

Northwest Atlantic



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United States Research Report for 1988

by

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A. Status of the Fisheries (Subareas 3-6 inclusive)

Brief summaries are provided on the status of fisheries for major species of finfish and shellfish. More detailed information on these and other species is included in a report entitled "Status of the Fishery Resources off the Northeastern United States" prepared annually by the Northeast Fisheries Center of the National Marine Fisheries Service (NMFS).

1. Atlantic Cod

USA commercial landings from Subarea 3-6 increased 29% from 26,807 mt in 1987 to 34,505 mt in 1988. Compared to 1987, landings in Subarea 3 increased 23% (269 mt vs 218 mt), landings in Subarea 4 decreased 63% (11 mt vs 29 mt), landings in Subarea 5 increased 29% (33,967 mt vs 26,293 mt), and Subarea 6 landings declined 3% (258 mt vs 267 mt).

Landings in 1988 from the Georges Bank fishery (Div. 5Z + SA 6) totaled 26,270 mt, 38% higher than in 1987 (19,035 mt). The 1988 catch, however, was still the third lowest since 1977. Fishing effort in 1988 increased 10% from 1987 and was a record-high. Commercial CPUE in 1988 was slightly higher than the record-low 1987 value. USA research vessel indices indicate that stock abundance improved in 1988 due to good recruitment from the 1987 year class. Fishery age composition data indicate that landings in 1988 were dominated by the strong 1985 year class.

Gulf of Maine (Div. 5Y) landings in 1988 were 7,956 mt, 6% higher than in 1987 (7,527 mt). The 1988 catch, however, was still the second lowest since 1974. Otter trawl effort, which accounted for 57% of the 1988 landings, declined 9% from the record-high 1987 level. Commercial CPUE in 1988 remained at the record-low 1987 level. Research vessel indices from both spring and autumn 1988 surveys were higher than in 1987 due to above-average recruitment from the 1986 year class and strong recruitment from the 1987 year class. Fishery age composition data indicate that landings in 1988 were dominated by the 1984 and 1985 cohorts.

2. Haddock

USA landings from Subareas 3-5 in 1988 declined to 2,916 mt, a record-low level. Landings from Georges Bank (Subdiv. 5Ze) increased 16% from 2,154 mt in 1987 to 2,492 mt in 1988. Abundance of the Georges Bank stock is presently at an all-time low and is expected to decline further since recent recruitment has been poor. Landings from the Gulf of Maine stock (Div. 5Y) dropped from 828 mt in 1987 to 416 mt in 1988, a 50% decline. Commercial CPUE and research vessel indices in 1988 indicate that Gulf of Maine stock abundance is also at a record-low.

3. Redfish

Subarea 4

USA landings of redfish from Division 4X declined from 47 mt in 1987 to 10 mt in 1988.

Subarea 5

USA landings of redfish from Subarea 5 declined from 1,859 mt in 1987 to 1,054 mt in 1988, marking the ninth consecutive year of decline. Landings in 1988 were the lowest since 1934. Redfish are now taken primarily as by-catch in the Gulf of Maine mixed species otter trawl fishery. Stock biomass has declined by over 80% since the late 1960s and commercial and research vessel survey indices continue to exhibit downward trends. The 1978 year class remains the only significant year class in the fishery. All subsequent year classes have been poor.

4. Pollock

Subarea 4

USA landings in from Subarea 4 declined from 102 mt in 1987 to 60 mt in 1988.

Subarea 5

USA landings from Subarea 5 in 1988 were 14,876 mt, 27% lower than in 1987 (20,289 mt). Commercial CPUE has declined since 1983. Commercial fishery age composition data for 1988 indicate that the last strong year class, the 1982 cohort, dominated the landings. Since subsequent recruitment has been average or below, exploitable stock biomass is now declining.

5. Yellowtail Flounder

Subarea 3

USA 1988 landings from Divisions 3L, 3N and 3O were 862 mt, a 44% decline from 1987 (1,533 mt).

Subarea 5

USA landings declined from 5,684 mt in 1987 to 4,009 mt in 1988 (-29%). Catches from the Georges Bank stock in 1988 were 1,866 mt, the lowest since 1946. Landings from the Southern New England stock in 1988 were 859 mt, a record-low. For both stocks, commercial CPUE and research vessel survey

abundance indices in 1988 declined to record-low levels. Both fisheries remain heavily dependent upon incoming year classes, although recent recruitment has been poor in both stocks.

Subarea 6

Landings in 1988 were 170 mt, 50% lower than in 1987 (341 mt).

6. Other Flounders

USA landings of flounders (other than yellowtail flounder) from Subareas 3 - 6 in 1988 totaled 30,776 mt, 4% less than in 1987. Compared to 1987, landings from Subarea 3 increased by 9% (1,743 mt vs 1,595 mt); landings from Subarea 4 declined by 69% (17 mt vs 54 mt); landings from Subarea 5 declined by 6% (19,434 mt vs 20,784 mt); and landings from Subarea 6 remained about the same (9,582 mt vs 9,600 mt).

Summer flounder (37% of total), winter flounder (27%), American plaice (15%), witch flounder (12%), and windowpane flounder (8%) accounted for 99% of the other flounder landings. Summer flounder landings decreased 2% from 1987 to 1988, winter flounder declined 7%, American plaice fell 7%, witch flounder declined 5%, and windowpane flounder landings increased by 11%. Survey abundance indices for most of the 'other flounder' stocks declined in 1988.

7. Silver Hake

USA commercial landings from Subareas 5 and 6 in 1988 were 16,128 mt, a 3% increase from 1987 (15,710 mt). Landings from the Gulf of Maine - Northern Georges Bank stock increased 20% from 5,657 mt in 1987 to 6,791 mt in 1988, while landings from the Southern Georges Bank - Middle Atlantic stock declined 7% between 1987 and 1988 (10,053 mt vs 9,337 mt). Since 1982-1983, when spawning stock biomass reached record-low levels, both stocks have increased gradually in abundance due to strong recruitment from the 1985 and 1987 year classes and low fishing mortality.

8. Red Hake

USA 1988 commercial landings from Subareas 5 and 6 totaled 1,738 mt, 13% less than in 1987 (2,009 mt). Landings in 1988 from the Gulf of Maine - Northern Georges Bank stock were 863 mt, down 15% from 1987 (1,014 mt), while 1988 landings from the Southern Georges Bank - Middle Atlantic stock were 875 mt, 12% lower than in 1987 (995 mt). In both stocks, fishing mortality is low and stock abundance has increased due to strong recruitment from the 1985 year class.

9. Atlantic Herring

USA landings from Subarea 5 in 1988 were 40,394 mt, 2% higher than in 1987 (39,479 mt). Landings from the Gulf of Maine stock in 1988 were 40,147

mt, the highest annual catch since 1981. The Gulf of Maine stock has been increasing gradually in abundance since 1982 when stock size was at a record-low. Landings from Division 5Z were 247 mt in 1988, primarily from Subdivision 5Zw (233 mt). There has been no directed herring fishery in Subdivision 5Ze since the collapse of the fishery in 1977. There is recent evidence of recovery of the Georges Bank population based on research vessel survey results. Herring landings in Subarea 6 in 1988 were 511 mt, 84% higher than in 1987 (278 mt).

10. Atlantic Mackerel

USA commercial landings in 1988 from Subareas 5 and 6 totaled 12,258 mt, 3% lower than in 1987 (12,592 mt), but still the second highest USA commercial catch since 1949. Total stock biomass (Subareas 2-6) has been increasing since 1980 and is now approaching record-high levels. Rebuilding of the stock has resulted from low fishing mortality rates coupled with strong recruitment from the 1981-1982 and 1984-1986 year classes.

11. Butterfish

USA landings in 1988 from Subarea 5 and 6 were 2,083 mt, 56% lower than in 1987 (4,702 mt), and the lowest USA commercial catch since 1977. The 1988 catch was about divided equally between Subarea 5 (1,083 mt) and Subarea 6 (1,000 mt). The decline in landings in 1988 is attributed to decreased availability of butterfish, rather than a decline in stock abundance.

12. Squid

USA landings of long-finned squid (Loligo pealei) from Subareas 5 and 6 increased from 11,426 mt in 1987 to a record-high 19,038 mt in 1988 (+67%). Of the 1988 USA total, 55% of the landings (10,540 mt) was from Subarea 5 and 45% (8,498 mt) from Subarea 6. Survey abundance indices in 1988 indicated that stock abundance was at a high level.

USA landings in 1988 of short-finned squid (Illex illecebrosus) from Subareas 5 and 6 totaled 1,958 mt, 81% lower than in 1987 (10,224 mt). The 1988 USA catch was the lowest since 1981. All but 49 mt of the 1988 catch was taken from Subarea 6. The sharp decline in Illex landings in 1988 appeared to be due to market conditions, not reduced stock abundance. Survey indices in 1987 and 1988 indicated that Illex abundance remained at its highest level since the late 1970s.

13. Sea Scallops

USA commercial landings from Subareas 5 and 6 in 1988 were 12,905 mt (meats), 2% less than in 1987 (13,227 mt). The 1988 catch was the second highest since 1979 and the fourth highest ever. Compared to 1987, Georges Bank (Div. 5Z) landings (6,151 mt) increased 24%, Gulf of Maine (Div. 5Y) landings (526 mt) increased by 38%, while Mid-

Atlantic (Subarea 6) landings (6,228 mt) declined by 21%.

USA commercial CPUE indices in 1988 declined slightly in the Georges Bank and Mid-Atlantic fisheries. The 1988 indices were still the second highest in each region since 1982 and 1979, respectively. For the Gulf of Maine fishery, CPUE increased in 1988 and was the highest since 1982. Total USA scallop effort (days fished in all areas) in 1988 increased 13% from 1987 and was a record-high.

Abundance indices from the USA 1988 sea scallop research vessel survey indicate stock abundance of USA offshore scallop resources remained high in 1988. For the Mid-Atlantic resource, the 1988 survey indices were the highest in the 14-year survey time series due to strong recruitment from the 1985 year class. In the USA sector of Georges Bank, the 1988 survey indices were slightly lower than high values obtained in 1987. The 1985 year class appeared to be of only average strength on Georges Bank.

B. Special Research Studies (Subareas 4-6)

1. Environmental Studies

- a) Hydrography. Current meters deployed in the inner New York Bight were recovered in May 1988. These measurements are part of a program to document the effects of the cessation of sewage sludge dumping at the 12-mile dumpsite. Current meters were then redeployed near bottom at four locations to continue the study. Two sections of oceanographic observations (temperature and salinity) were made in the area of the meters in May and November.

Computer programs were developed to compare satellite sea-surface temperature data (AVHRR) on one day with data on any other day to produce a contoured map of the differences. The capability to answer the frequently-asked question as to how this year's conditions compare with last year's has now been improved considerably.

Reports were compiled for 1987 summarizing environmental conditions in the shelf and slope waters off the northeastern U. S. A., dealing with the movements and paths of the Gulf Stream warm-core rings, the position and variability of the shelf/slope front, and water column temperature structure across the New York Bight.

A report was prepared on a nearshore band of cold water along the New Jersey Coast during the summer months of 1988, caused by unusually persistent southwesterly winds which led to prolonged upwelling.

A report was issued describing the oceanographic conditions on the northeast continental shelf during 1987 as observed on four surveys of the shelf region.

A report was provided describing the seasonal influx of Slope Water into Great South Channel. The influx was evident in both physical water properties and in the occurrence of

ichthyoplankton of fish species from the slope region.

A report was prepared which presented a method for estimating the expected surface or bottom temperature for any one day of the year at any location on the northeast continental shelf. The method is based on eleven years of MARMAP I hydrographic sampling. A disk with a computer program for making the temperature estimates is included with the report.

- b) Zooplankton. Copepod data gathered on MARMAP I surveys between 1977 and 1984 from Georges Bank (≥ 60 M) and western Gulf of Maine were analyzed to characterize the seasonal abundance patterns of Calanus finmarchicus, Centropages typicus, and total copepods. These data were further examined to identify significant departures from the fitted cycles and to relate these to inter-annual variability in water temperature, stratification, and wind stress. In the early 1980s abundance of these animals declined and there was a decay in the seasonal pattern. Calanus abundance correlated with stratification in the Gulf of Maine and Georges Bank, whereas Gulf of Maine Centropages correlated with temperature. Total copepods (without Calanus and Centropages) in both areas, and Georges Bank Centropages showed no definable relationship with the environmental parameters examined in this study.

The twenty-seventh year of monitoring the Gulf of Maine with the Continuous Plankton Recorder has been completed. Zooplankton abundance as measured by total Copepoda was significantly higher in the spring over the Crowell Basin and the Nova Scotian Shelf than the long term means. With the exception of the winter over Massachusetts Bay, the Gulf showed no major departures of zooplankton abundance from normal. Low salinities, which coincided with low zooplankton abundance during 1983 and 1984, were present early in 1988; but there was no corresponding low in the plankton. The thirteenth year of monitoring the New York to Bermuda transect was completed. The unusual temperature and salinity conditions in the Mid-Atlantic Bight are being compared to the phyto- and zooplankton conditions there.

A report was prepared on the use of image analysis in the study of large marine ecosystems. It was concluded that computerized image analysis can speed ecosystem monitoring by automating plankton identification and sizing. For greatest efficiency, a real time in situ image analyzer should be built to give instantaneous underway readouts of plankton identification and concentration. Proposals for the development of this equipment have been prepared.

- c) Ichthyoplankton. A two year study to measure the changing status of Atlantic Sea Herring in the Nantucket Bay/Georges Bank area was initiated in the autumn of 1988. Objectives of the four monthly cruises from early October through mid-January were to: (1) determine the distribution, abundance, and production of larval herring, (2) provide estimates of adult spawning biomass in each of the three subareas, provide collections of larvae from each subarea for age/growth and genetics analyses, and (3) record environmental

observations throughout the study area. Ichthyoplankton samples were collected with a 61-centimeter bongo fitted with a 0.505 millimeter mesh net. Sampling procedure followed standard MARMAP I protocol; i.e., the net was payed out at 50 meters per minute and retrieved at 20 meters per minute. Towing speed varied between 1.5 and 2.5 knots to maintain a 45 degree wire angle during each tow. Samples are being processed by the Polish Sorting Center; results are expected by late spring of 1989. Ageing studies using otoliths are underway at NEFC's laboratory at Woods Hole, Massachusetts. The field work will be repeated in the autumn of 1989.

Laboratory rearing of embryos and larvae spawned by sand lance collected over a year ago at Watch Hill, Rhode Island, and sand lance collected on Georges Bank in September 1988, continued. Spawning adults had a range of meristic counts encompassing values reported for both Ammodytes americanus and A. dubius. Meristic counts fell into categories corresponding to the origin of the specimens. Crosses between the two supposed species have produced viable larvae. A varying proportion of embryos appeared to develop to the point when hatching should have occurred, but failed to hatch, possibly due to a deficiency in hatching enzyme. The phenomenon was not observed in earlier work with the inshore species. Groups of larvae representing the two species and the hybrid are being reared through the juvenile stage. Life history and morphometric characteristics will be determined. Samples are being preserved for biochemical studies. The possibility of cooperative studies with scientists of the University of Maine, Orono, Maine on molecular systematics is being explored.

A comparison of growth and survival of egg and larval winter flounder from Narragansett Bay, Rhode Island, and Long Island Sound, New York, continued. Results show differences in larval survival between the Madison (control) and Morris Cove (pollution impacted) sites in Long Island Sound. Survival of larvae from Narragansett Bay fell between these groups. Any effects of size or age of females and spawning time on egg and viability of egg and larvae appear subtle. Egg size and viability were lower among late spawners. The project is part of a long-term study of the effects of biological factors, natural environmental variability, and pollution on production of winter flounder.

Results of field studies have shown that recently-settled juvenile cod and haddock, observed by submersible dives and research bottom trawls, primarily inhabit an extensive lag pebble-gravel deposit located on the northeastern edge of Georges Bank at depths of 70 to 100 meters. Pelagic juvenile gadids normally are widespread on the bank in late spring. By late July, they become demersal and are abundant only on the gravel bed, which apparently favors their survival through predator avoidance and/or enhanced food availability. Coloration of the juveniles mimics the appearance of the pebble bottom, probably making them less vulnerable to predation there than on light colored sand bottom of most areas of the bank. It appears that the gravel habitat, in particular the large pebble-gravel deposit on northeastern Georges Bank, is

essential to the recruitment success of the Georges Bank gadid population. By September, the young fish are no longer present on the gravel bed because their night-time feeding forays off the bottom cause them to be transported southeastward in the clockwise current gyre on the bank. During the day, demersal juveniles remain within a few centimeters of the bottom, maintaining their position by constant swimming into the strong bottom current. Thus, abundance estimates based on research bottom trawls vary greatly within those based on submersible observations, with the trawl data underestimating the numbers of juvenile fish present.

Analyses of field data collected from various cruises on Georges Bank continued including: (1) temperature-salinity data for zooplankton collections to establish sigma-t characteristics of the three major faunal groupings found of Georges Bank; (2) identification and enumeration of zooplankton from the 95 station coverage of Georges Bank sampled during juvenile fish survey (ALBATROSS IV Cruise 87-04); (3) the relationship of sand lance and larval herring from the ICNAF ichthyoplankton data series; and (4) completion of analyses of cod and haddock larvae and pelagic juveniles for RNA, DNA, and protein. The fish were collected at discrete depths at stratified and well-mixed sites on Georges Bank (ALBATROSS IV Cruise 87-07). The data will be used to assess fish condition.

- d) Benthic Studies. Studies of factors limiting shellfish production were conducted. They included: (1) experiments on effects of organic contaminants in sediment trays on settlement of larval bivalves and other invertebrates; (2) interviews with lobster persons to assess any changes in catches and pot conditions that might be related to phase out of sewage sludge disposal; and (3) means of reducing predation on juvenile hard clams, Mercenaria mercenaria (e.g., spreading Spisula shells). Other benthic studies included: (1) patterns of benthic macrofauna assemblages on the northeast U. S. continental shelf over space and time; and (2) descriptions of new species from the same sampling program.

Manuscripts were completed on: (1) the seasonal distribution of Crabs on the Northeast U. S. continental shelf; (2) a review of the history of fishing and shellfishing in Raritan Bay (New York/New Jersey); (3) assemblages of benthic macrofauna in the New York Bight, 1979-87; (4) Lumbrineris (Annelida and Polychaeta) collected in two northwestern Atlantic surveys, with descriptions of three new species; (5) effects of high concentrations of sediment metals on larval settlement in areas of high and low ambient contamination; (6) description of the winter dredge fishery for blue crabs in Raritan Bay; and (7) summary of benthic macrofauna information for the Middle Atlantic Bight.

A paper was also completed, in cooperation with the Department of Marine Fisheries, State of Maine and the Bigelow Marine Biological Station at Boothbay Harbor, Maine, on the distribution, abundance and behavior of sea pens (Pennatula spp.) in the Gulf of Maine.

- e) Environmental Quality. An intensive monitoring study of the 12-mile sludge dumpsite in the New York Bight continued through 1988. Monthly biological, chemical, and physical measurements were continued after the complete phaseout of dumping in late December 1987. Results from July 1987 to July 1988 were presented in a second annual report, indicating that some changes, which may reflect recovery, were observed. For example, sediment core analysis suggested a significant recent transport of particles originating at the dumpsite, down the Hudson Valley; also values of the bottom water dissolved oxygen minima at the dumpsite have decreased. Although benthic infauna analyses have shown no significant change between 1987 and 1988, there were fewer oscillations in total and crustacean species counts in 1987. Dominant species of fish and macro invertebrates have remained similar, but there has been a general decrease in the variation of trawled catch biomass among reference and control stations. Food habit studies indicate prey items have remained similar at these stations. As observed during earlier months of the survey, winter flounder disease incidence has remained generally low.

2. Fish Biology Studies

- a) Migrations and Stock Identification. Studies continued on identification of Atlantic salmon and striped bass stocks using image analysis. Equipment from Biosonics Corporation, Seattle, Washington, has been used to explore different methods of measurement of scales and otoliths of several species, and preliminary results are encouraging. The continent of origin of salmon can be determined easily using discriminant analysis, and determination of the river of origin appears possible.

The Hudson River and Chesapeake Bay stocks of striped bass appear to differ in their scale morphology, as indicated previously using a prototype image analysis system. Various biochemical methods are being compared this year for stock discrimination of the species.

A manuscript has also been completed which suggests that the seasonal migratory movements of mackerel in the Mid-Atlantic is related strongly to sea temperature.

- b) Age and Growth. Approximately 30,000 age determinations were completed for 12 species of finfish and shellfish. A technical manual describing methods of age determinations for species of fish from the NW Atlantic has been published.

A method to age sea scallops from the mid-Atlantic/Georges Bank region has been developed and validated.

The minimal number of fish or invertebrates required to obtain adequate samples for aging has been established.

A study of growth-maturity interactions of Acadian redfish has been completed; a manuscript relating to the interactions has been prepared.

A manuscript analyzing changes in the growth rates of mackerel was completed, suggesting that the growth rate has decreased as the size of the stock has increased.

- c) Pathobiology. Monitoring studies of Swan Point, Chesapeake Bay soft shelled clams (Mya arenaria) indicate the sarcoma disease reported last year reached a high of 74 % in July 1988. By September the disease had disappeared in both populations of juvenile and adult clams. A very heavy mortality occurred in clams throughout Chesapeake Bay the summer of 1988 that was not related to the presence of the sarcoma disease. Poor environmental conditions related to the extreme summer drought that occurred in the area during this period may have precipitated the wide spread mortalities of clams.

A modification of the standard thioglycollate culture technique was developed for diagnosing the protozoan pathogen "DERMO" (Perkinsus marinus). The new method uses hemolymph instead of tissues, yet maintains diagnostic sensitivity while cutting the processing time in half and significantly reducing the cost of needed materials.

"MSX" (Haplosporidium nelsoni) and "DERMO" (Perkinsus marinus) continued to cause mortalities in the salinity areas of Chesapeake Bay. Field studies conducted in moderately saline areas of the Tred Avon River, Maryland showed both diseases were infecting oysters, but that no significant die-offs were occurring.

- d) Physical and Genetic effects of Pollutants.
Reproductive Success of Winter Flounder:
Consistently, over three reproductive seasons (1986-1988), embryos of winter flounder (Pseudopleuronectes americanus) from the deepest and the most presumed pristine waters of Long Island Sound off Shoreham, Connecticut, had the best survival rate and most normal development. The fish sampled from the most shallow, near-shore waters in New Haven Harbor had the highest mortality and gross abnormality. These differences were substantiated by measures made with sublethal indicators. Embryos of winter flounder from all other sites sampled in Long Island Sound had mortalities which fell somewhere between the levels of mortalities of fish off Shoreham and in New Haven Harbor. The degree of early reproductive success corresponds more to an inshore-offshore pollutant gradient than an east-west gradient, at least for the Long Island Sound sites sampled.

In nature, reproduction may be more impaired than estimated in the laboratory, if flounder from populations sampled in more deep waters in the study come much further in-shore to spawn. Also, egg quality and sublethal effects on embryos are expected to be correlated with defects in larval fish, and even with growth of juvenile fish.

The eggs, the newly-hatched larvae, and the larval yolk sacs of flounder found in Boston Harbor were all significantly smaller than those of Long Island Sound flounder. The higher the

levels of lead and PCB of the oocytes, the smaller the eggs is the sampled fish. Although there was a significant relationship between egg size and age of Long Island Sound flounder, this was not so for Boston Harbor flounder.

In the sample subset comprising mostly embryos of Boston harbor flounder, there was a significant linear correlation of total pre-hatch mortality with oocyte zinc levels; and a less strong one between mitotic abnormality and oocyte pesticide levels. There were significant correlations of oocyte pesticide and PCB levels with abnormal differentiation and depth of embryo cells. In a much larger set of data from Long Island, there were no statistically significant correlations between PCBs and any reproductive effects indicator.

Hard Clam Reproductive Success. Another reproductive study confirmed the utility of resource shellfish as an in situ model for similar studies of habitat degradation and pollution on populations. The spawned shellfish egg is particularly sensitive to water quality. Over the two breeding seasons of this study, the hard clam Mercenaria mercenaria showed associations between poor water quality, decreased production, and size of its eggs. These traits were further linked to increase frequency of mitotic and cellular abnormality in early embryo development, as well as to larval viability.

Dinoflagellate Studies. A bloom of the dinoflagellate, Prorocentrum, that occurred in western-to-central Long Island Sound during the summer of 1987 was associated with reduced growth rates of hard clams planted in predator-proof cages near Greenwich and Milford, Connecticut. In contrast, during 1988, microscopic examination of Long Island Sound seawater, sampled each 3-4 weeks from western, central, and eastern stations revealed no blooms of dinoflagellate, but rather, consistently diverse, diatom-dominated assemblages. No mid-summer drops in clam growth rates were observed in 1988, providing further evidence that Prorocentrum was responsible for slowed mid-summer clam growth in 1987, and emphasizing the importance of phytoplankton quality as well as quantity (chl a) in determining the growth of filter-feeding bivalve mollusks.

Antibody Studies of Winter Flounder. Antibody titers for several hundred serum samples from winter flounder of Long Island Sound and Boston Harbor were compiled. With one exception, antibodies to a panel of eight bacterial pathogens were higher in fish taken from degraded environments. The exception, low antibody levels in fish from Black Rock Harbor near Bridgeport, Connecticut, could have resulted from short residence times for fish in the harbor. Catch records are currently being examined to determine seasonal and catch-per-effort statistics for the Black Rock Harbor site. Comparison with statistics from other sampling sites may indicate whether flounder spend little time in Black Rock Harbor.

Reproductive Success of Lobsters in Long Island Sound. Reproductive success of a species is often a clear indicator of the future status of the

population of that marine organism. During 1988 a project was initiated to evaluate reproductive success of lobsters collected from several areas of Long Island Sound. Egg-bearing lobsters were brought into the laboratory and the eggs were hatched and cultured in laboratory containers. Reproductive success was measured by monitoring hatching success, number of days required to reach the fourth larval stage, and growth and survival of juvenile (post-larval) lobsters up to 180 days old. Hatching success was better than 95% at all three collection sites. The number of days required to reach the fourth molt stage was a very normal 15-20 days in lobsters from each station. A total of 239 post-larval lobsters were cultured for 180 days with survival and growth monitored regularly. Growth and survival were slightly lower in lobsters from New Haven, Connecticut, intermediate in those collected off Bridgeport, and best among the lobsters from Milford. It is interesting to note that when reproductive success of winter flounder was reported last year, New Haven was also the site signaled out as the area with lowest indication of reproductive success. This study will be repeated in 1989 to see if this indication continues. An additional station in the far western end of the Sound will also be included.

- e) Research Vessels Surveys. In 1988 the NEFC conducted routine spring and autumn bottom trawl surveys from Cape Lookout, North Carolina to Nova Scotia during March-April and September-October, respectively. In addition, NEFC conducted one MARMAP I survey from Cape Hatteras to Nova Scotia, three Enforcement Surveys, two Gear Testing and one Fishing Power Experiment, a Sea Scallop and an Icelandic Scallop Survey, two Larval Herring Surveys, two Current Meter Experiments, two Oceanography and Sediment Sampling Surveys, one Sand/Lance Survey, a Blue Crab Larvae Survey, a Ship Wake Measurement Experiment, and six Pelagic Blue Fish Larvae Surveys.
- f) Population Studies and Multispecies Modeling. A short term projection model of the abundance of several pelagic species in the Northeastern U. S. has been constructed, and is now being tested. The model focuses on the predatory relationships among adult animals; the principle species are mackerel, herring, sand lance, silver hake, several marine mammals, and marine birds. Data are being assembled to provide preliminary estimates of present abundance levels, predatory preferences and consumption rates, and spatial overlap patterns. Preliminary sensitivity tests have been used to identify additional data needs, including (1) marine mammal abundance, (2) directed trawl surveys, (3) additional food habits data from fish, especially cetaceans, and (4) sea bird distribution. The model is intended to help evaluate the short term effect of changes in fishing rates on different species of fish.
- g) Mackerel Population Estimates. Fecundity estimates of Atlantic mackerel, *Scomber scombrus*, were derived from specimens collected near spawning areas on the Continental Shelf of the U. S. and Canada in 1987. The 1981 and 1982 year classes were dominant in both locations. Estimates of the population spawning in U. S. waters were lower than those reported in other studies. However, estimates of both the U. S. and

Canadian spawning populations were higher than those reported previously for Canadian waters and several Northeast Atlantic spawning.

- h) Food Habits Studies. In a study of potential sources of invertebrate predators on fish, the gut contents of over 1,900 juvenile squid (*Loligo pealii*) taken from spring, summer, and fall trawl surveys were examined. As mantle length (mean length) increased from 2.0 to 4.0 centimeters, the squid feeding habit changed from planktivory to planktivory supplemented by cannibalism. By 4.0 centimeters (mean length) juvenile fish remains began to appear in the squid stomachs, and, in the largest specimens examined, the diet consisted of approximately equal quantities of fish, squid, and crustaceans.

Data were collected on stomach contents of more than 9,400 fish in 1988, chiefly on the spring and fall groundfish surveys. Priority was given to piscivores including elasmobranchs (40%, mostly dogfish and skates), hakes (30%) and cod (10%). Sand lance continued to be the major fish prey overall. The incidence of herring as prey continued to increase, particularly in dogfish stomachs. This is consistent with the increased level of herring abundance on Georges Bank.

Analysis of mackerel gut contents from a May 1986 study by two vessels on Georges Bank showed significant predation by mackerel on O-group sand lance; O-group cod and haddock were also found in the stomachs of mackerel. Discontinuities in the distribution of mackerel and the O-group fish suggested that mackerel predation may have had a significant impact on the abundance of the O-group fish in the path of the migrating mackerel.

3. Marine Mammals and Sea Birds

A preliminary analysis of contemporaneous marine mammal sighting and trawl survey observations was completed. The spatial and temporal overlap of principal pelagic prey species and cetaceans and marine birds was examined as a possible indicator of predatory interactions, an especially difficult question for research on cetaceans. Several directions for further analysis were suggested utilizing other data collected during trawl and plankton surveys, especially the stomach contents data collected during the trawl surveys. A manuscript was completed describing results from an initial experimental sighting survey of harbor porpoise in the Bay of Fundy suggesting an approach to testing key assumptions of line transect theory. A follow-up experimental survey to test several assumptions was completed.

4. Fishing Power and Gear Selectivity

Field work for a study designed to compare the fishing power of the R/V's ALBATROSS IV and DELAWARE II was completed. Two hundred twenty seven pairs of tows were completed between September 19 and October 28, 1988. These tows were completed while the ALBATROSS IV was conducting the autumn bottom trawl survey. The study area was from Cape Charles, Virginia, to the Scotian Shelf.

5. Fisheries Economics

A research report on modeling spatial distributions of effort, landings, processing and consumption was submitted for publication. Vessel time series data bases are being developed for projects to model: a) vessel response to limitations on fishing areas, and b) the total supply of effort to a given fishery from all sources. Economic performance tables on vessels in the major fisheries in the Northeast Region have been produced. Other investigation publications deal with compensation for marine resource damage, coastal property values, forecasting recreational fishing, and estimating coastal demographic changes.