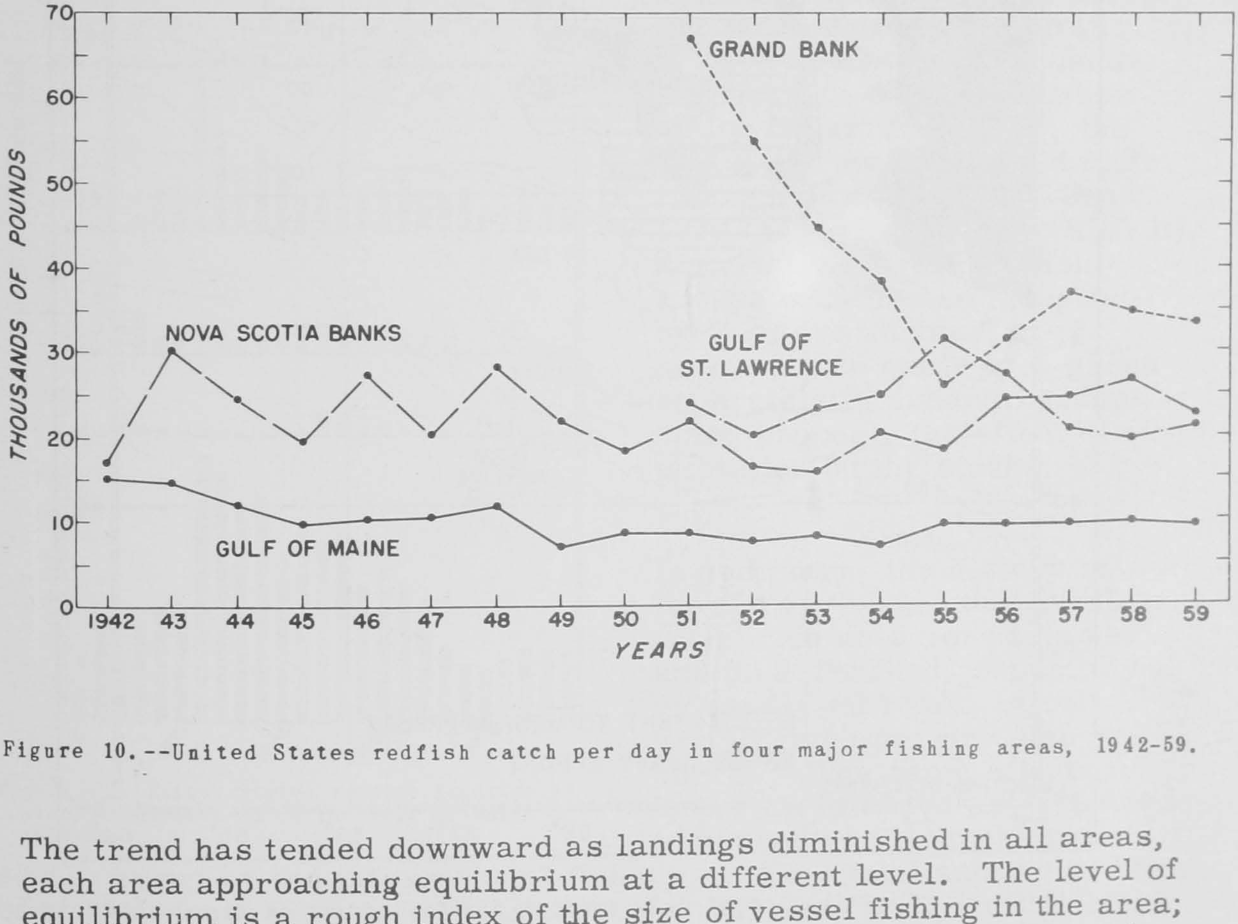


Figure 10.--United States redfish catch per day in four major fishing areas, 1942-59.

The trend has tended downward as landings diminished in all areas, each area approaching equilibrium at a different level. The level of equilibrium is a rough index of the size of vessel fishing in the area; in order to fish profitably, the larger boats require a higher catch per day than the smaller boats. If fishing effort were increased markedly in those areas presently at equilibrium, a short-term increase in landings would probably prevail, followed by a further decrease in landings and catch per unit effort.

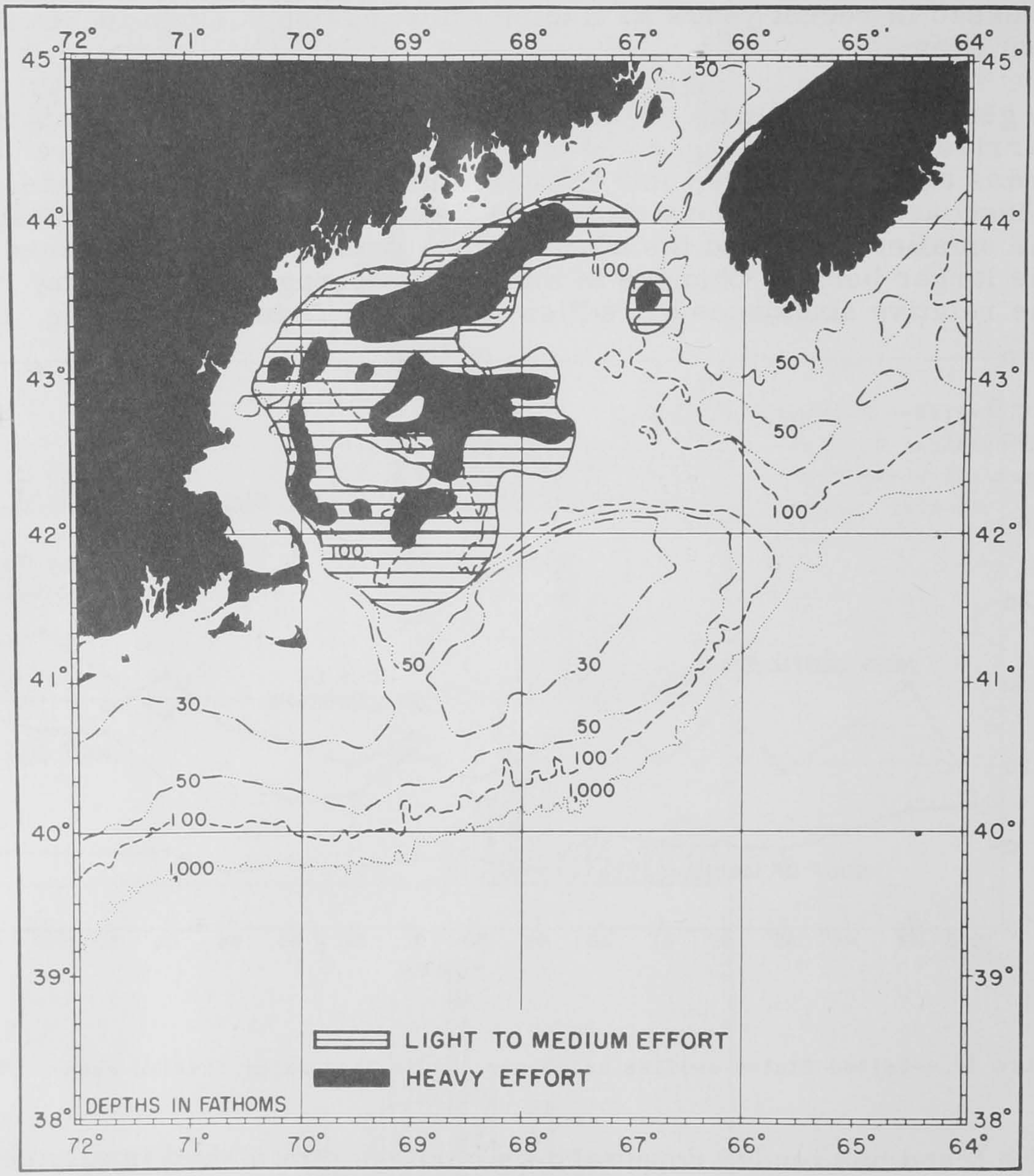


Figure 11.--Distribution of U.S. redfish fishing effort in the Gulf of Maine, 1942-48.

The United States redfish fishery began in the Gulf of Maine, an area that has been one of the most intensively exploited redfish areas in the North Atlantic. In those waters, redfish are found chiefly around the rocky edges of the deep holes in depths between 50 and 110 fathoms. As a result, the bulk of the landings have come from a few localized centers of concentration. These centers are indicated by the distribution of redfish fishing effort in the Gulf of Maine during the period 1942 through 1948 (fig. 11).

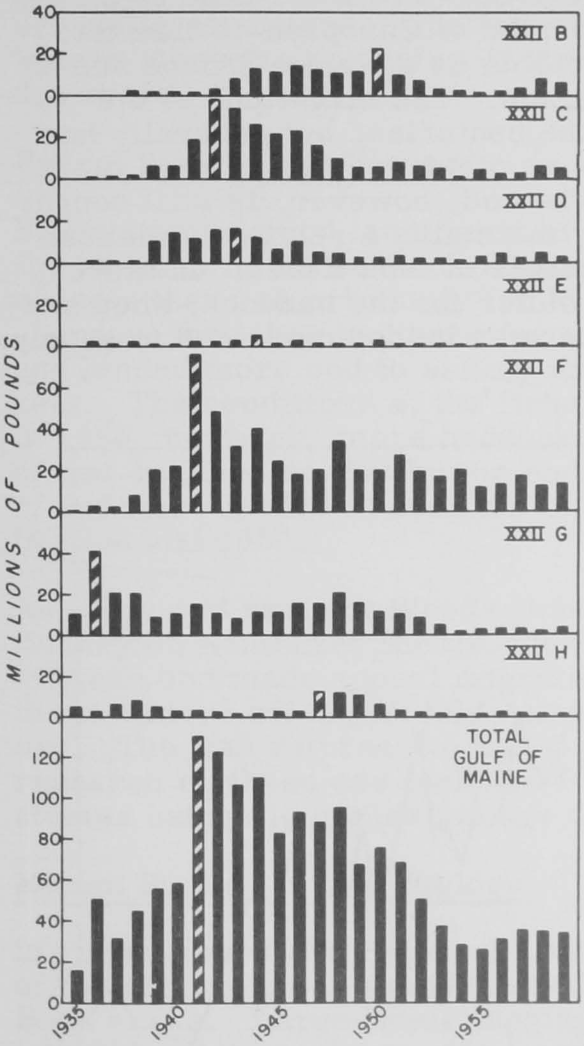


Figure 12.--United States redfish landings by statistical subarea in the Gulf of Maine, 1935-59.

Within the Gulf of Maine the fishery developed with the successive exploitation of the several centers of redfish concentration. The sequence of exploitation is shown graphically in the estimated landings from each statistical subarea since 1935 to the present time (fig. 12). Although the peak landings for the entire Gulf of Maine occurred in 1941, the various grounds reached their respective maxima between 1936 (XXII G) and 1950 (XXII B). Since the separate redfish groups were fished independently of one another, it is necessary to study each group separately in order to understand properly the effect of exploitation on the stocks.

In summary, the history of the fishery shows that landings from each area rose to a peak and then declined, especially on the Grand Bank. A reduction in catch per day also occurred. The same effects of heavy exploitation are expected to appear on all stocks presently fished by the international fishery, and the total annual landings of redfish from the North Atlantic Ocean may very well decline in the coming year.

COD PROGRAM

A. C. Jensen, Chief,
and H. E. Murray

The history of the New England cod fishery is intimately associated with the history of the region itself and, in fact, the cod fish was the foundation upon which many great mercantile organizations were founded and great personal wealth derived. From the time of the aboriginal inhabitants, through the period of European settlement, cod fishing was an important activity both as a source of food and as a means to secure goods for world trade. The magnitude of the fishery has fluctuated greatly over the centuries, but generally has declined during the past few decades as other species became more important to the fishing industry. The cod, however, is still sought by New England fishermen and today maintains a relatively modest but secure position in the annual landings of food fishes. In more recent times the cod has acted as a buffer for the haddock; when haddock were scarce on the banks, fishermen landed more cod to supply the market demand for fish.

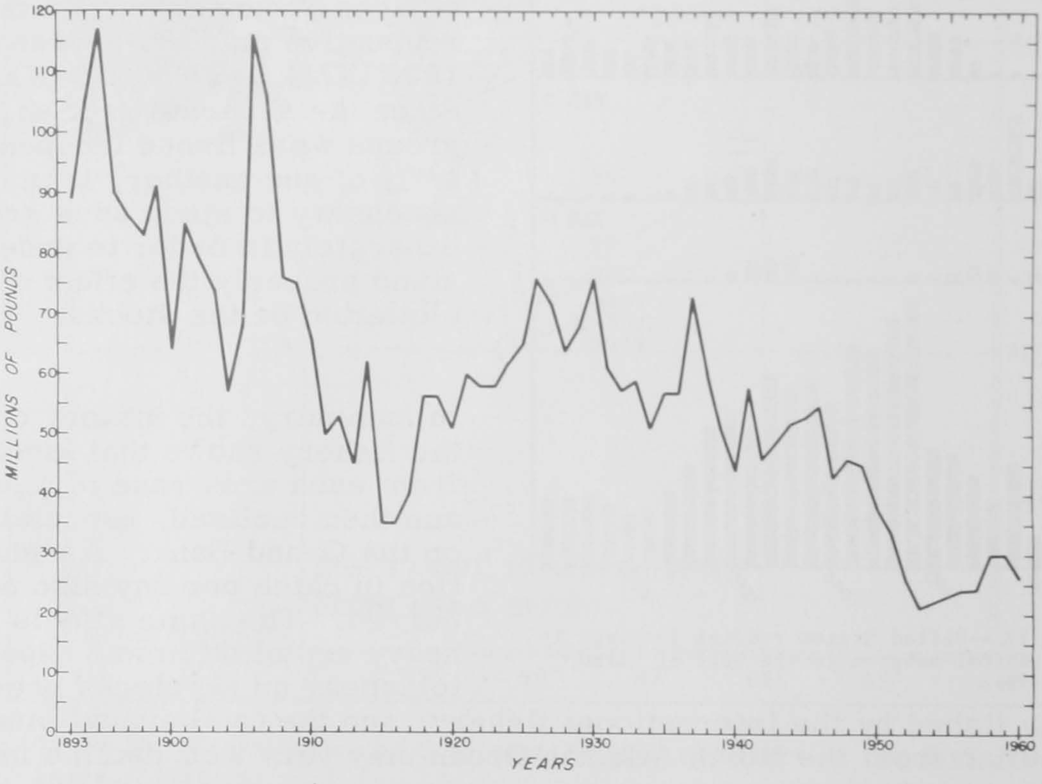


Figure 13.--Annual landings of cod in the United States from New England waters during the period 1893-1960.

Accurate statistics are not available for cod landings prior to about 1893, but from that date to the present we have very reliable data (fig. 13).

The changes in cod landings during this period generally follow the fluctuations in the entire New England fishing industry. The rapid increase in landings in 1905-06 probably is a result of the introduction of the otter trawl, replacing the less efficient longline and handline gears. From 1914 to 1927 fishing effort for all species was low, and this is reflected in the lower cod landings. During the 1930's fishing activity experienced a rapid series of ups and downs, caused by several interrelated factors including a scarcity of fish on the grounds, and a tieup of vessels because of the generally depressed economic conditions. The trend in cod landings from New England waters since the beginning of the 20th century, however, has been downward.

Recent State of the Fishery

Fluctuations in cod landings during the past 3 years are a result of fluctuations in the haddock fishery (most of the cod are caught by vessels that fish primarily for haddock). In 1958 haddock were less abundant than they had been for several years and the fleet caught and landed more cod to satisfy the demands of the New England markets. The conditions of the fishery were virtually the same in 1959. In 1960, however, more haddock became available and the landings of cod declined so that by the end of the year about 26 million pounds of cod were landed in contrast to the peak of 30 million pounds landed in 1958 and 1959.

An early cod study at Woods Hole involved the important summer cod fishery on Nantucket Shoals. It was found, for example, that some of these cod made annual migrations to the south and west, to winter in the waters off the Middle Atlantic states of New York and New Jersey. The fish returned to the shoals for the summer. Additional research on these cod included food habits studies, and age and growth studies using the scales for age determination.

Recent Studies in Cod Biology

In recent years cod research has been concerned with identification of the cod groups in the Gulf of Maine, Georges Bank, and Browns Bank areas. Large-scale tagging experiments and a study of the distribution of the cod parasite *Lernaeocera branchialis* have increased our knowledge of the New England stocks.

Some attention has been paid as well to the cod in the waters south of Cape Cod, and an identification made of a separate group that ranges from Nantucket Shoals to North Carolina. It is this group that supports the important winter cod fishery off the Middle Atlantic states and also takes part in the seasonal migration to Nantucket Shoals. To learn something of the possible fate of the eggs and larvae of the

Middle Atlantic cod, a drift bottle campaign was carried out in which nearly 1, 300 drift bottles were dropped from U. S. Naval airships over the waters of the Continental Shelf from Sandy Hook, New Jersey, to Chincoteague Bay, Virginia.

Drift bottles have been returned at a rather slow rate. To date, after 28 months, 47 (3%) have been reported to this Laboratory. Although bottles were dropped as far as 125 miles from shore, nearly all the returns were from stations 10 miles or less from shore, suggesting that the surface waters over the Continental Shelf were probably swept out to sea.

There have been four long-distance returns, one each from the Azores, Bermuda, Ireland, and the Outer Hebrides off Scotland. Each was from a different drop station, and no other returns have been reported from these stations. These long-distance returns further bear out the hypothesis of offshore drift of the surface water. A large part of the cod eggs and larvae from the Middle Atlantic spawning probably is swept out over the great depths to be lost to the fishery, or to populate other grounds.

Future Studies in Cod Biology

Cod research in progress now, or planned for the near future, includes studies of the age and growth of the New England and Middle Atlantic stocks, further refinement of the definition of the stocks through additional tagging, serological studies, morphometric and meristic studies, and a long-range study of the recruitment of young cod to the fishery. Preliminary investigations to find the best method to determine the age of our cod are now underway. European and Canadian biologists determine the ages of their cod by counting the growth zones in the otoliths (ear stones), but in times past they have also counted growth zones on the scales, in certain bones, and in fin rays.

There are several advantages to be gained from using scales for age determination: ease of collection, preparation, and reading, and the obvious advantage of being able to remove scales from live fish in tank experiments or tagging studies without harming the fish. To collect otoliths, however, the fish must be killed and some slight dissection performed. It is desirable in certain instances to use otoliths for age determination, particularly with larger (thus older) individuals since, in these cases, otoliths seem to be more accurate indicators of age. For the present our studies will be concerned principally with a critical examination of scales and otoliths from the same fish to determine the best material for age determination of cod.

HAKE PROGRAM

R. L. Edwards, Acting Chief,[4/]
and L. M. Lawday

Hake research began at the Laboratory in 1955. The problems faced at that time were those presented by an intensive silver hake fishery. Questions asked were: How extensive are the silver hake populations? How much exploitation can they stand? Are we exploiting them wisely today? If management is necessary, what measures should be taken?

Six years is not sufficient time in which to collect the necessary biostatistics to answer these questions, especially when some of the necessary biological parameters were totally unknown at the start. However, much progress has been made. Distributional surveys have been conducted, divisions of stock investigated, growth rates and mortality rates have been studied, food habits have been looked into, and mesh selection experiments made.

There are two species of whiting along our coast, Merluccius bilinearis (silver hake), which supports the present hake fishery, and M. albidus, a deepwater species which is not now exploited. Also present and constituting a sizeable biomass is the red hake (Urophycis chuss), the principal species in the New England industrial fishery, as well as a minor human food species.

The silver hake fishery had its beginning during the early 1840's, when small quantities were prepared for the fresh fish market. During the early years the fishery was largely a pound and trap net operation, but in the 1930's, the more efficient and versatile otter trawler became the principal fishing gear. The silver hake has always been primarily utilized for human food, but in recent years it has been used also for mink food and for industrial purposes. About 20 million pounds were landed in 1937, and since then landings have risen steadily to a peak of nearly 180 million pounds in 1957 (fig. 14).

One important aspect of the hake research program has been the measurement of changes in relative abundance of the various species in commercial catches, especially that of silver hake. These data have been collected since 1956, and they will be used for preparing general abundance indices, for estimating mortality rates, and for determining the effect of fishing on the stocks. So far no definite effect of fishing is apparent.

Abundance is not the same in each area and has fluctuated annually within areas; but so far no trends are apparent (fig. 15a).

4/ R. L. Fritz to March 1961

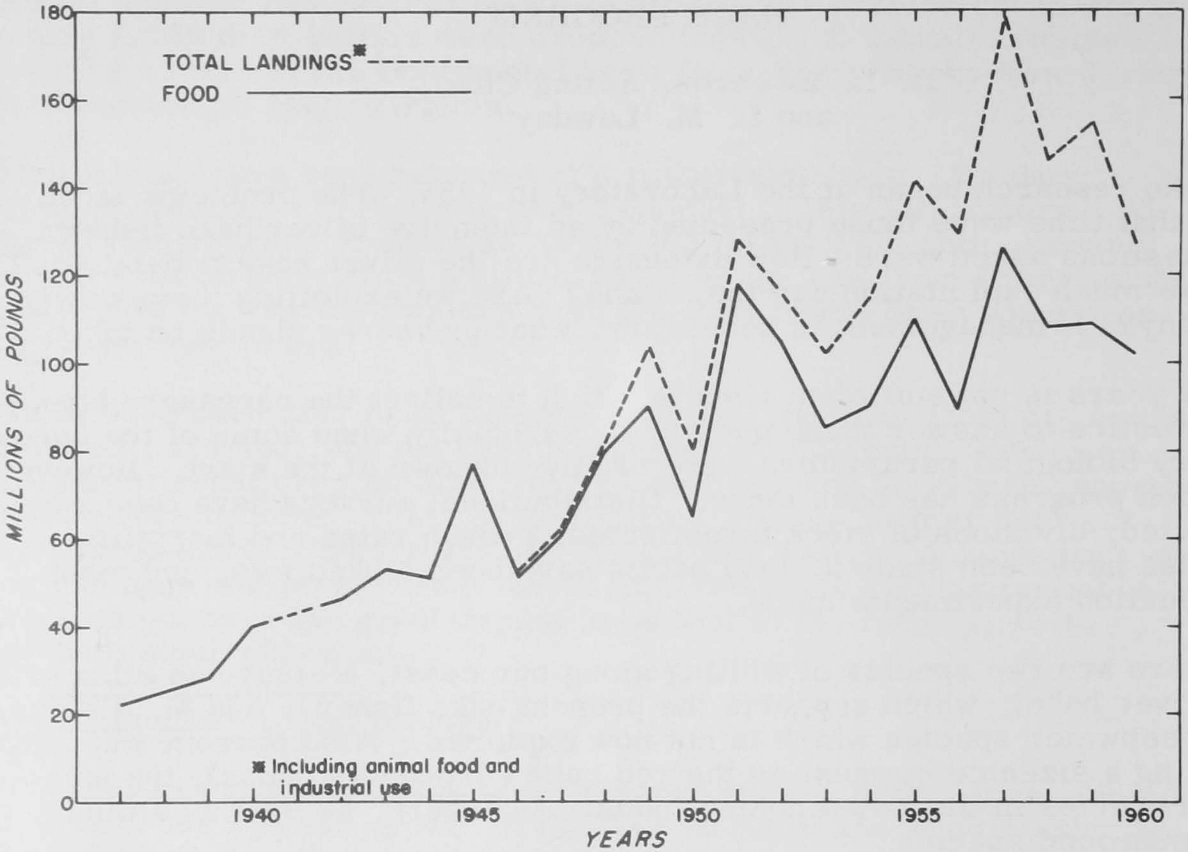


Figure 14.--Landings of silver hake in the United States, 1937-60.

The silver hake fleet contains vessels of several sizes, but the largest number of vessels are those included in the OTM (otter trawler, medium) category between 51 and 150 gross tons. The number of vessels that fish for silver hake fluctuates considerably from month to month, because many boats seek other species from time to time.

The statistical areas utilized in this study are those most heavily fished by the silver hake fleet during the season. These areas are located along the inshore waters from Maine to Cape Cod, and offshore on Georges Bank.

Seasonal changes in silver hake abundance in each area have been examined. This species undergoes a seasonal migration, appearing inshore in the early spring and remaining all summer in depths less than 50 fathoms. During this period silver hake are common along the coast of New England and on Georges Bank. Our surveys indicate that in many places they are the most abundant groundfish in spring and summer. During the late fall the species disappears from inshore waters.

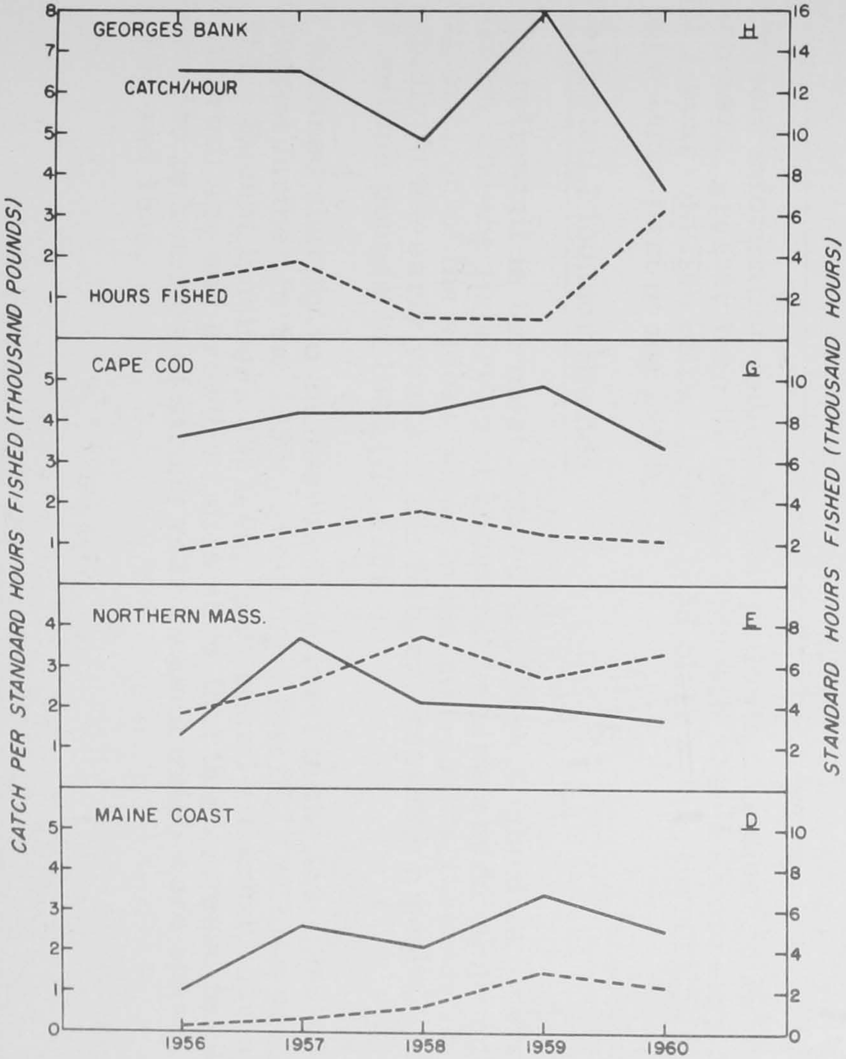


Figure 15a.--Annual variations in abundance of silver hake in several fishing areas. All classes of vessels included.

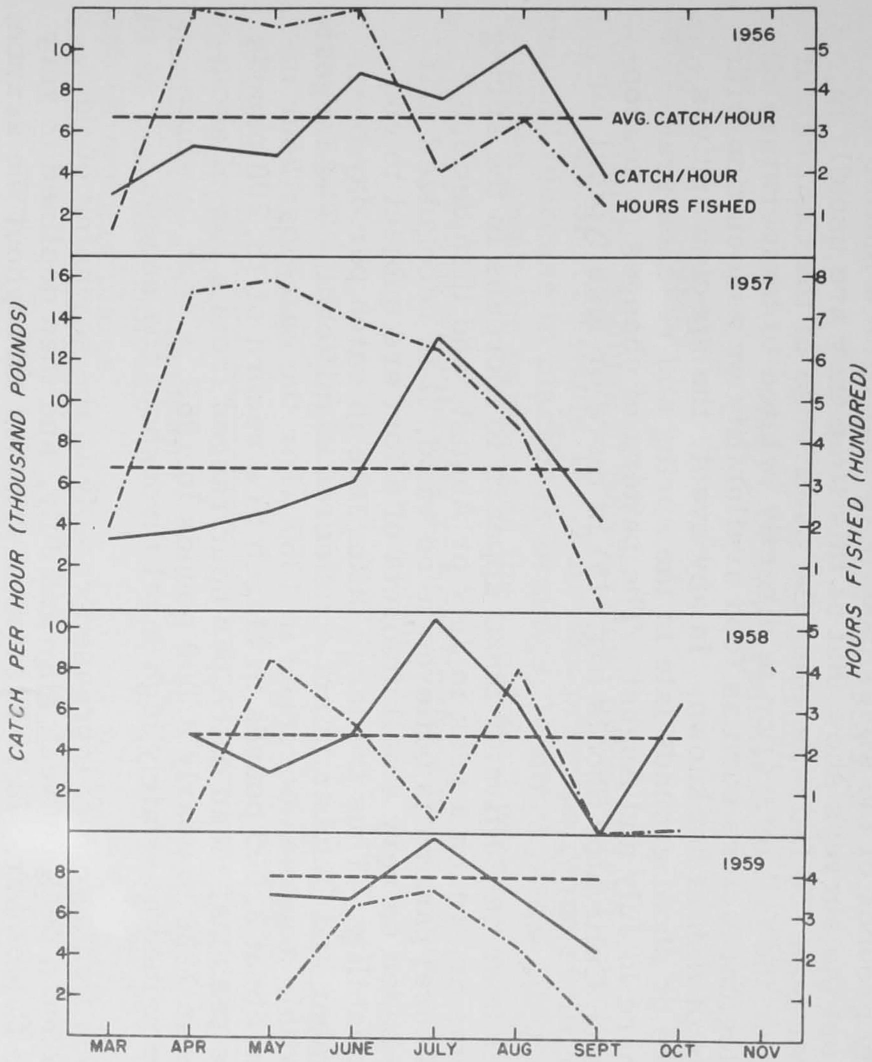


Figure 15b.--Seasonal variations in the catch per hour of medium otter trawlers on Cultivator Shoal (Statistical Area II H).

The wintering grounds of the silver hake have long been a matter of conjecture, but the surveys show that at this time they are usually in depths greater than 100 fathoms along the outer edge of the Continental Shelf. Whether the fall migration is directly related to temperature or to other ecological factors such as food availability or association with other species of fish is not known. In any event, the species arrives on the inshore or shoal grounds late in the spring and reaches peak abundance there in July and August. The pattern of changes in seasonal abundance on Cultivator Shoals (fig. 15) is more or less typical for all grounds.

The catch per hour on Cultivator Shoal appears to increase in the spring and early summer, reach a peak in July or August, and then decline. While this general pattern is believed to be valid, it is recognized that such indices based on very small amounts of effort are subject to considerable variability. Thus the large difference in catch per day between September and October is not considered significant. The largest fluctuation within a season occurred in 1957 when the catch per hour increased from about 3,000 pounds in March to a record of 13,200 pounds in July. The seasonal mean catch per hour ranged from a low of about 5,000 pounds in 1958 to nearly 8,000 pounds in 1959, a year in which abundance remained at a fairly high level throughout the season.

Except in 1958 fishing effort increased rapidly in the beginning of the season, reached a peak between May and July, and then declined to very low levels by September. In 1958 effort fluctuated throughout the season.

FLOUNDER PROGRAM

F. E. Lux, Chief,
and F. E. Nichyparowich

State of the Fishery

Total flounder landings at New England ports in 1960 increased slightly over those of 1959 (table 1). This was principally the result of a substantial increase in blackback landings; landings of the other flounders remained about the same as in the previous 2 years.

Table 1.--Flounder landings at New England ports (in millions of pounds)

Species	1958	1959	1960
Yellowtail flounder	32.8	29.0	29.9
Blackback (winter flounder)	14.1	14.3	17.1
Fluke (summer flounder	5.5	5.5	6.7
Dab (American plaice)	3.0	3.1	3.0
Graysole (witch flounder)	3.1	2.9	3.1
Total	58.1	54.4	59.8

Present information indicates that yellowtail landings in 1961 will be somewhat greater than in 1960. This will result from heavy landings of 3-year-old fish of the strong 1958 class which currently is furnishing a large part of the catch.

Yellowtail Flounder Studies

The yellowtail is the most important of New England commercial flatfishes, and the fishery is of comparatively recent development. Active exploitation of the stocks began in the mid-1930's. The catch rose rapidly in the early years of the fishery, reaching a peak of nearly 70 million pounds in 1942 (fig. 16).

It declined sharply to an intermediate level in the late 1940's and then dropped further in the 1950's reaching a low of 12 million pounds in 1954. Recent landings, 1957-60, have shown a marked increase. Yellowtail age and growth studies show that this increase in catch has been due to a series of strong year classes which were spawned in 1955, 1956, and 1958.

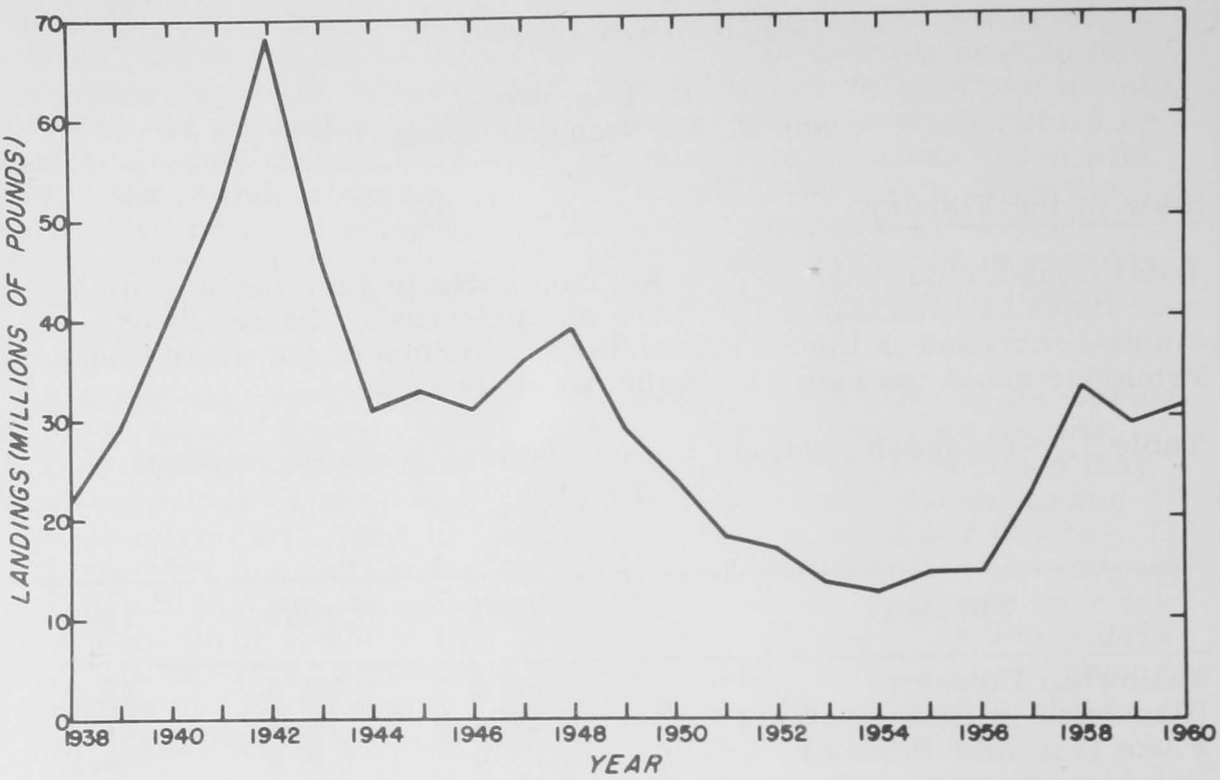


Figure 16.--Landings of yellowtail flounder in New England in the period 1938-1960.

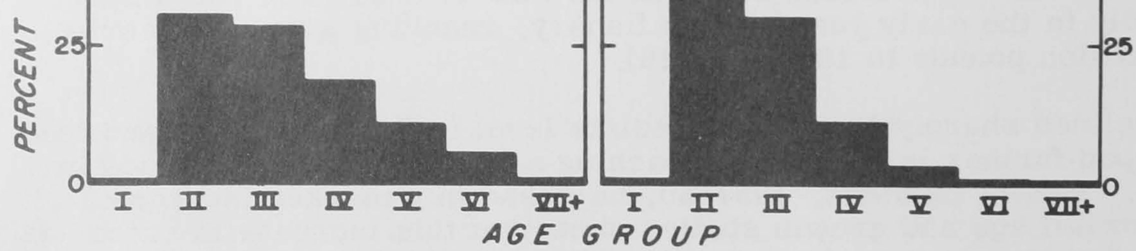


Figure 17.--Average age composition of yellowtail flounder population for two periods in the life of the fishery.

A comparison of the age composition of commercial yellowtail landings in the 1940's with that of the late 1950's (fig. 17) shows that a significant change has taken place in age group representation in the catch. In the earlier period age groups 4, 5, and 6 formed a substantial part of landings, while in the period 1957-60 age groups 2 and 3 made up over 80 percent of landings. With fewer age groups making up most of the catch the fishery is presently in a less stable condition than during the 1940's. A single poor year class might decrease landings substantially, while two in a row could have serious effects.

Fluke Studies

Much of the New England catch of fluke is taken during winter and early spring months when the fish are concentrated on offshore grounds from Hudson Canyon to Veatch Canyon. In april 1961, 1,800 fluke were tagged on these fishing grounds to determine migration patterns, and to obtain information on subdivisions of the population. Through June 1961, 60 recaptures of tagged fluke had been reported. About half of these were from the tagging area, the others were taken on inshore grounds from Long Island to Martha's Vineyard.

SEA SCALLOP PROGRAM

J. A. Posgay, Chief,
A. S. Merrill, L. R. Porter, Jr., H. W. Jensen,
and F. E. Nichyparowich[5]

The Fishery

Sea scallop landings in the United States in 1960 hit an all-time high. Almost 22 million pounds of meats were landed from Georges Bank as a result of 8,039 fishing days on the grounds (table 1). An additional 2.8 million pounds were landed from other grounds extending from Chesapeake Bay to the Gulf of Maine.

Table 1.--United States landings of sea scallop meats, millions of pounds

Year	Georges Bank	Other grounds	Total
1951	12.4	6.2	18.6
1952	12.1	5.1	17.2
1953	16.3	3.4	19.7
1954	15.5	1.9	17.4
1955	18.3	3.8	22.1
1956	17.5	2.5	20.0
1957	17.3	3.4	20.7
1958	14.4	4.3	18.7
1959	18.7	3.4	22.2
1960	21.9	2.8	24.7

Abundance

Sea scallops have been unusually abundant on the Georges Bank grounds for the past 2 years as the result of recruitment of a dominant year class in 1959. Lack of data on past year classes prevents any good quantitative comparison of the relative abundance of this year class with those of previous years. However, a crude approximation can be arrived at by noting that the average landing per day spent on the grounds was 1,580 pounds for the period 1949-58 and 2,450 pounds for the period 1959-60.

Quantitative samples have been collected by research vessels in the past few years (fig. 18). From these, it is possible to compare the relative abundance on different grounds in different years.

5/ Until January 1, 1961

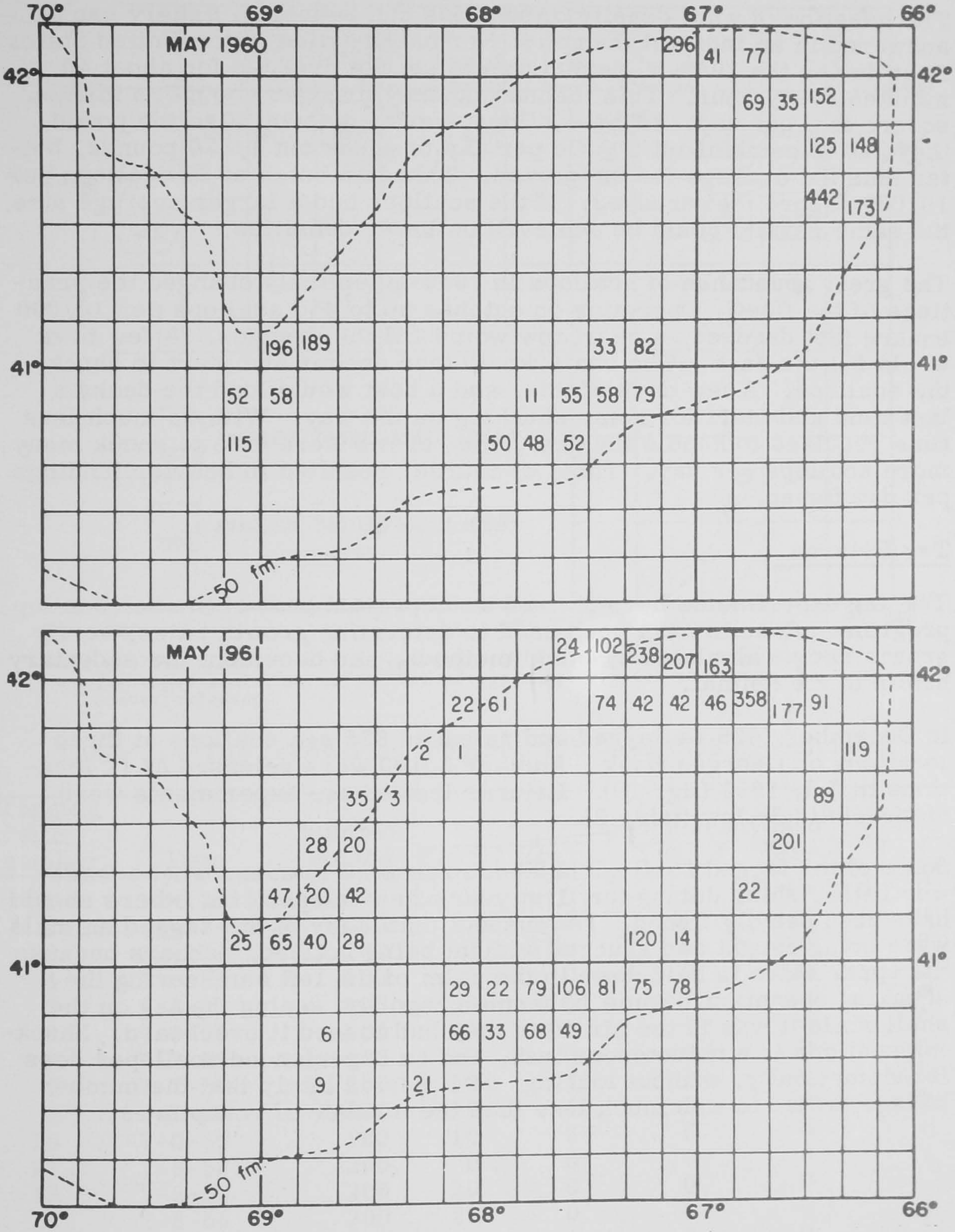


Figure 18.--Relative abundance of sea scallops on Georges Bank in 1960 and 1961. The figures give the number of scallops larger than 70 mm. taken per 10,000 square feet dredged.

The question of what density of scallops can support a fishery can be answered in an indirect manner. Normal practice of the United States fleet during the 1949-58 period was to set the dredges for about 40 minutes every hour. This means that they dredged about 7.5 million square feet per day. If the scallops averaged about 30 to the pound, they had to catch about 50,000 per day to shuck out 1,670 pounds, better than the average for the period. This is a catch of 67 scallops per 10,000 square feet dredged. If the scallops had a larger average size, the same results could be achieved on lower densities.

The great abundance of scallops in 1959-60 entirely changed the practices of the fleet. Operating on catches up to 450 scallops per 10,000 square feet dredged, a short tow would fill the dredges. A few tows would fill the deck. The boats would then anchor and start to shuck the scallops. A few days of this, and a boat would load the decks a last time and start for home shucking on the way. With so much less time required to handle the gear, the crews were able to shuck many more scallops per day. This, of course, resulted in heavier landings per day fished.

Tag Returns

Tagging experiments have formed an important part of the sea scallop program. Results have been used to determine growth rates, verify growth rates calculated by other methods, and document the sedentary habits of the animal.

In December 1955 we tagged and released 825 sea scallops at three locations on Georges Bank. Another 2,100 were released at 11 locations in July 1956 (fig. 19). Returns from these experiments were disappointingly low (table 2).

Some of the tagged scallops had been released in areas where there was little fishing during the first year after release, but others should have been heavily fished. We suspect that many of our tagged animals were being caught and shucked without being noticed, perhaps because the upper valve is held down in the palm of the left hand during the shucking operation. Some fishermen reported seeing the tag on the shell while it was in the air after they had tossed it overboard. Shucking scallops is a monotonous task, and an experienced scalloper does it automatically, without looking, so it seems likely that the number of tags turned in was much less than the number of recaptures.

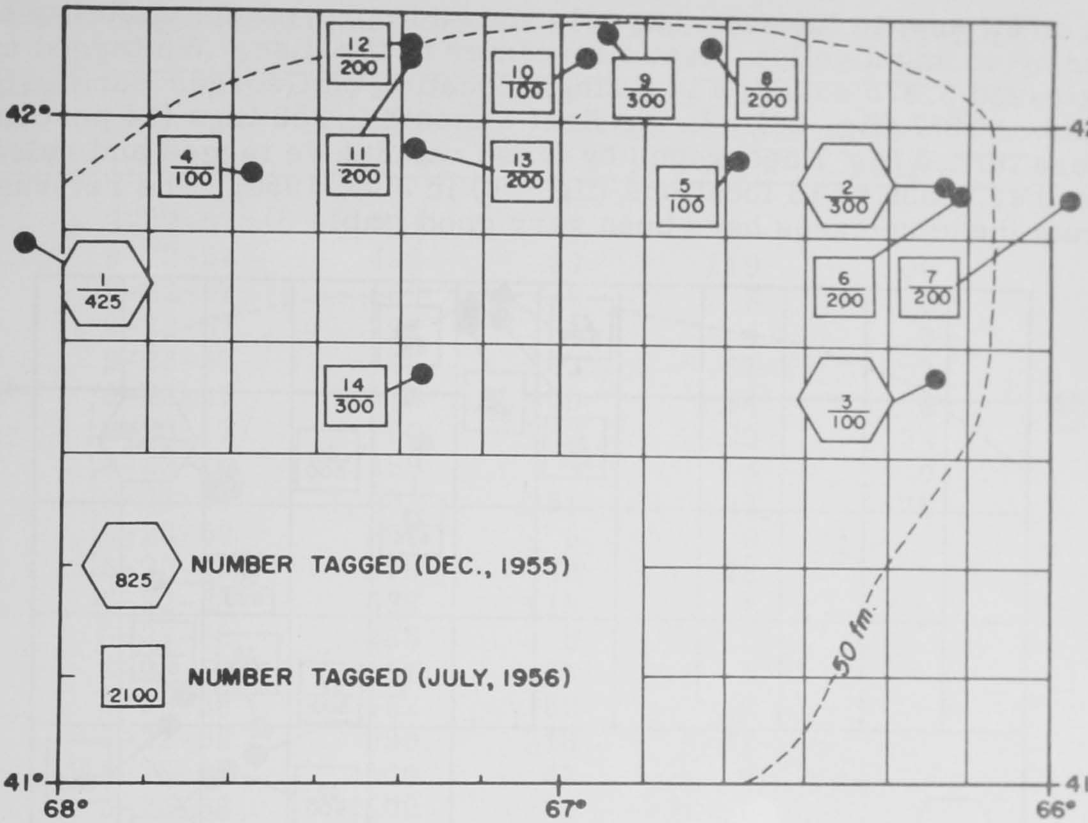


Figure 19.--Locations of tagged sea scallops released in 1955 and 1956. The upper number is the number of the tagging site; the lower, the number released.

Table 2.--Tag recoveries from the 1955 and 1956 experiments

Tagging site number	Date	Number tagged	Number recovered Year 1	Year 2	Year 3	Year 4	Year 5
1	12-12-55	425	0	0	0	0	0
2	12-13-55	300	12	3	0	3	0
3	12-17-55	100	0	0	0	0	0
4	7-6-56	100	0	0	0	0	0
5	7-6-56	100	0	0	0	0	0
6	7-7-56	200	0	0	0	0	0
7	7-7-56	200	0	0	0	0	0
8	7-7-56	200	0	1	0	0	0
9	7-7-56	300	3	4	0	0	2
10	7-8-56	100	10	3	0	0	
11	7-8-56	200	0	0	0	0	
12	7-8-56	200	29	0	0	0	
13	7-8-56	200	20	0	0	0	
14	7-8-56	300	0	0	0	0	
Total		2,925	74	11	0	3	

In an attempt to increase tag returns we improved the visibility of the tag by adding a yellow plastic streamer to the disc. We tagged and released 5,375 scallops in a single location on Georges Bank in September 1957 (fig. 20). In the first 6 months, 758 tags (14 percent) were turned in. Encouraged by these results we tagged and released another 9,539 at 13 locations (fig. 20) in June 1958. The returns from these releases have been very good (table 3).

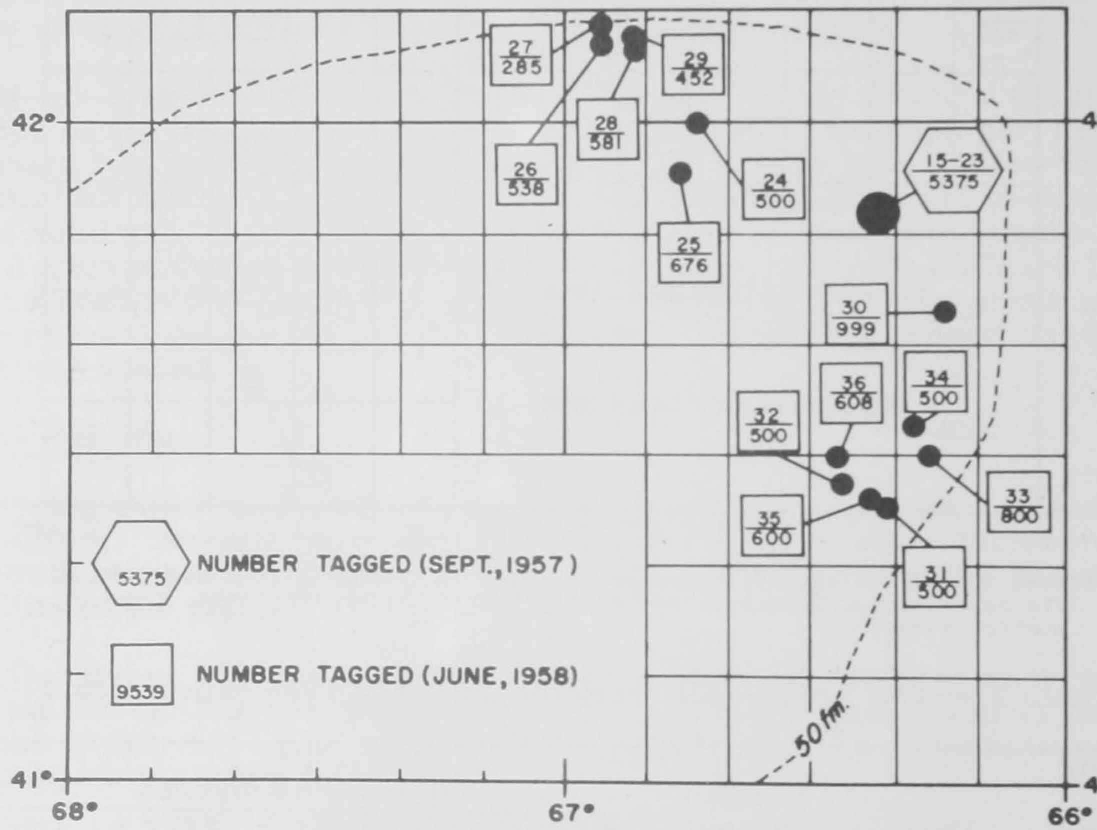


Figure 20.--Location of tagged sea scallops released in 1957 and 1958. The upper number in the number of the tagging site; the lower, the number released.

Movement

The sea scallop is a vigorous swimmer, and there have been persistent reports of scallop beds moving away to the distress of the fishermen. There have also been reports, at least one of which is known to be reliable, of large numbers of small scallops being seen at the surface in areas where depth was as great as 25 fathoms.

Table 3.--Tag recoveries from the 1957 and 1958 experiments

Tagging site number	Date	Number tagged	Number recovered		
			Year 1	Year 2	Year 3
15	9-22-57	294	11	0	0
16	9-22-57	498	59	119	30
17	9-22-57	589	0	3	0
18	9-22-57	297	31	4	0
19	9-23-57	495	103	67	2
20	9-23-57	575	200	84	6
21	9-23-57	790	230	99	22
22	9-23-57	355	5	4	0
23	9-23-57	1,482	351	225	21
24	6-23-58	500	0	0	
25	6-23-58	676	85	46	
26	6-22-58	538	119	61	
27	6-23-58	285	0	0	
28	6-23-58	581	55	4	
29	6-23-58	452	60	2	
30	6-21-58	999	318	61	
31	6-23-58	500	42	0	
32	6-24-58	500	42	0	
33	6-24-58	800	206	1	
34	6-24-58	500	62	1	
35	6-25-58	600	160	0	
36	6-25-58	608	3	8	
Total		12,914	2,142	789	

Recapture locations are known for 2,191 tagged sea scallops. Over a period of 2-1/2 years, 80.4 percent were reported within 2 miles of the release location, and 97.1 percent within 10 miles (table 4). A small tendency for dispersal to increase with time is apparent. This may be the result of the disturbance caused by dredging. It must be stressed that some of the reported locations of capture may be considerably in error. Also, it is possible but unlikely that the tag inhibits movement.

Table 4.--Distance of reported recapture location from release location for 2,191 tagged sea scallops by half-year periods

Half-year periods	Less than 2 miles %	2-10 miles %	Over 10 miles %	Total number
1	84.3	12.0	3.7	1,115
2	84.2	13.9	1.9	374
3	83.9	14.5	1.6	380
4	51.7	45.3	3.0	232
5	75.6	21.1	3.3	90
Total	80.4	16.7	2.9	2,191

From the above results, we conclude that the movements of individual sea scallops probably are random. It seems unlikely that aggregations move about, but they may become dispersed. These conclusions refer only to scallops larger than 75 mm. in length; smaller scallops have fragile shells which usually break during tagging and therefore little is known about their movements. Large-scale movement of smaller scallops still remains a possibility.

Growth

The large number of returns from the 1957 and 1958 tagging experiments provided very satisfactory samples for calculating growth rates; but, since the important grounds were widely separated, we felt that different areas would have different growth patterns. Tagging all over Georges Bank would be a tedious and expensive operation, so we made a vigorous attempt to master the technique of locating annual rings on the shell as had been done by Canadian biologists working with sea scallops from the area off Digby, Nova Scotia.

For this purpose we used a sample of 392 tagged shells which had been returned after being at large for about a year. The Walford regression for this sample, calculated from the increment added between release and recovery, was $L_t + 1 = 47.3 + .662L_t$. Measurements between the annual rings on a sample of 411 shells from the same location gave us $L_t + 1 = 42.4 + .706L_t$. To avoid subjective bias, the different methods were used by different investigators. The two equations gave almost the same results, and it was concluded that age readings were valid.

	L_t	L_{t+1}	L_{t+2}	L_{t+3}	L_{t+4}	L_{t+5}
Tags	85.0	103.6	115.9	124.0	129.4	133.0 mm.
Rings	85.0	102.4	114.7	123.4	129.5	133.8 mm.

The position of the annual ring between the tagging check ring and the margin suggests that it was formed in late spring, sometime during April or June when water temperatures are minimum.

Maturation and Spawning

Gonads of mature scallops taken in the summer are readily visible without dissection (fig. 21). Both male and female gonads are similar in size and shape but those of a ripe female are bright coral-red and those of a male are creamy white. Hermaphroditism is rare but there is some evidence of sex reversal.

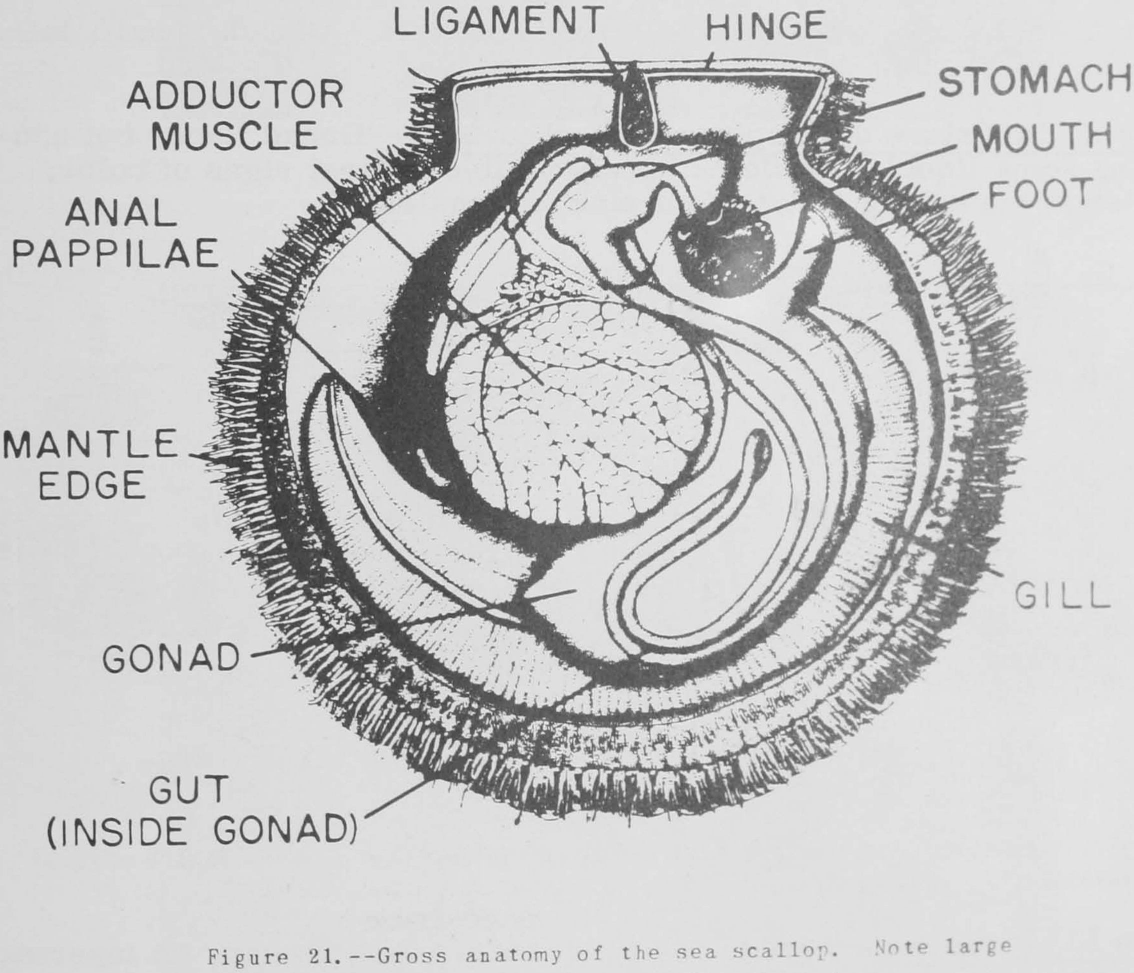


Figure 21.--Gross anatomy of the sea scallop. Note large gonad with loops of the gut passing through.

Scallops in their second year (about 30-55 mm. in length) usually show little or no development of gametes and it is difficult or impossible to separate the sexes. Most individuals develop sperm or eggs during their third year and spawn at age 3 (about 70-80 mm.). Thereafter, they spawn every year. Among juveniles usually there are about

20 percent more males than females but at about age 4 or 5 and older there are approximately equal numbers of males and females.

Spawning takes place during early fall, the exact time differing somewhat from place to place and from year to year. On Georges Bank, spawning usually starts sometime between the last week of September and the second week of October. Individual scallops may spawn out completely in a short interval of time or intermittently over a longer interval. In any particular area, spawning may be finished in a few days or extend over a month or more.

For convenience in describing what is essentially a continuous activity of the gonad from resting through gamete development to spawning, we have divided the process into six stages. Although these stages are based on the macroscopic appearance of the gonad, the degree of development during each stage has been examined histologically.

Stage I, Immature.--Sexes are indistinguishable. Gonads small, thin, translucent.

Stage II, Immature developing; adult recovery.--Gonad flabby but containing some liquid. Follicles barely visible. First signs of color; whitish in males (fig. 22c), light pink in females.

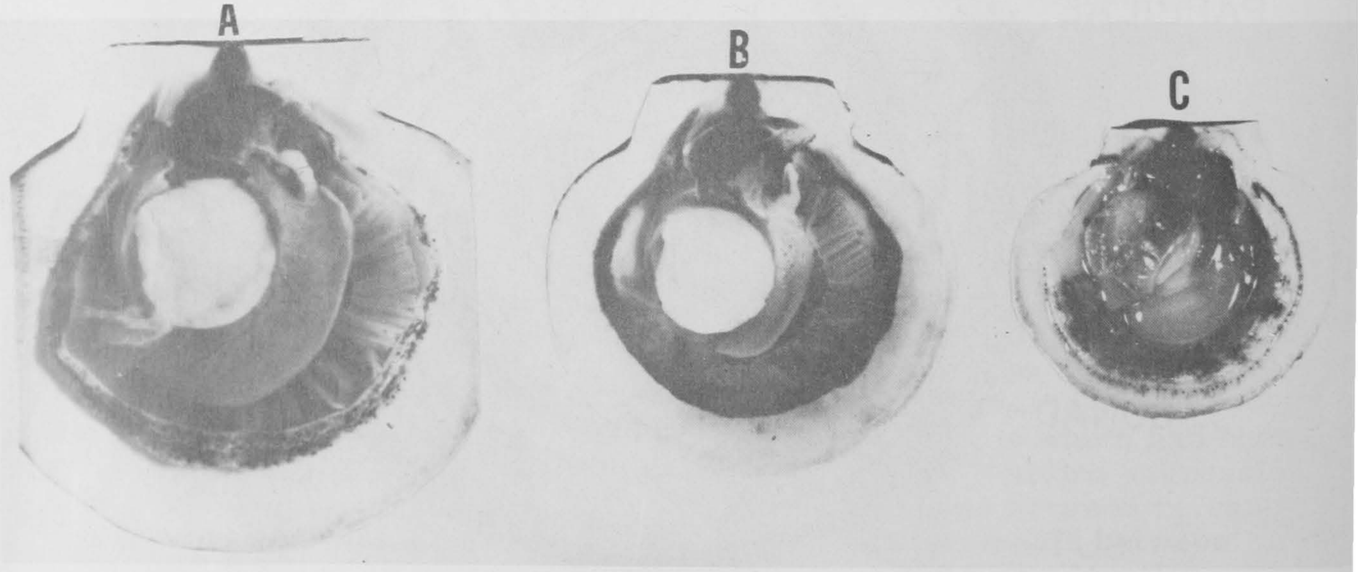
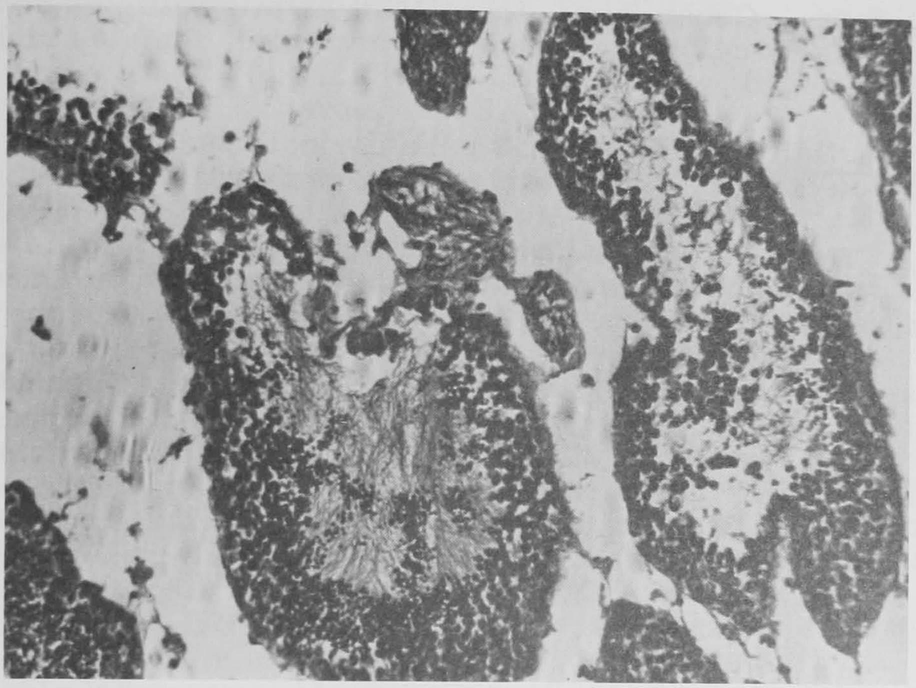


Figure 22.--Changes in the gonad of the sea scallop. a - ripe female, b - spent female, c - ripening male.

Stage III, Ripening.--Gonad larger, rounder, and firmer with tapering tip. Follicles easily visible. Color brighter; males grayish, females orange-pink to orange-red.



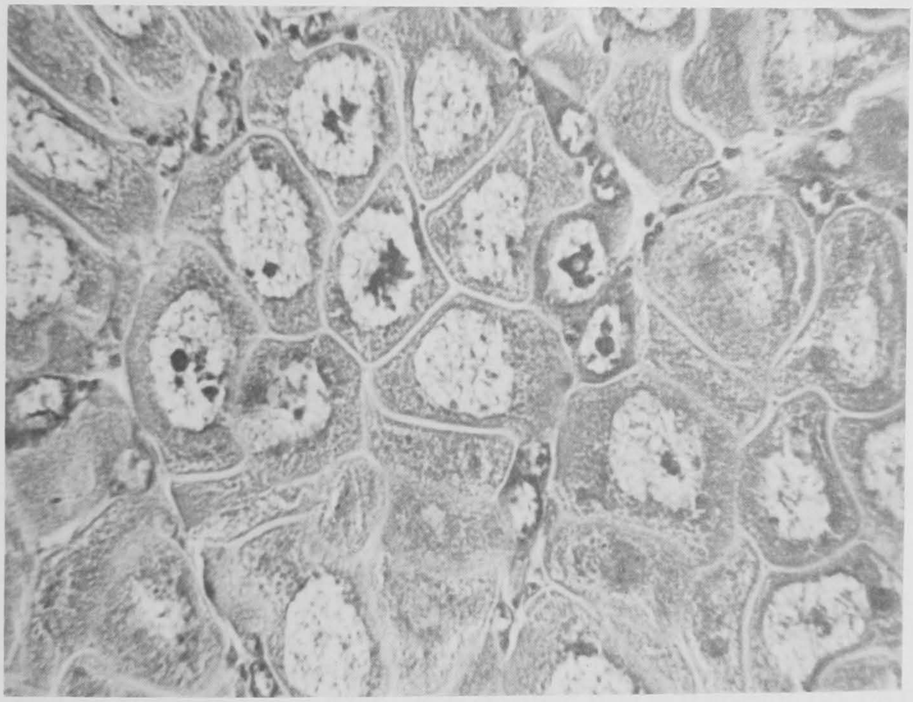


Figure 23.--Photomicrographs of transverse sections through sea scallop gonads. a - Male partially spent. Note sperm tails in center of follicles and the space between follicles (200X). (b) Ripe female. Note densely packed follicle with polygonad-shaped ovacytes (110X).

Stage IV, Ripe.--Gonad large, thick, and firm. Follicles completely packed and highly colored. Males creamy white, females rich coral-red (fig. 23a, 23b).

Stage V, Partially spent.--Gonad partially collapsed, flabby. Color still bright in follicles which still contain gametes (fig. 23a).

Stage VI, Spent.--Gonad collapsed, thin, and flabby. Follicles are apparent. Sexes hard to separate. Males dull gray, females dull gray-orange (fig. 22b).

After spawning in early fall, the sea scallops off New England recover rapidly and reach Stage II by January or February. They pass through Stage III and become ripe (Stage IV) in late April. They remain ripe and full all summer until spawning time.

GROUNDFISH ECOLOGY PROGRAM

R. L. Fritz, Chief[6/],
J. R. Donovan, and S. R. Nickerson

The Groundfish Ecology Program was established in this Laboratory in the latter part of 1959 for the purpose of investigating relationships between groups of species and directing the Laboratory's groundfish surveys. This program, in cooperation with the Hake and Haddock Programs, began its research on the pressing problem of groundfish nursery areas where a potential management conflict exists.

When the haddock mesh regulation was put into effect in 1953, many years of research had preceded that action. At that time significant numbers of smaller haddock were not harvested by other fisheries. In recent years new fisheries have developed that, by their nature, do harvest ever larger amounts of small haddock as well as other groundfish species. The number of trips has increased steadily in recent years with the result that the total poundage landed has become a significantly large amount. This is particularly true of the landings from certain nursery grounds and at certain seasons when small haddock tend to congregate. The harvesting of these smaller haddock may be substantially decreasing the potential haddock yield and reducing the benefits that accrue from mesh regulation. Since the silver hake and haddock fisheries require different management techniques (e. g., different minimum mesh sizes), and inasmuch as they are carried out on the same nursery grounds, more information is needed on the composition of both the fish population and the catch from these areas.

There are three particular inshore areas that may be classified as "groundfish nursery grounds" (fig. 24), the Ipswich Bay-Isle of Shoals region, Stellwagen Bank, and the Nauset grounds. To be considered a nursery ground an area must, over an extended period of time, support large numbers of pre-recruit groundfish. Stellwagen Bank and the Nauset grounds especially are characterized by large numbers of such fishes as will be shown later.

Among the fisheries that are catching, or that may catch, large numbers of small haddock, cod, and other groundfish species, are 1) the mixed groundfish fleet, 2) silver hake (whiting) fleet, 3) industrial fishery, and 4) the animal food fishery. Without exception, each of these four fisheries has steadily increased its volume of landings from nursery grounds in the past 10 years. This is especially true in respect to the industrial fishery, the silver hake fishery on particular grounds, and the animal food fishery. The landings of the mixed groundfish fleet are not completely available and are not given.

These landings are summarized in table 1.

6/ J. B. Skerry to March 1961.

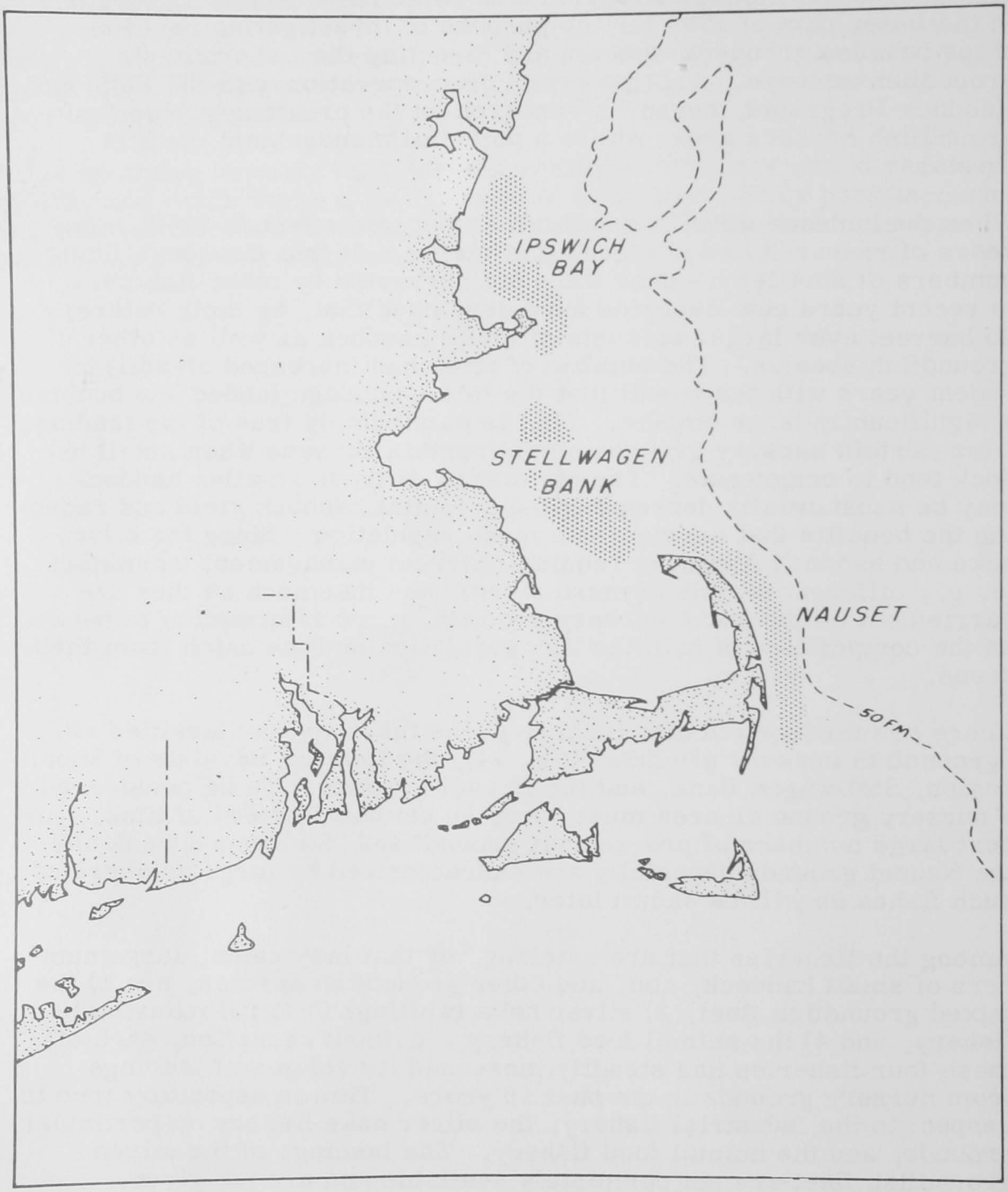


Figure 24.--Areas covered by research vessel cruises.

Table 1.--Landings, since 1950, of the fisheries that predominantly operate on the so-called groundfish nursery grounds in the Gulf of Maine, to nearest 1,000 pounds

Year	Fishery			
	Silver hake		Industrial	Animal
	Ipswich and Stellwagen	Nauset only	All grounds	All grounds
1950	28,500	1,690	5,500	1,000
1951	54,430	8,970	800	1,800
1952	51,330	2,550	70	1,000
1953	63,140	6,840	5,600	1,400
1954	53,540	17,820	22,670	4,000
1955	32,660	14,330	14,220	9,000
1956	26,310	17,420	15,950	9,500
1957	50,170	20,350	37,620	15,000
1958	46,120	21,540	16,430	16,000
1959	34,690	21,840	30,480	20,000

The industrial fleet operating out of Gloucester fished the nursery grounds because they are nearby areas where red and silver hake are most abundant. This fishery was in part the silver hake fishery, depending on the market situation, the vessel captain, and the relative abundance of other species. The samples obtained from industrial trips were reasonably representative of the unsorted catch of any small mesh fishery on these grounds. The nets used by either of these fisheries are usually standard mesh otter trawls with small mesh (1-1/2 or 2-inch) liners in the cod ends.

Ipswich Bay-Isle of Shoals Ground

This area lies chiefly to the north of Cape Ann. Much of the fishing takes place along the 30-fathom contour characterized by a bottom of muddy sand. Vessels of the silver hake and industrial fisheries as well as mixed groundfish vessels operate on this ground.

The species composition for the Ipswich Bay area is given in table 2. The red hake clearly dominates the catch, and the silver hake is the second-most abundant fish, particularly in the fall. Dab are commonly taken in fair numbers in the fall months. Small haddock are usually present, sometimes in large number.

The changes in species composition for the period 1957-59 are presented in table 3, and the pounds landed of each of the species for each year are given. During this period approximately 10 million pounds of industrial fish for reduction were landed from Ipswich Bay, of which an estimated 156,000 pounds was haddock; 31,000 cod; 484,000, dab; and 65,000, redfish.

Table 2.--Percent by weight of the more important species taken by the industrial fishery in the Ipswich Bay area, 1956-59

Number of samples	Month						
	May	June	July	Aug.	Sept.	Oct.	Nov.
	5	9	4	3	1	4	3
Species	%	%	%	%	%	%	%
Haddock	0.3	3.8	0.6	1.6	5.5	0.4	4.0
Cod	0.1	1.1	--	0.4	--	0.6	0.2
Silver hake	11.6	8.4	6.1	17.8	37.9	25.2	35.5
Red hake	53.3	56.4	80.3	49.3	42.4	33.7	23.3
White hake	1.2	--	--	--	--	--	--
Yellowtail	0.1	1.2	--	--	--	--	--
Blackback	--	--	0.4	0.3	--	--	--
Dab	4.4	3.2	1.5	1.7	1.5	18.4	8.3
Greysole	0.3	0.4	--	0.3	--	--	0.7
Herring	0.1	3.1	0.9	2.0	11.9	1.4	0.3
Alewife	--	0.3	--	5.5	--	--	5.9
Blueback	0.9	4.7	2.8	4.0	--	--	--
Shad	--	1.9	1.1	2.1	--	--	1.6
Redfish	2.3	0.1	--	0.1	--	0.1	--
Ocean pout	0.6	3.7	0.5	2.2	--	0.9	1.6
Angler	9.8	4.0	1.6	9.3	--	9.3	4.9
Longhorn sculpin	0.1	3.1	0.1	0.1	--	--	0.2
Spiny dogfish	3.1	2.9	3.6	2.5	--	--	2.3
Little skate	0.9	0.2	--	--	--	2.0	0.3
Big skate	0.4	--	0.5	--	--	0.5	--

Table 3.--Prorated annual landings by the industrial fishery of various species in percent by weight and total pounds (thousands) landed for each year in Ipswich Bay area

	Year					
	1957		1958		1959	
Number of samples	12		9		8	
Species	lb.	%	lb.	%	lb.	%
Haddock	23	1.3	42	1.7	91	1.5
Cod	4	0.3	22	0.9	5	0.1
Silver hake	464	25.9	316	12.8	794	13.4
Red hake	726	40.5	1409	57.1	3177	53.8
White hake	6	0.3	--	--	--	--
Yellowtail	--	--	20	0.8	2	+
Blackback	3	0.2	1	+	--	--
Dab	149	8.4	111	4.5	224	3.8
Greysole	1	+	5	0.2	26	0.4
Herring	42	2.4	71	2.9	73	1.2
Alewife	17	1.0	--	--	53	0.9
Blueback	77	4.3	88	3.6	155	2.6
Shad	13	1.0	21	0.8	58	1.0
Redfish	4	0.2	28	1.1	33	0.6
Ocean pout	23	1.3	56	2.3	40	0.7
Angler	102	5.7	149	6.0	524	8.9
Longhorn sculpin	2	0.1	54	2.2	5	0.1
Spiny dogfish	39	2.2	28	1.1	288	4.9
Little skate	13	0.8	8	0.3	38	0.6
Big skate	6	0.3	12	0.5	11	0.2

Stellwagen Bank

Stellwagen Bank is a sandy lateral moraine of roughly elliptical shape lying northwest of the tip of Cape Cod. The average depth of fishing varies from 20-30 fathoms. It is a favorite fishing ground of the mixed groundfish fishery as well as the industrial and animal food fisheries.

Here the red hake and the silver hake are the predominant species. On an annual basis both species are about equally abundant, but the red hake is more abundant in the fall and silver hake in the spring. Seasonal changes in abundance of minor species are pronounced, due in part to late summer influxes of warmer water species. Cod is the most abundant of the minor species on Stellwagen, whereas the dab was the most important among minor species in Ipswich Bay.

During the period 1957-59 approximately 30 million pounds of industrial fish were landed from Stellwagen Bank, including an estimated 1,496,000 pounds of haddock; 1,147,000 of cod; 134,000 of greysole; 744,000 of dab; and 355,000 pounds of redfish.

Nauset Area

This fishing ground extends the length of the eastern shore of Cape Cod. The bottom is sandy in less than 30 fathoms, and sandy mud or mud below 30 fathoms. The data presented here are based on samples from industrial landings of fish caught in less than 40 fathoms. This is a popular groundfish area, and vessels representing any fleet may be found working it from time to time.

This ground, like Ipswich Bay, is dominated by the red hake, with silver hake a poor second in relative abundance. The haddock stands out amongst the minor species. It is always present in fair numbers and is particularly abundant in the fall.

During the period 1957-59 approximately 44,238,000 pounds of fish for reduction were taken from the Nauset area, of which an estimated 1,341,000 pounds were haddock; 171,000, cod; 360,000, dab; and 130,000 pounds, pollock.

Results of 1960 Groundfish Ecology Nursery Grounds Study

Four research vessel cruises were made to obtain further species composition and distributional data in the critical areas. These cruises took place in July, August, September, and November 1960. A series of tows with a standard 36 Yankee otter trawl were made on each of the three nursery grounds. Since it is virtually impossible to obtain fish weight aboard ship, comparisons between research samples and industrial samples were made in terms of numbers.

Table 4.--A comparison of the industrial landings (I) and the research vessel catches (R). Industrial percentages based on samples taken 1956-59 and research cruises made in July, August, September, and November 1960

	Ipswich Bay								Stellwagen								Nauset							
Month	July		Aug.		Sept.		Nov.		July		Aug.		Sept.		Nov.		July		Aug.		Sept.		Nov.	
Number of samples	10	7	6	5	9	5	8	4	13	4	12	1	9	17	8	7	6	23	6	24	5	15	4	5
Species	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I
Haddock	12.5	4.4	9.9	0.6	5.4	2.6	1.7	3.2	56.8	4.1	23.4	1.1	29.8	3.8	28.9	4.4	15.7	3.1	21.2	3.0	15.8	3.1	25.3	17.1
Cod	3.3	--	3.5	0.5	1.4	0.3	0.5	--	6.1	0.7	6.0	--	4.8	3.5	4.2	1.2	1.3	--	0.7	--	0.6	--	0.4	0.1
Silver hake	12.9	24.0	37.9	34.0	38.6	34.4	47.9	40.1	1.5	76.0	22.5	42.8	6.5	48.5	3.8	43.3	18.4	30.8	26.8	33.6	28.3	26.0	9.5	14.1
Red hake	12.7	49.9	8.5	36.6	4.8	23.1	9.3	--	--	5.1	4.8	23.7	3.3	22.9	--	34.2	22.1	59.3	14.9	55.6	9.5	54.2	4.2	44.5
White hake	0.7	0.3	1.3	0.1	--	--	17.2	17.5	--	--	--	--	--	--	0.7	--	0.8	1.5	0.2	0.9	0.1	0.3	1.3	0.7
Yellowtail	0.6	--	0.4	--	1.8	--	4.9	--	1.6	--	1.4	--	--	0.4	1.3	--	0.4	0.3	0.2	0.3	0.1	0.3	1.0	0.2
Blackback	0.9	--	0.6	--	0.1	--	2.5	0.1	1.6	--	0.4	--	0.4	--	0.3	--	--	--	--	--	--	--	0.5	--
Dab	11.3	5.9	12.9	6.9	12.1	20.2	6.4	18.1	4.1	5.1	3.3	15.9	0.7	5.0	2.4	5.6	11.7	0.8	10.2	0.9	0.8	1.9	2.7	3.0
Greysole	0.5	--	1.4	0.6	1.1	1.2	0.5	1.9	0.3	--	0.4	1.1	--	0.7	0.9	0.4	1.9	--	0.6	0.1	--	--	--	0.1
Herring	0.2	4.0	2.2	0.2	2.6	4.5	0.3	0.9	0.4	1.0	1.7	0.5	0.1	7.7	0.1	0.1	3.7	1.8	9.6	0.8	10.7	6.6	--	0.7
Alewife	0.5	--	1.6	1.3	2.3	--	0.5	--	0.1	--	--	--	1.8	0.2	0.4	0.5	--	--	--	--	0.2	0.1	0.3	--
Blueback	2.2	7.5	2.7	7.0	15.6	3.4	--	12.9	--	1.9	--	--	7.0	1.4	--	3.4	--	0.1	0.2	0.2	--	3.5	--	11.3
Shad	2.2	0.2	--	0.4	2.3	0.1	0.2	0.6	--	--	--	--	0.2	0.3	0.3	--	--	0.1	--	--	--	--	1.9	1.2
Redfish	20.7	0.3	2.3	8.2	1.1	4.4	2.5	0.4	0.4	0.4	0.4	4.8	0.1	2.7	--	1.8	5.3	--	3.6	--	0.1	--	0.5	0.8
Ocean pout	2.5	1.2	3.3	1.5	0.7	3.2	0.2	0.8	3.3	1.3	9.2	1.1	2.4	0.4	--	0.5	9,3	1.2	2.9	1.1	0.6	2.0	0.9	0.6
Angler	0.5	0.5	0.7	0.7	0.5	0.7	0.3	1.0	0.3	0.4	0.5	1.1	0.2	0.2	0.2	--	1.0	0.1	1.0	0.1	1.1	0.2	0.1	0.2
Longhorn sculpin	0.5	0.1	0.6	0.3	0.2	0.2	0.6	0.2	0.8	0.6	2.6	--	1.0	0.5	--	0.9	2.3	0.4	0.2	0.3	0.4	0.5	0.1	2.0
Spiny dogfish	3.4	0.3	5.1	0.6	5.8	0.8	0.8	0.2	20.6	0.3	19.9	2.1	37.6	0.1	48.3	0.8	2.4	0.3	3.4	0.1	15.0	0.4	--	0.4
Little skate	--	--	--	--	--	0.2	--	0.1	0.1	--	0.1	--	0.1	0.2	0.1	0,1	--	0.1	--	0.1	--	0.2	--	0.3
Big skate	--	0.1	--	--	--	0.2	--	0.2	1.0	--	1.6	--	1.6	0.1	0.1	--	0.5	--	0.7	--	0.1	--	--	--

It is noteworthy that the percentages of haddock and spiny dogfish in research vessel catches were much higher than in the industrial samples, while the percentages of the other species were of similar orders of magnitude (table 4). Probably the chief cause of these differences is that the industrial and silver hake fleets do not fish the areas at random. They avoid dogfish and usually do not search out the haddock. On the other hand, research vessel catches give an unbiased picture of species composition.

BENTHIC ECOLOGY PROGRAM

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

Haddock, cod, flounders, and hakes spend most of their lives in the vicinity of the sea floor, feeding on invertebrate animals and the smaller fishes that abound in that stratum. The so-called benthic and epibenthic organisms (animals which live in or on the sea bottom) are the principal source of nourishment for these vast stocks of commercially valuable fishes. Taking inventory of these foods is one of the major aspects of the Benthic Ecology Program. Since the organisms that make up benthos (bottom fauna) vary tremendously in quantity as well as in species composition from one locality to another, consideration of their geographic distribution is especially important. Moreover, water depths and type of bottom sediment and their relationship to the benthos have been studied, inasmuch as they are two of the factors which result in geographic differences in benthic populations.

Geographic Distribution

The quantitative geographic distribution of the Georges Bank benthos was measured both in terms of weight and numbers of specimens. However, in regard to nourishment for groundfish, weight is a much more meaningful measure than numbers. Dry weight of organisms with the calcareous material omitted (e.g. mollusk shells) gives an accurate and useful assessment of weight.

Four major taxonomic groups of invertebrates which make up the bulk of the Georges Bank benthos are: crustaceans, mollusks, echinoderms, and annelid worms. Other groups, such as the coelenterates, ascidians, brozoans, nemerteans, and others, were present only in relatively small quantities or in limited areas. The geographic distribution of each of these groups according to high density (greater than 1.0 g./$m.^2$) occurrence or low density (less than 1.0 g./$m.^2$) is illustrated in figure 25.

Crustaceans were most plentiful in the vicinity of the perimeter of the bank, especially near the southern part. High density areas were found on the northeastern and south-central parts of Georges Bank and the eastern and southern sections of Great South Channel.

Mollusks were most common in eastern Great South Channel and on the south-central and east-central parts of Georges Bank. The total area where large quantities of mollusks are present was small compared to that for crustaceans and the other major groups.

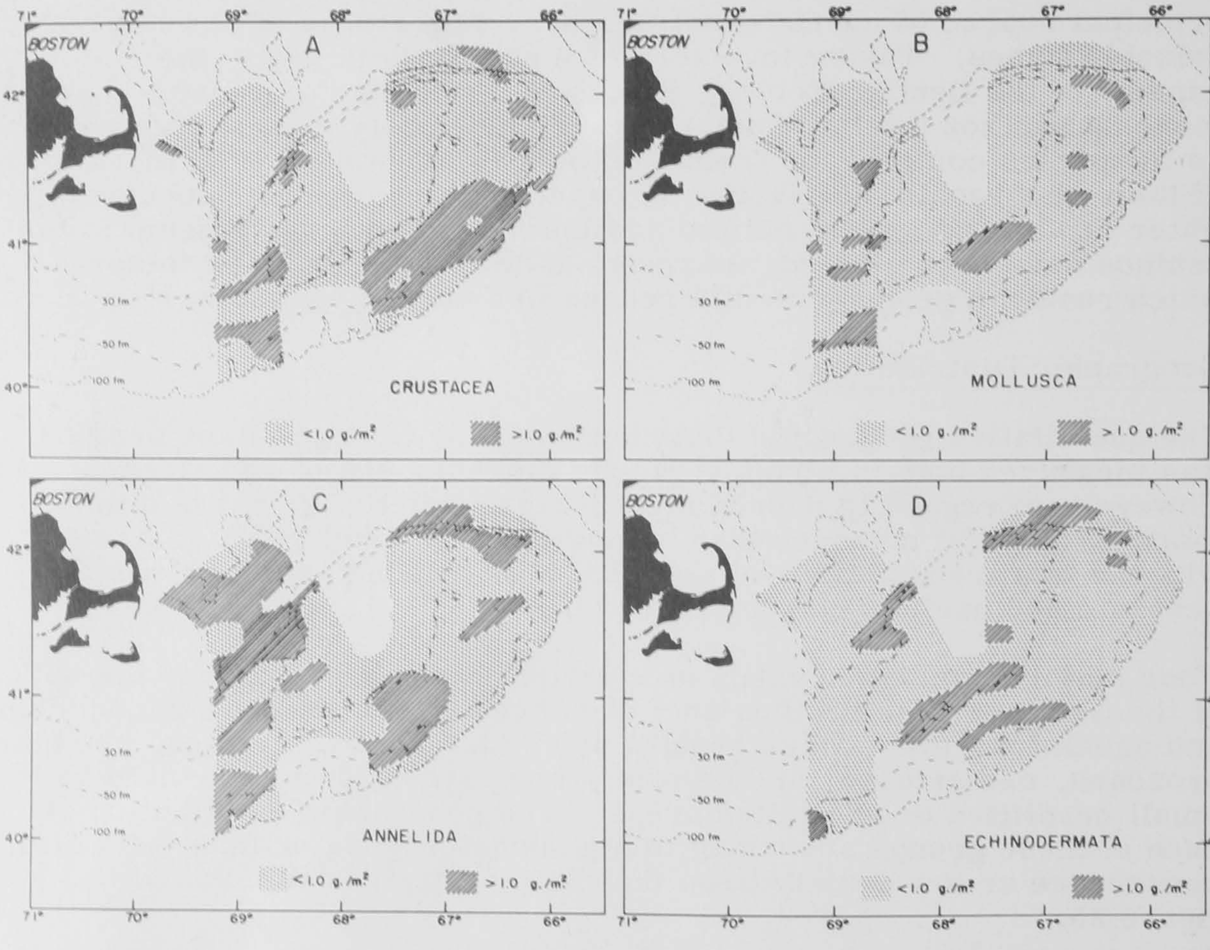


Figure 25.--Geographic occurrence of major benthic components. High density (greater than) 1.0 g./m.^{2} dry weight, indicated by shading; (less than) 1.0 g./m.^{2}, by stippling.

Annelids were prevalent on the northeastern and south-central parts of Georges Bank as well as throughout most of Great South Channel. It was the only group present in high quantities in the deepwater basin northwest of Georges Bank. Annelids were present in high concentrations over a greater area than the other groups.

Echinoderms were particularly abundant in the central and south-central sections of the bank. High density also occurred along the northern and northwestern perimeter of Georges Bank. Their abundance near the center of the bank and their scarcity in Great South Channel were markedly different from the distributional pattern of the other groups.

Bathymetric Distribution

Shallow, intermediate, and deepwater zones of Georges Bank differ significantly in the quantity of organisms they support. Total biomass, and also the quantities of many taxonomic groups, varied enormously at different water depths (fig. 26). In figure 26 the quantity of each of

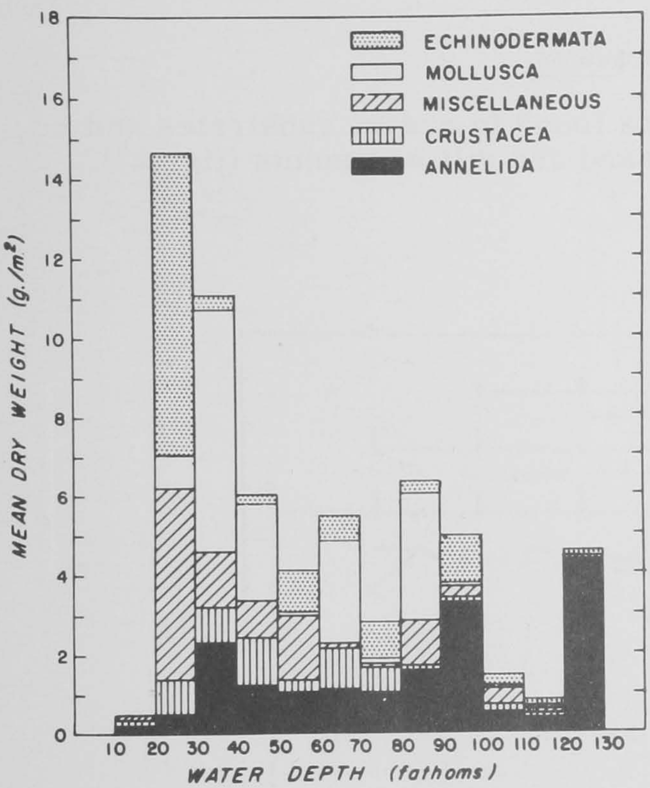


Figure 26. -- Relationship between the dry weight of major benthic components and water depth.

the four major taxonomic groups, plus the Miscellaneous which includes all minor groups, is plotted for each 10-meter depth zone.

Crustaceans exhibited a general decrease in quantity as water depth increased from 20 to 130 fathoms. The 20- to 30-fathom depth zone was especially rich, averaging 4.8 g./m.^{2}. Moderate quantities were found at depths between 30 and 90 fathoms, and very small amounts occurred in the deep waters (90-130 fathoms) and in 10- to 20-fathom depths.

Mollusks varied considerably in quantity from one depth zone to another. Significant amounts of mollusks were found at depths between 20 and 90 fathoms. The largest quantity was present in the 30- to 40-fathom depth zone with an average of 6.2 g./m.^{2}.

Echinoderms were taken at all water depths between 20 and 130 fathoms. They were very abundant in the 20- to 30-fathom depth zone, moderately common between 50 and 100 fathoms, but quite sparse at all other depths that were sampled.

Annelids were rather evenly distributed in moderate abundance in depths ranging from 30 to 90 fathoms. In shallower waters they were present only in small quantities. In water deeper than 100 fathoms they varied considerably in quantity from 0.3 to 4.2 g./m.^{2}.

Benthic Fauna and Sediment Relationships

By far the greatest faunal weight was found in gravel substrates and medium quantities occurred in the sand and silt sediments (fig. 27).

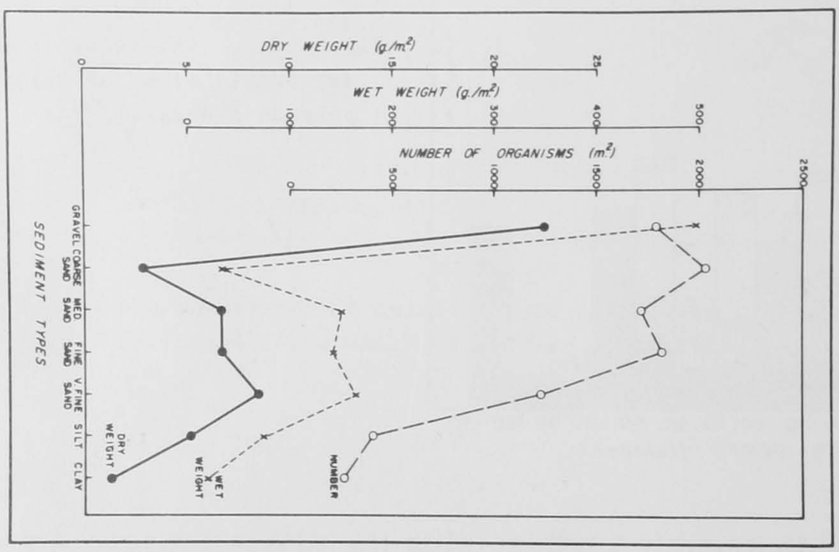


Figure 27.--Numbers and weights of Georges Bank benthic fauna in relation to bottom sediments.

Clays, the finest grained sediments, supported the lowest quantity of benthic animals.

The relationship between numbers of specimens and sediment types was somewhat similar to that for weight and sediment types. This relationship indicates a general decrease in numerical abundance associated with decreasing sediment grain size. Greatest numbers of specimens were found in the sand and gravel sediments; fewest specimens occurred in the silt and clay sediments.

PLANKTON PROGRAM

R. R. Marak, Chief,
and R. R. Stoddard

For many years fishery biologists have been studying the causes of year class fluctuations in a fishery. Because of the number of factors which might cause these fluctuations, many approaches have been tried. We have attempted, through a series of early life-history and ecological studies, to gain some insight into this problem.

One of the difficulties in studies of this type is the problem of sampling a large area (Georges and Browns Banks and the Gulf of Maine) comprehensively and in a short time. In 1953, 1955, and 1956 this was possible through the use of the Hardy Continuous Plankton Recorder. Other concurrent data (results of hatching and rearing experiments, and measurements of temperature, salinity, and surface drift) were obtained, providing information which could be correlated with distribution and abundance of eggs and larvae.

During the past year the work of this program has been almost entirely concerned with completing the analysis and documentation of the results of the Hardy Plankton Recorder cruises. The distribution of eggs and larvae of haddock showed that each year major spawning concentrations occurred on the northeast part of Georges Bank and on Browns Bank. The relative abundance of eggs and the time of maximum spawning, however, appeared to vary among years (fig. 28). Both the time of spawning and egg survival may depend partly upon temperature which changes with the season and currents. The buoyant eggs rise toward the surface and are carried away from the spawning grounds by surface currents. The subsequent survival of eggs and larvae depends upon, in part, the environmental conditions encountered in the surface waters.

Drift studies, using bottles and buoys, have shown us that the net surface drift (nontidal drift) on Georges Bank during the spawning season was south during the 3 years of our study. Eggs and larvae swept onto the southern part of Georges Bank may suffer high mortalities due to the warmer waters encountered.

Through the use of high-speed samplers developed at this Laboratory, we have determined the vertical distribution of larval and postlarval fish. Haddock larvae tend to concentrate at the thermocline, and there is no evidence that extensive vertical migrations occur. This knowledge, coupled with the fact that greatest percentage of the haddock eggs are found in the surface layers, will facilitate future sampling. As a result of artificial spawning and hatching experiments, we are now able to identify almost any egg or larva taken in our area during the spring.

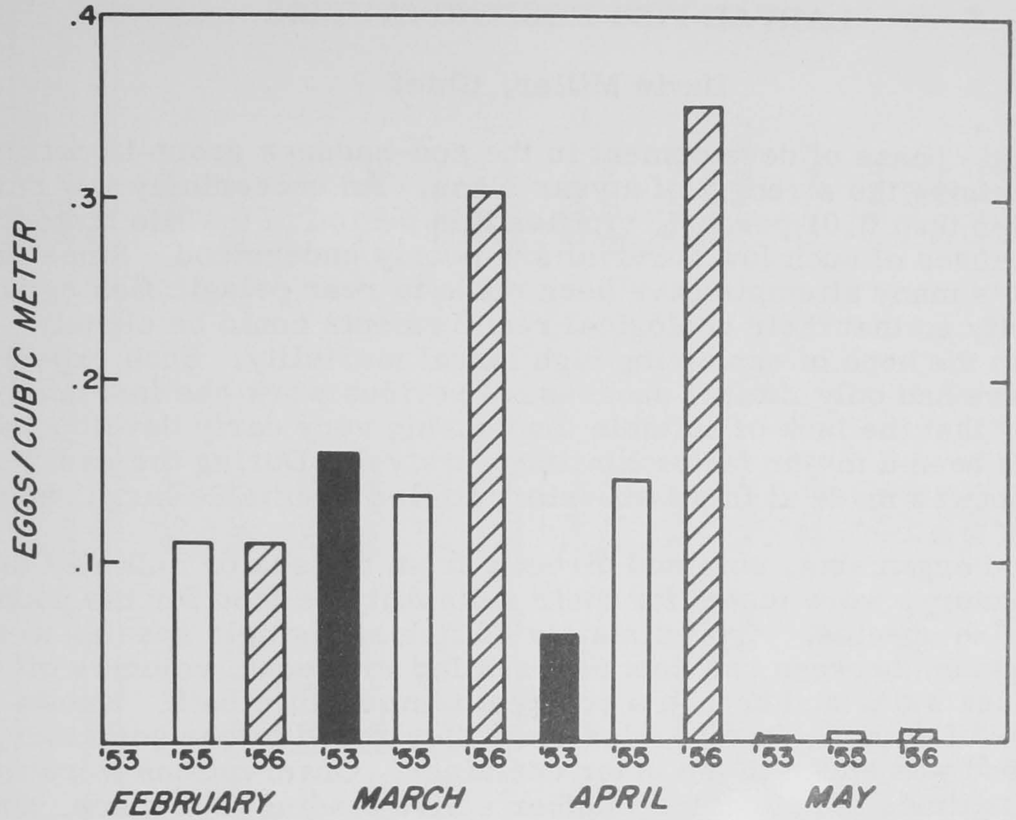


Figure 28.--Abundance of haddock eggs in the Gulf of Maine-Georges Bank area, February-May, 1953, 1955, and 1956.

Stomach analyses of these larvae have shown that their diet consists mainly of copepods and that there is a strong selection as to the size of food they eat. It is an important part of our work to know just what food is available to the fish.

LARVAL FISH FEEDING STUDIES

David Miller, Chief

The pelagic phase of development in the cod-haddock group is critical in determining the strength of a year class. An exceedingly low survival, less than 0.01 percent, typifies this period in the life history, but the causes of such low survival are poorly understood. Since the late 1800's many attempts have been made to rear pelagic fish eggs to maturity so that their ecological requirements could be closely studied in the hope of explaining high larval mortality. Such experiments have had only limited success. Previous work has indicated, however, that the lack of suitable food during very early development may have been a major factor limiting survival. During the past year an attempt was made at this Laboratory to find a suitable larval food.

Eight food organisms, obtained directly from the sea or cultured in the laboratory, were tested for their suitability as food for the young of eight fish species. Approximately 40 fish of a single species were evenly divided between two containers filled with equal volumes of filtered sea water and kept in a constant temperature bath. Known quantities of a single food species were then added to one container, and no food was added to the other container. Observations were made at various times to determine whether active feeding took place, and differences in survival between fed and nonfed larvae were recorded.

Out of the eight food organisms tested, only two crustaceans, Tisbe and Artemia, were ingested by the fish (table 1). Previous studies have shown that larval haddock, cod, and pollock do not utilize algae. In the present experiment unicellular plants were not ingested by sculpin larvae; and several larval fish species refused nematodes (Anguillula), the eggs and larvae of the clam (Mercenaria), and sea urchin eggs and plutei (Arbacia) (table 1).

Observations of cod, haddock, red hake, and sculpin larvae suggest that movement of prey is a necessary visual stimulus to feeding. The amount of feeding was much greater on nauplii of Artemia than on Tisbe nauplii; the former moved constantly throughout the container, whereas the latter attached themselves to the walls of the container and moved only intermittently.

Another important factor is, of course, the size of the food organism. Only the largest haddock and cod larvae were able to swallow Artemia nauplii, whereas killifish larvae, almost twice the length of cod and haddock when first hatched, were able to swallow Artemia easily. Nauplii of Tisbe were small enough for even the smallest larvae, but this crustacean was seldom eaten by any of the young fishes, probably because of its behavior.

Table 1.--The comparative effectiveness of eight organisms as food for the larval and juvenile stages of several fish species

Organism and developmental stage: Food species	Organism and developmental stage: Fish species	Number of food species ingested	Survival of fed vs. unfed fish larvae
Phaeodactylum tricornutum (all stages)	Longhorn sculpin (larval)	None	Same
Isochrysis galbana (all stages)	Longhorn sculpin (larval)	None	Same
IIIc* (cryptomonad - all stages)	Longhorn sculpin (larval)	None	Same
Anguillula aceti (young & adult)	Longhorn sculpin (larval)	None	Same
Arbacia punctulata (egg & pluteus)	Longhorn sculpin (larval)	None	Same
	Red hake (larval)	None	Same
	Common sea robin (larval)	None	Same
Mercenaria mercenaria (egg & trochophore)	Longhorn sculpin (larval)	None	Same
	Haddock (larval)	None	Same
Tisbe furcata (nauplii & adult)	Longhorn sculpin (larval)	Few	Same
	Common sea robin (larval)	Few	Same
	Striped killifish (larval and juvenile)	Many	Greater
	Pollock (juvenile)	Many	Greater
Artemia salina (nauplii & adult)	Haddock & cod (larval)	Few	Same
	Longhorn sculpin (larval)	Few	Same
	Red hake (larval)	Few	Same
	White hake (juvenile)	Many	Greater
	Striped killifish (larval and juvenile)	Many	Greater
	Sand flounder (juvenile)	Many	Greater
	Pollock (juvenile)	Many	Greater

* Species not determined

Among all the fish species at the larval stage (except larval killifish) there was very little difference in survival between fed and nonfed fish. Utilization of the Crustacea by small fish larvae was so limited that no difference in mortality was expected. However, the killifish larvae and juveniles of this and other species fed extensively on *Artemia*, and in all these cases mortality was markedly higher in nonfed controls (table 1). In the containers receiving food, the killifish (both larvae and juveniles) and four other species captured as juveniles (8-15 mm.) achieved noticeable growth and survived for various periods all exceeding 1 month.

The problem of discovering a suitable food for small pelagic fish larvae remains; however, the present studies have defined more precisely the requirements of a desirable food organism.

FISH BEHAVIOR

R. Livingstone, Jr.

Differential behavior.--In some of the underwater television (UTV) films we have observed a differential behavior of haddock and whiting when entering the cod end of the otter trawl. Haddock entered the cod end in its upper half above the camera which was located centrally, while whiting entered close to the bottom often in contact with the meshes. Haddock entered the cod end facing up-current, down-current, and cross-current; while whiting tended to enter facing down-current or cross-current. Haddock turned up-current frequently and swam vigorously to keep pace with the net; whiting appeared to be more lethargic, drifting or weakly swimming into the cod end. Once in the cod end small haddock escaped by swimming upward through the meshes. Whiting, on the other hand, escaped through the sides and end of the cod end. Haddock which contacted other fish reacted violently by shooting upward or to the sides.

Based on these observed differences in behavior between the two species, a series of fishing experiments was planned in an attempt to develop a net which would retain whiting but allow escapement of small haddock. Preliminary experiments were conducted with a net having a window and deflector on the upper side of the cod end or on the belly of the net just forward of the cod end. Results corroborated the previous observations of the different behavior of the two species, but the escapement of haddock was insufficient to justify the loss of whiting.

Keeping Pace.--Many species of groundfish will respond visually to a moving background by swimming along with it, maintaining a constant position in relation to the background. Such behavior has been observed in otter trawls with UTV. As the fish are displaced or drift down the net to the cod end, they frequently turn in the direction the net is moving with the result that groups of fish may be facing in the same direction. Depending on the species, the rate of entry into the net, the amount of light, and the towing speed, movement to the cod end may be orderly with the fish orient to each other and the net, or disorderly with frequent collisions and disorientations. Cod and pollock, for example, have been observed to swim in the same location in the net, sustaining the speed of the net for 20 minutes or longer, while other species such as whiting were carried past and accumulated in the posterior part of the cod end.

Many species keep pace with the net during towing, but when the net is motionless or rises vertically as during haulback, movements are more random.

Some general conclusions of the report are presented below. Changes in yields are all on a per-recruit basis and apply to present levels of effort.

1. Yield of cod taken by lines (the only species caught in large quantities by this gear) would benefit substantially (up to 20 percent in some areas) from an increase in mesh size to 6 inches because line gear is selective for large fish.

2. Trawl landings of cod would benefit in the long run in most areas with an increase from the present 4-or 4-1/2-inch mesh to a 5-inch mesh, at which size immediate losses would range from 2-10 percent. Long-term gains (up to 8 percent) would occur in some areas with an increase to 6 inches. However, long-term losses (up to 8 percent) are indicated for some areas, and immediate losses range from 10 to 35 percent.

3. For haddock, nearly all of which are taken by otter trawl, there are small long-term gains (1-4 percent) for increases from the present 4-or 4-1/2-inch mesh to a 5-inch mesh, but immediate losses are estimated at from 7 to 35 percent. Meshes of 5-1/2 and 6 inches give long-term losses between 2 and 14 percent, and immediate losses of 20-60 percent.

4. The total landings of cod and haddock combined (by all gears) show small long-term gains (up to 2 percent) for mesh sizes up to 5-1/2 inches in the whole ICNAF area, the loss of trawl haddock being more than compensated for by gains to line-caught cod.

5. Effects of mesh increase on yields of most of the redfish stocks could not be assessed because of insufficient data. Yields of the southern fisheries (off Nova Scotia and south) would probably suffer rather high immediate and long-term losses by increasing the present 2-7/8-inch mesh to meshes of 4 or more inches. The more northern fisheries, based on stocks composed of larger fish, and presently using 3-1/2-inch meshes, might better accommodate a 4-or 4-1/2-inch mesh; but the changes in yields have not yet been estimated.

6. Of the other species commercially important in subarea 5 (Georges Bank and Gulf of Maine), yellowtail flounder yields would be affected little by increasing the present 4-1/2-inch mesh to a 5-1/2-inch mesh. Silver hake, now caught with a 2-1/2-inch mesh, would suffer an immediate loss of about 40 percent with a 4-inch mesh; long-term assessments could not be obtained, but the present fishing intensity would have to be high to achieve any long-term gains with meshes of 4 inches or greater.

7. For the Georges Bank haddock fishery, the yield is now the maximum obtainable with the present mesh (4-1/2 inches) and level of effort.

8. On the basis of the working group's report, the member nations of ICNAF adopted a 4-1/2-inch minimum mesh size for cod and haddock throughout the Convention Area and for redfish in the northern half of the Convention Area. The commissioners of countries concerned with subarea 5 recommended that flounders in that subarea also be included in this regulation. Further study of these species in subarea 3 is needed before any recommendation for regulation can be proposed.

The assessments are not highly accurate in some cases, primarily because accurate estimates of fishing and natural mortalities could not be obtained from the data available. The working group is continuing its investigations, and hopes to derive more precise assessments and furnish more information about the effects of changing fishing conditions on the assessments.

TAGGING

S. L. Cogswell, Chief

A tagging program for scup (porgy) in the Woods Hole-Buzzards Bay area of Cape Cod was completed in September. The 2,420 fish tagged were obtained from a trap in Buzzards Bay (fig. 30). The following five types of tags were used in an attempt to find a tag which was well suited to scup: Petersen disc through nape; Atkins with spaghetti attachment through dorsum, trailing, with single knot; same with double knot; same tag with spaghetti attachment looped over back; and dart-spaghetti tag.

So far, Petersen disc tags have yielded the highest in returns followed by Atkins-spaghetti looped, double-knotted, and single-knotted in that order. Only one dart-spaghetti tag was returned, and subsequent laboratory tests with live scup have shown that the flesh deteriorates rapidly at the penetration site of the dart. This condition did not develop around the small diameter material of the stainless steel pin used in attaching Petersen disc tags, but it was apparent on many of the scup tagged with Atkins-spaghetti tags (fig. 31). Dart-spaghetti tags could be easily drawn out of the fish once the deterioration process had set in - which occurred in some instances only 5 or 6 days after tagging (figs. 32, 33, and 34).

In addition to a suitable tag, adequate detection of tagged fish and knowledge of recapture locations are essential for a successful tagging program. Dates and locations of recapture often are not readily available with scup tag returns because the fish are not processed individually until they reach retail markets (which occur in all the coastal states from New Jersey to Florida and inland to Tennessee, Pennsylvania, and Ohio), where many tags are discovered. In 1959 scup were tagged in cooperation with the State of New Jersey, and none of the inland tag returns gave recapture locations. It was clear that an adequate description of scup movements would require a substantial increase in the proportion of tag returns yielding recapture location.

In an attempt to achieve this objective we distributed descriptive posters and interviewed representatives of fish companies from Long Island, New York, to Norfolk, Virginia. We found that tracing recapture locations of inland returns was possible because most of the fish shipping companies at the ports kept records of the capture location of each catch landed; and fish originating from any particular catch could be traced by dates and identification numbers on boxes, even though fish might be distributed through one or more wholesaler before reaching the retailer.


USN

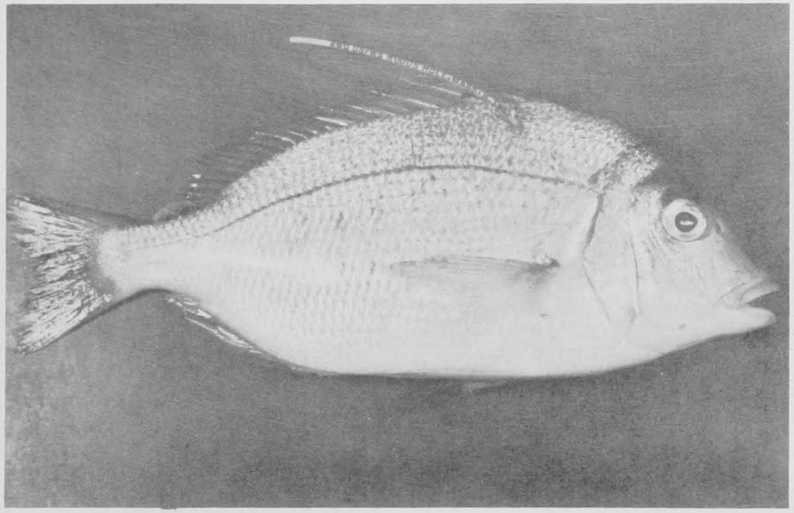


Figure 31.--Dart-spaghetti tag at time of tagging.

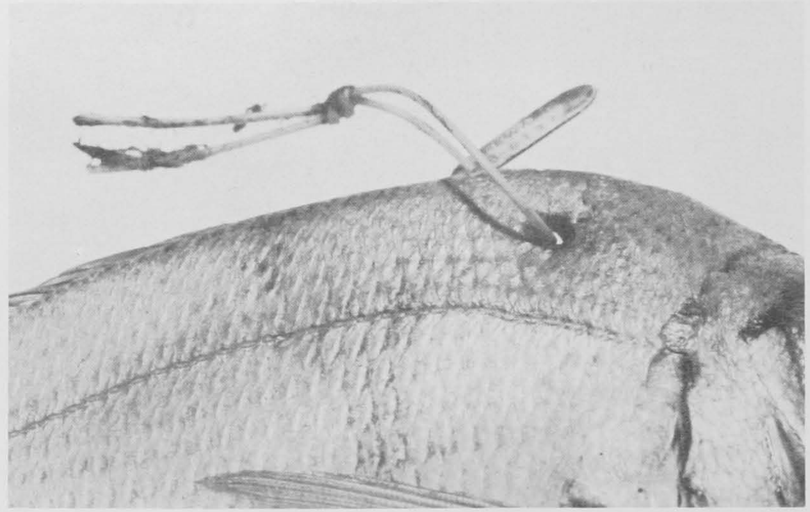


Figure 32.--Atkins-spaghetti tag (looped) showing deterioration.

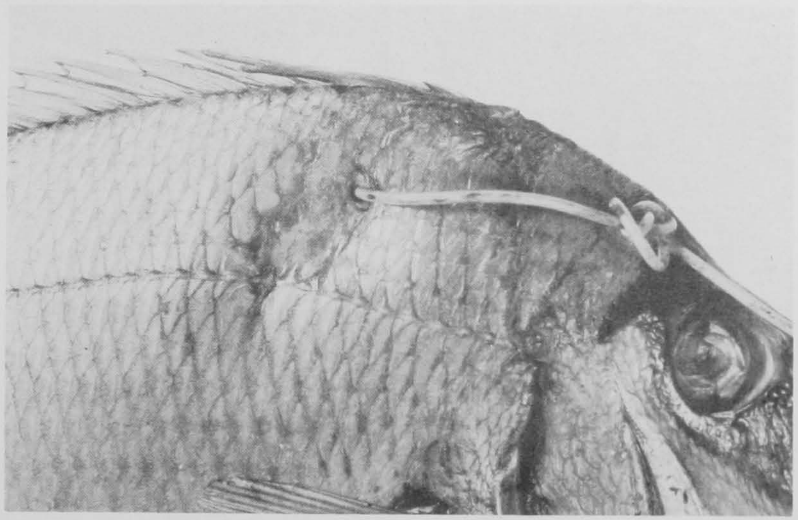


Figure 33.--Atkins-spaghetti tag (trailing) showing deterioration.

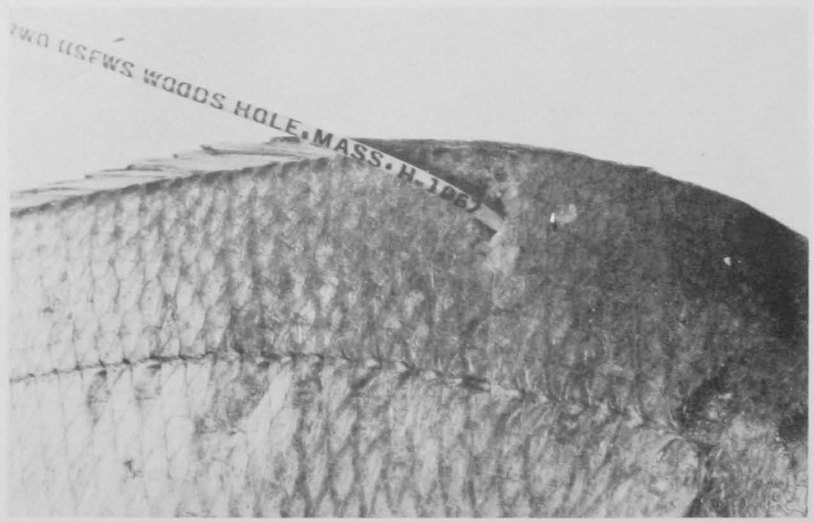


Figure 34.--Dart-spaghetti tag showing deterioration.

Instruction cards (fig. 35) were distributed through fishing companies and major wholesalers to the retailers. These cards requested the information which permitted tracing the recapture location of a tagged fish by a sequence of letters from this Laboratory, beginning with the place of tag detection, and working back through distribution points, and finally to the port where the fish was landed.

PLEASE POST

REWARD ONE DOLLAR FOR SCUP (PORGY) TAG WITH INFORMATION

SEND TAG AT ONCE TO USFWS, WOODS HOLE, MASS., WITH FOLLOWING INFORMATION: (1) LOCATION CAUGHT, (2) DATE, (3) GEAR, (4) DEPTH, (5) NAME OF VESSEL AND (6) NAME AND ADDRESS OF FINDER.

IF ITEMS 1 THROUGH 5 ABOVE ARE NOT KNOWN--SEND ANY INFORMATION WHICH WILL HELP US TO TRACE THE TAG TO THE TIME AND PLACE WHERE THE FISH WAS CAUGHT, AS NAME AND ADDRESS OF DEALER FROM WHOM THE FISH WAS PURCHASED, AND DATE OF PURCHASE--INVOICE NUMBER, BOX NUMBER, ETC.

THANK YOU

U. S. DEPARTMENT OF INTERIOR, BUREAU OF COMMERCIAL FISHERIES BIOLOGICAL LABORATORY, WOODS HOLE, MASS.

This publicity program which preceded the 1960 scup tagging program resulted in a large increase in the proportion of returns with desirable information as compared with the less publicized 1959 tagging. Of returns originating from retail stores, 61 percent eventually yielded dates and locations of recapture in the 1960 study, whereas in 1959, none of inland returns provided the desired information. Of total returns from all sources, 74 percent were accompanied by recapture data in the 1960 program versus 35 percent in 1959. It is significant also that 35 percent of the 1960 returns originated from commercial fishermen as compared with only 4 percent in 1959. Personal contacts in the ports and placement of posters aboard vessels was effective in obtaining earlier detection of tags, thereby increasing efficiency of the tagging program.

A study of dogfish was begun by tagging 414 dogfish at both inshore and offshore positions during several cruises of the Delaware and cruises of chartered vessels.

In April biologists of this laboratory tagged 1, 800 fluke (summer flounder) at stations 80 miles offshore from Cape Cod west to the Block Island area.

The tagging unit completed plans with State of New Jersey biologists for a coordinated program for tagging 3, 500 fluke at Sandy Hook Bay, and Cape May, New Jersey, beginning July 1961. The coordinated program with the State of Massachusetts for the tagging of blackback (winter flounder) continued during the year, and plans were made for further tagging of this species along the north shore of Massachusetts.

A mailing list of party vessel captains and sport fishing clubs was compiled from tag returns of the scup and fluke programs. This list will be used to distribute tagging announcements and tag return news releases. A new chart overlay form letter is now being used for acknowledging tag returns. The new form was designed for general use in all investigations.

AQUARIUM

C. L. Wheeler, Chief

The completion and occupation of the new aquarium building in April was a highlight of the year. The acquisition of the new facility was of twofold importance, for it provided once again a public attraction which had been missing from the Woods Hole scene since 1954, and it furnished to the Laboratory a much-needed research adjunct.

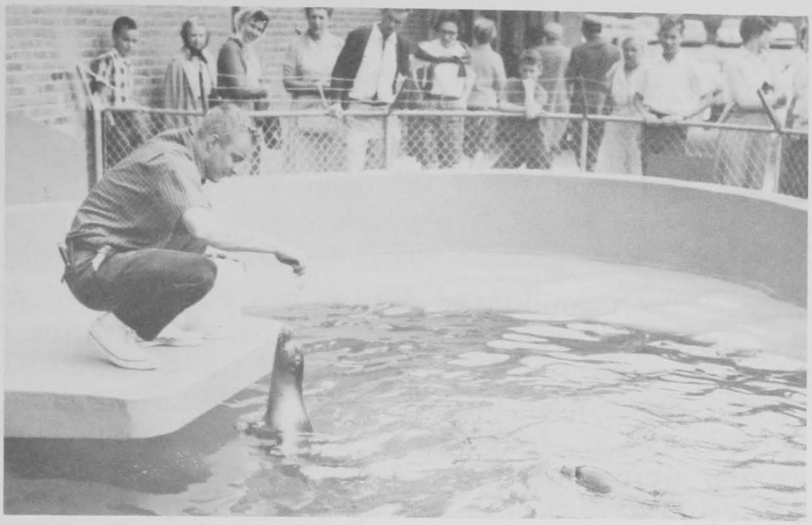
Since the aquarium was to be opened to the public on July 1, the months of May and June were devoted to preparations for this event. The salt-water systems were put into operation, fish and invertebrates were collected for display, and the exhibition area was furnished with wall panels, models, and other items relating to the work being done at the Laboratory and to the marine resources of the western North Atlantic.

The 38-foot power boat Blueback was transferred to Woods Hole from the Bureau of Commercial Fisheries Laboratory at Boothbay Harbor. Regular trips were made to the fish trap near the entrance to Quissett Harbor, and scup, menhaden, sea robins, butterfish, and other representatives of the local fish fauna were obtained for the aquarium. The Blueback was also used for seining and handlining missions in the vicinity of the nearby Elizabeth Islands. The Delaware obtained offshore specimens on several of her regular spring trips. By a combination of these efforts, a collection of 42 species of fish and invertebrates was ready for exhibition by June 30. Each of the 16 glass-fronted display tanks had been prepared for its inhabitants by paving the bottom with gravel and creating a naturalistic background of rocks, seaweeds, barnacle-encrusted timbers, and other appropriate objects. The acquisition of three seals for the pool in front of the aquarium building was accomplished on June 23 and constituted a preliminary attraction of considerable popularity.[7]

Experiments relating to the long-term holding of fish in large-capacity, temperature-controlled tanks were continued from the previous year. Two additional units, each capable of holding 1,000 gallons of sea water, were constructed and put into operation, and one of these was equipped with a plywood hood for fish behavior studies. Both of the new tanks were fitted with plexiglass observation windows but otherwise were essentially similar in structure to the prototype unit. Whiting were kept in one tank through the winter, and the other tank was used this spring to study the behavior of scup, tomcod, and other species.

---

[7] Although the aquarium "season" of 1961 is technically not in this report year, it can be stated that between July 1 and September 10 more than 200,000 persons visited the aquarium.



SHELLFISH LABORATORY

P. S. Galtsoff, Chief,
W. N. Shaw, P. A. Philpott,
and R. L. von Arx

Oyster Biology

The principal research conducted during the past year dealt with the anatomy and functions of gonads, the structure of mature egg and sperm, and fertilization and development of the oyster. Great advances in cellular physiology made during the past decade and a voluminous literature on structure of invertebrate eggs necessitated careful revue and appraisal of the work conducted on sex cells of bivalves and particularly of various species of oysters. Additional cytophysiological studies on eggs and sperm of Crassostrea virginica were made to clarify certain obscure but important cytological details. The focal point of these studies involved the nature of various cytoplasmic particles and their localization in a mature egg. Various methods were employed: metachromatic reaction, vital stains, specific stains for lipids, centrifugation, and observations of live eggs and spermatozoa under highest magnifications available with phase contrast oil immersion lenses.

The mature egg of the oyster has a thin hyaline membrane with an inner lining of thin cortical particles. The egg cell is opaque because of the great number of yolk granules which obscure other cytoplasmic elements. The distribution of both lipid-yolk, which is deeply stained by Sudan II, Sudan III, and Black Sudan-O, and of the less abundant protein yolk which remains unstained, was recorded by photomicrography. By using Janus Green vital stain, the mitochondria were revealed and were found to form a distinct subcortical layer consisting of small rod-like particles.

The metachromatic (Toluidin Blue) stain applied to intact and centrifuged eggs showed the presence of other particles, possibly identical with the alpha and beta particles of French cytologists. By centrifuging, the two types of yolk were separated, the lipid yolk concentrating at the centrifugal pole and the protein yolk particles accumulating at the opposite axis of the egg. Egg cytoplasm was found to contain also numerous particles less than 0.5 microns in diameter, these are known under the general term of lysosomes, and since their dimensions are at the limit of the resolving power of light microscopy they can be properly studied only with electron microscopy. Unfortunately no opportunity was available during the past year to use the electron microscope.

The question of chromosome number in Crassostrea virginica and other Ostreidae is of importance for the breeding experiments which are now being conducted at various laboratories in this country and abroad. Because of the small size of chromosomes and opacity of eggs the details of the reduction division escaped observation. Mitoses of cleaving blastomeres are easily observed but only rarely could a preparation be obtained that was sufficiently clear and sharp for chromosome counts. Various methods were used: whole mounts of fertilized eggs were treated according to the Feulgen method; sections of eggs were stained both with Feulgen and Heidenhain's iron haematoxylin; and squash preparations were stained with orcein-acetate. It appears from the study of this material that the most probable diploid number in Crassostrea virginica is eight.

The polar bodies (fig. 36) were seen in many preparations, but the details of the reduction division which apparently takes place during second polar body formation escaped observation.

The formation of the fertilization membrane following the attachment of sperm to the cortical layer of the egg was clearly seen (fig. 37).

The function of the acrosome of a spermatozoan in fertilization was watched under high magnification of phase contrast lenses. In contact with the egg water, the acrosome (of some of the spermatozoa) bursts and ejects a filament which presumably carries a lysine. In Crassostrea virginica the acrosomal filament of the sperm was found to be about four times longer than the head. The exact significance of the acrosomal reaction and the role of the filament are not known. The reaction takes place in several species of bivalves, starfishes, sea urchins, worms, and other invertebrates. Apparently it plays a significant role in fertilization. The fact that in C. virginica and in other invertebrates the reaction takes place only in a few spermatozoa is regarded by some cytologists as a screening process which tends to eliminate the supernumerary spermatozoa from entering the egg membrane and in this way reduces the chances of polyspermy. Cell reactions, such as discharge of the acrosomal filament and partial disintegration or dissolution of egg cortex at the point of entry of sperm, determine the success or failure of fertilization during spawning. Frequent failures in reproduction of marine populations may be caused by the inhibition of this kind of reaction.

The data accumulated in the laboratory on sex change in adult Crassostrea virginica were reanalyzed and the results were published in the general review on Physiology of Reproduction in Mollusks by P. S. Galtsoff. During the 4 years of observations on the group of 202 adult (4-year-old) oysters selected for the experiment, the sex was determined by stimulating spawning on each individual mollusk. The oysters were marked, and the test repeated every year. At the start the males comprised 64.4 percent and the females 35.6 percent of the entire group. By the end of the experiment the proportion of males decreased to 44.1 percent, the females comprised 41.2 percent, and 13.7 percent of the 8-year-old oysters failed to spawn. One of the oysters that survived the test alternated its sex every year. The

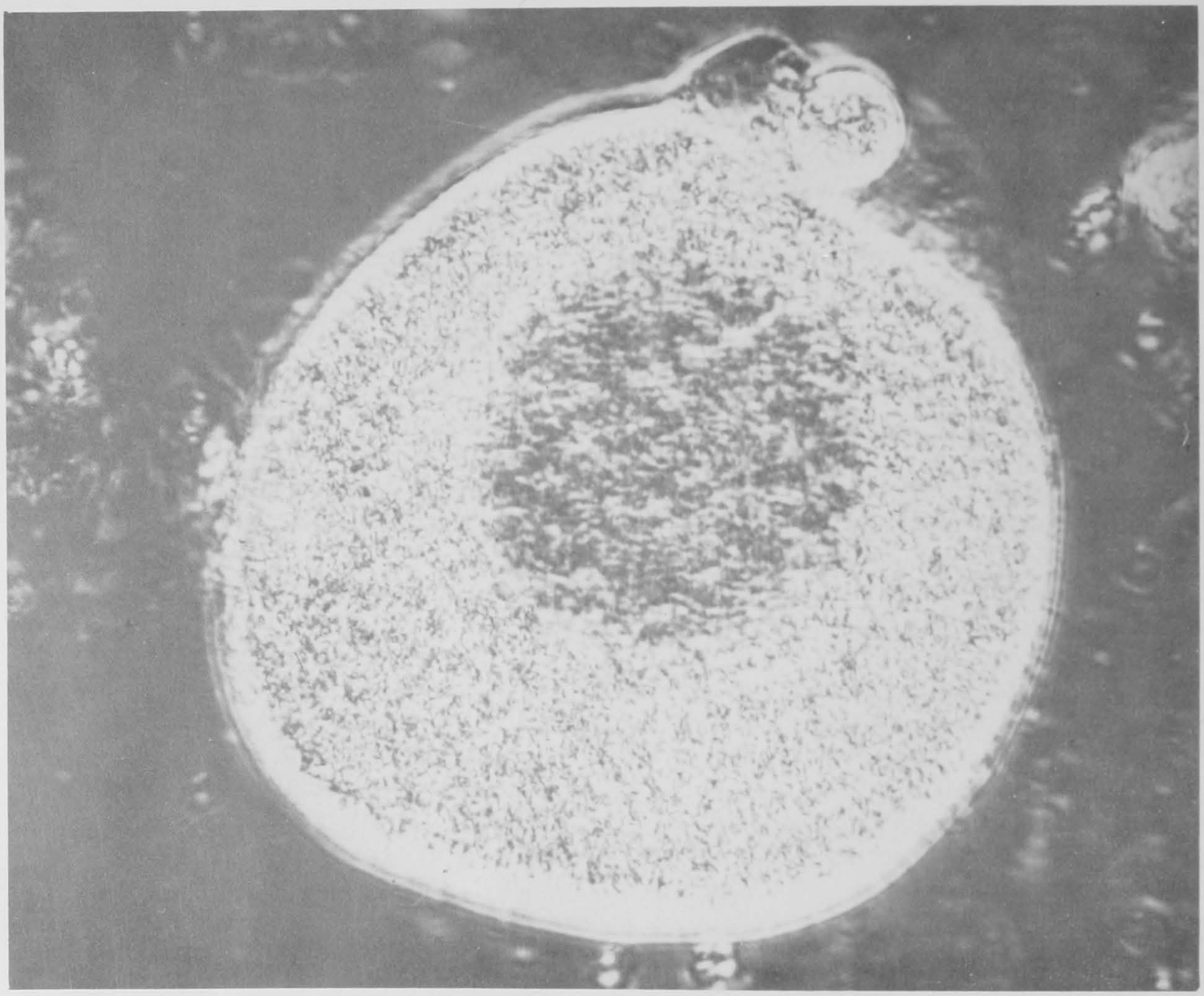


Figure 36.--Live fertilized oyster egg after the formation of the second polar body; cleavage was delayed. Phase contrast oil immersion. Miscroscopic magnification about 2,000; enlarged photographically to 3,300x.

Figure 37.--Fertilized oyster egg. Note the fertilization membrane, the subcortical granules, the large nucleus which begins to break down, and two spermatozoa attached to the membrane. Magnified about 2,000x.

majority of oysters experienced only one change of sex during the 4-year period. The annual changes from male to female phase averaged 12.8 percent while the annual changes from female to male averaged 15.5 percent. It may be inferred that the increased number of females recorded by the end of the fourth year was due to higher survival rate of mollusks during the female phase.

INSTRUMENTATION

J. M. Crossen, Chief

Because of increased interest in oceanographic research and technological advances in instrumentation, many instruments useful in marine research have become commercially available. Such equipment, however, must often be modified and adapted before the researchers' specific needs are satisfied. The development and operation of two instruments useful in fishery biology are described here.

Photoelectric Fish Egg Counter

An electronic fish egg counter (fig. 38 and 39) was developed to the point where it is a useful tool in counting haddock and hake eggs. A similar device has been developed at the Marine Laboratory, Aberdeen, Scotland [8]. The eggs are counted individually by the interruption of a light beam focused on a (RCA-1P21) photomultiplier tube which senses variations in the level of illumination. These pulsed variations are fed to a limiter-shaper circuit and then inserted into an electronic scaler which displays the random event counts.

Previous to the actual counting operation, the ovaries are preserved in a solution of Gilson's fluid to remove all the ovarian tissue and to avoid clumping of the smaller (0. 3-0.5 mm.) immature eggs. The eggs are then placed within a glass funnel containing water and uniformly distributed by an air driven agitator. By varying the agitator speed, the flow of eggs through the system may be controlled. A flow rate of well over 100 per second has been attained.

The counting chamber consists of an interchangeable glass tube inserted within a brass cylinder which attaches to the photomultiplier housing. The 3. 0 mm. I. D. glass tube tapers to 1. 8 mm. I. D. at the center. This tube allows the largest eggs to pass one at a time. At the center of the glass tube a 1. 5-mm. orifice directs the light beam to the photo tube cathode.

A tapped tank maintains a constant head of water in the funnel. After the eggs have been counted they are collected at the bottom of a flask from which the water is siphoned to a drain.

Preliminary tests have been run using haddock eggs varying in size from immature eggs of 0. 3-0. 5 mm. to mature eggs averaging 1. 5 mm. Sensitivity of the photo tube is set at a threshold where all mature eggs are counted. This eliminates the necessity for separation of small and large eggs. An accuracy of 99 percent has been maintained up to a counting rate of 50 per second.

---

[8] I. G. Baxter, 1959, "An Automatic Fish Egg Counter". Herring Committee of ICES.

Figure 38.--Photograph of egg counter (inset).

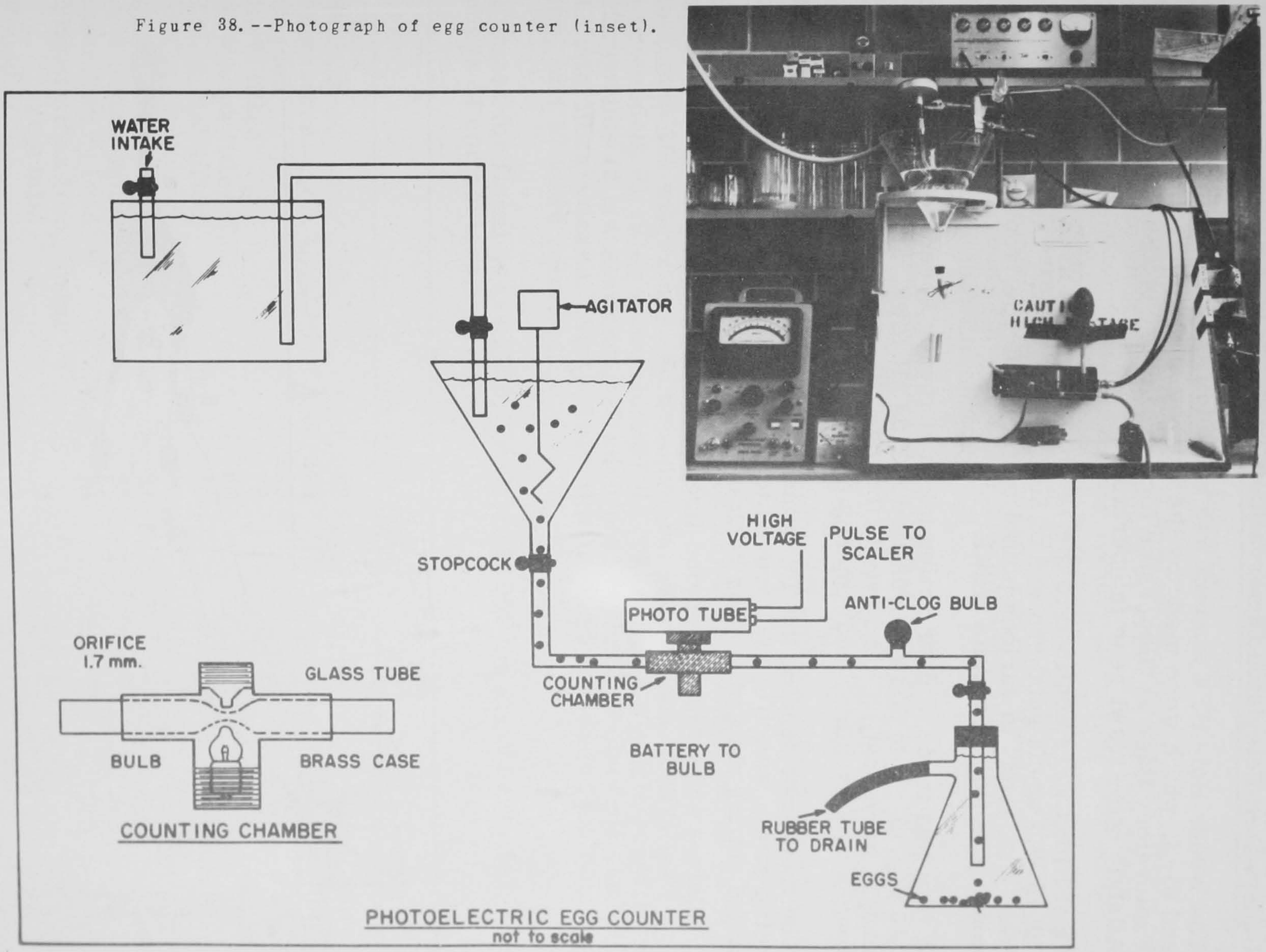


Figure 39.--Diagram of egg counter showing counting chamber.

Underwater Television Observations

The Woods Hole UTV system was used on Delaware cruises 60-9 and 61-3, which were made by the Bureau of Commercial Fisheries Exploratory Base at Gloucester for the purpose of observing North Atlantic otter trawl gear in operation.

Operations were confined to the 12- to 20-fathom area (42°13'N.-70°15'W.) at the southern end of Stellwagen Bank. The TV camera was "trolleyed" to various points on the headrope, footrope, and doors of a No. 41 manila trawl.

A film was made of door action taken at towing speeds of 120 to 210 r.p.m. The cod end was tied during all tows, and among the fish caught were dogfish, yellowtail flounder, ocean pout, skate, lumpfish, long-horned sculpin, and American lobster.

The method of sending the TV camera down the trawl wire or on a third strain wire (fig. 40) proved to be very satisfactory, since it enabled setting out and hauling back of the trawl in the normal manner.

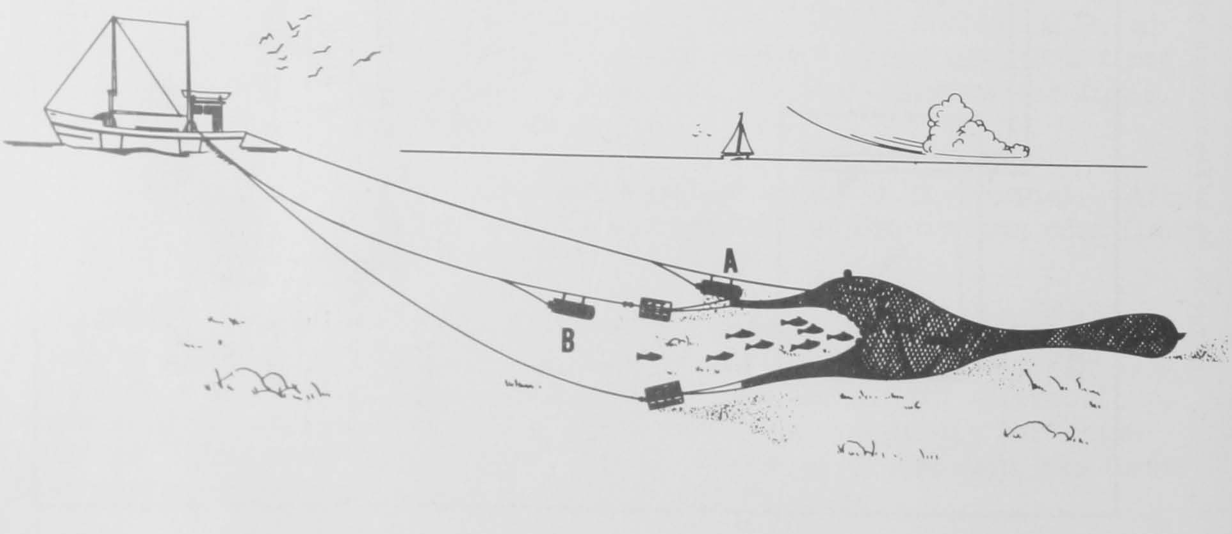


Figure 40.--(A) UTV camera "trolleyed" down to mouth at bottom or top of trawl.
(B) Trawl wire to door.

LIBRARY

Elizabeth B. Leonard

The Laboratory's library is now well settled-in after the last move. There is adequate shelf space for expansion for the next few years, unless the present volume of incoming fishery literature increases drastically. Our library specializes in fishery biology and related material, and in conjunction with the very complete biological library of the Marine Biological Laboratory across the street, offers unparalleled sources of material for any marine fishery investigation undertaken by this Laboratory.

The library at present has about 1,000 texts and treatises and nearly 1,500 volumes of pertinent periodicals. It receives, on an exchange basis, many contributions each year from other research institutions. A reprint collection is maintained in addition to collections of meeting documents, technical abstracts and research reports.

During the past year, a total of 1,702 items were added; cards were made for 315 of this total. Of the total number, 1,566 were serials, including 262 magazines and newspapers. Ninety new book titles were added; 91 titles were classified. There were 4 single reports, 15 reprints (2 translations), 27 additional copies, 14 discards, and 13 interlibrary loans. Sixty-five volumes were forwarded for binding, and 57 were returned.

Figures for fiscal years 1959, 1960, and 1961 are given below for purposes of comparison.

	Fiscal year		
	1959	1960	1961
Serials	1,568	1,507	1,566
Magazines	294	301	262
Carded	295	306	315
Book titles	78	58	--
New book titles	68	46	90
Titles classified	61	40	91
Single reports	6	9	4
Reprints	37	35	15
Additional copies	35	23	27
Interlibrary loan	42	34	13
Translations (inc. under reprints)	7	11	2
Bound	3	249	57
New serial titles	24	8	6
Total	1,944	1,722	1,702
Discards	4	94	14
Net gain	1,940	1,628	1,688

PUBLICATIONS

Conover, John T., Raymond L. Fritz, and Manuel Vieira

1961. A morphometric study of silver hake. U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report--Fisheries No. 368, 13 p.

Couture, Lawrence H.

1960. I. ICNAF mesh regulations, Operation of 10% Annual Exemption October 1, 1957, through September 30, 1959. International Commission for the Northwest Atlantic Fisheries, Annual Proceedings, vol. 10, p. 120-122.

Edwards, Robert L., and Robert Livingstone, Jr.

1960. Observations on the behavior of the porpoise Delphinus delphis. Science, July 1, 1960, vol. 132, no. 3418, p. 35-36.

Edwards, Robert L., and Lewis M. Lawday

1960. Species composition of industrial trawl fish landings in New England, 1958. Special Scientific Report--Fisheries No. 346, 20 p.

Edwards, Robert L.

1960. A new Austromenopon (Menoponidae-Mallophaga) parasitizing shearwaters(Puffinus-Procellariformes). Canadian Entomologist, vol. 92, no. 11, p. 817-819, November 1960.

Edwards, Robert L.

1961. Studies of the Philopteridae (Mallophaga) from birds of the order Procellariformes. I. The Genus Halipeurus Thompson. Journal of Parasitology, vol. 47, no. 1, p. 125-157, February 1961.

Edwards, Robert L.

1961. The fishes of Richmond Gulf, Ungava, Canada. Proceedings of the American Philosophical Society, vol. 105, no. 2, p. 196-205.

Fritz, Raymond L.

1960. A review of the Atlantic coast whiting fishery. Commercial Fisheries Review, vol. 22, no. 11, p. 2-11.

Fritz, Raymond L.

1961. Size distribution by depth of the longfin hake, _Phycis chesteri._ Copeia, 1961, no. 2, p. 229-230, June 19.

Galtsoff, Paul S.

1960. The three hearts of the oyster. Biological Bulletin, vol. 119, no. 2, p. 291.

Galtsoff, Paul S.

1960. Physiology of reproduction in molluscs. Anatomical Record, no. 138, p. 349-350.

Galtsoff, Paul S.

1961. Physiology of reproduction in molluscs. American Zoologist, no. 1, p. 273-289.

Graham, Herbert W.

1960. XI. United States research in the Convention Area during 1959. International Commission for the Northwest Atlantic Fisheries, Annual Proceedings, vol. 10, p. 112-115.

Jensen, Albert C.

1961. Recaptures of tagged spiny dogfish, _Squalus acanthias._ Copeia, 1961, no. 2, p. 228-229.

Jensen, Albert C.

1961. Scientists forecast improved catch of haddock on Georges during '61. National Fisherman, and Maine Coast Fisherman, vol. 41, no. 12, p. 10, March 1961.

Lux, Fred E.

1960. Length shrinkage of yellowtail flounder between live and landed condition. Transactions of the American Fisheries Society, vol. 89, no. 4, p. 373-374.

Lux, Fred E.

1961. Bureau studies yellowtails to balance market here. Sunday Standard-Times, New Bedford, Mass., February 26, 1961, p. 17.

Mather, III, Frank J., and Howard A. Schuck

1960. Growth of bluefin tuna of the western North Atlantic. U.S. Department of the Interior, Fish and Wildlife Service, Fishery Bulletin 179, vol. 61, 52 p.

Merrill, Arthur S., and John B. Burch

1960. Hermaphroditism in the sea scallop, Placopecten magellanicus (Gmelin). Biological Bulletin, vol. 119, no. 2, p. 197-201.

Merrill, Arthur S.

1961. Remarks concerning the benefits of systematic and repetitive collecting from navigation buoys. American Malacological Union, Buffalo Museum of Science, Bulletin No. 27, January 1, 1961 (abstract).

Merrill, Arthur S.

1961. Shell morphology in the larval and postlarval stages of the sea scallop, Placopecten magellanicus (Gmelin). Bulletin of the Museum of Comparative Zoology, vol. 125, no. 1, p. 20, 3 plates.

Shaw, William N.

1960. Observations on habits and a method of trapping channeled whelks near Chatham, Massachusetts. U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report--Fisheries No. 325, 6 p.

Shaw, William N.

1960. A fiberglas raft for growing oysters off the bottom. Progressive Fish-Culturist, vol. 22, no. 4, 154 p.

Sherman, Kenneth, and John P. Wise

1961. Incidence of the cod parasite Lernaeocera branchialis L. in the New England area, and its possible use as an indicator of cod populations. Limnology and Oceanography, vol. 6, no. 1, p. 61-67.

Skerry, John B.

1961. An eastward extension of the winter movement of mackerel, Scomber scombrus. Copeia, 1961, no. 1, p. 115.

Wigley, Roland L.

1960. Note on the distribution of Pandalidae (Crustacea, Decapoda) in New England waters. Ecology, vol. 41, no. 3, July 1960.

Wigley, Roland L.

1960. A new species of Chiridotea (Crustacea: Isopoda) from New England waters. Biological Bulletin, vol. 119, no. 1, p. 153-160, August 1960.

Wigley, Roland L.

1961. Bottom sediments of Georges Bank. Journal of Sedimentary Petrology, vol. 31, no. 2, P, p. 165-188.

Wigley, Roland L.

1961. A new isopod, Chiridotea nigrescens, from Cape Cod, Massachusetts. Crustaceana, vol. 2, part 4, p. 286-292.

Wigley, Roland L.

1961. Natural history of a selected species of marine invertebrate. In: High School Biology - Biological Investigations for Secondary School Students, p. 381-383; American Institute of Biological Sciences, Johnson Publishing Co., Boulder, Colo.

Wise, John P.

1960. Book review. Dangerous marine animals by Bruce W. Halstead. Transactions of the American Fisheries Society, vol. 89, no. 3, 1960, p. 318.