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United States Research Report for 1989
by

H.C. Boyar and F.M. Serchuk

NOAA/NMFS, Northeast Fisheries Center
Woods Hole, MA 02543, USA

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 3% from 34,505 t in 1988 to 35,571 t in 1989. Compared to 1988, landings in Subarea 3 decreased 59% (111 t vs 269 t), landings in Subarea 4 increased 45% (16 t vs 11 t), landings in Subarea 5 increased 3% (34,950 t vs 33,967 t), and Subarea 6 landings increased 91% (494 t vs 258 t).

Landings in 1989 from the Georges Bank fishery [Div. 5Z+6] totalled 25,050 t, 5% lower than in 1988 (26,310 t). Otter-trawl effort decreased 5% from the record-high 1988 level, while USA commercial CPUE remained the same in 1989 as in 1988. USA research vessel indices indicate that stock abundance improved markedly in 1989 due to good recruitment from the 1987 and 1988 cohorts. Fishery age composition data indicate that landings in 1989 were dominated by the strong 1985 and 1987 year classes.

Gulf of Maine [Div. 5Y] landings in 1989 were 10,394 t, 31% higher than in 1988 (7,958 t), and the highest annual catch since 1985. Otter trawl effort, which accounted for 59% of the 1989 landings, declined 14% from 1988, and was the lowest since 1981. USA commercial CPUE increased sharply in 1989 to its highest level in six years. Research vessel survey indices indicate that stock abundance continued to improve in 1989 due to above-average recruitment from the 1986-1988 year classes. Fishery age composition data indicate that landings in 1989 were dominated by the 1985 and 1986 cohorts.

2. Haddock

USA landings from Subareas 3-6 in 1989 declined to 1,733 t, a record-low level. Landings from Georges Bank [Subdiv. 5Z] decreased 42% from 2,492 t in 1988 to 1,435 t in 1989. Abundance of the Georges Bank stock continues to remain near record-low levels, despite some modest increases in stock size during 1988 and 1989 due to recruitment of the 1987 year class. Landings from the Gulf of Maine [Div. 5Y] haddock stock in 1989 were a record-low 263 t, 37% lower than in 1988 (416 t). Commercial CPUE and research vessel indices in 1989 indicate that Gulf of Maine stock abundance is at a record-low level and still declining.

3. Redfish

Subarea 4. USA landings of redfish from Division 4X totalled only 2 t in 1989.

Subarea 5. USA landings of redfish from Subarea 5 declined from 1,054 t in 1988 to 629 t in 1989, marking the tenth consecutive year of decline. Landings in 1989 were the lowest since 1934. Redfish are 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 is currently between 20,000 - 25,000 t. The 1978 year class remains the only significant year class in the fishery. All subsequent year classes have been poor.

Pollock

Subarea 4. USA landings from Subarea 4 declined from 60 t in 1988 to 35 t in 1989.

Subarea 5. USA landings from Subarea 5 in 1989 were 10,510 t, 29% lower than in 1988 (14,876 mt), and the lowest annual catch since 1975. USA commercial CPUE has declined consistently since 1983. Commercial fishery age composition data for 1989 indicate that the last strong year class, the 1982 cohort, no longer dominates the landings. Stock biomass is now declining as a result of high fishing mortality.

Yellowtail Flounder

Subarea 3. USA 1989 landings were 319 t, a 63% decline from 1988 (862 t).

Subarea 5. USA landings increased from 4,009 t in 1988 to 4,732 t in 1989 (+18%). Although landings from the Georges Bank stock in 1989 dropped to 1,134 t [the lowest since 1946], landings from the Southern New England stock nearly tripled between 1987 and 1989 (859 t to 2,477 t). For both stocks, research vessel survey abundance indices increased sharply in 1989 and were the highest since 1983 due to strong recruitment from the 1987 year class. In the latter half of 1989, landings from both stocks were dominated by fish from the 1987 cohort reflecting heavy dependence by these fisheries on incoming recruitment.

Subarea 6. Landings increased from 170 t in 1988 to 527 t in 1989.

Other Flounders

USA landings of flounders [other than yellowtail flounder] from Subareas 3 - 6 in 1989 totalled 21,541 t, 30% less than in 1988. Compared to 1988, landings from Subarea 3 declined by 18% (1,429 t vs 1,743 t); landings from Subarea 4 declined by 71% (5 t vs 17 t); landings from Subarea 5 declined by 21% (15,439 t vs 19,434 t); and landings from Subarea 6 declined by 51% (4,668 t vs 9,582 t). Winter flounder (31% of total), summer flounder (29%), American plaice (16%), windowpane flounder (12%), and witch flounder (11%) accounted for 99% of the other flounder landings. Winter flounder landings decreased 19% between 1988 and 1989, summer flounder declined 46%, American plaice fell 26%, windowpane flounder increased 5%, and witch flounder landings declined by 35%. Survey indices for nearly all of the 'other flounder' stocks declined in 1989.

Silver Hake

USA commercial landings from Subareas 5 and 6 in 1989 were 17,821 t, a 10% increase from 1988 (16,128 t). Landings from the Gulf of Maine - Northern Georges Bank stock declined to 4,647 mt in 1989 [the lowest level since 1982], while landings from the Southern Georges Bank - Middle Atlantic stock (13,174 t) increased 41% from 1988 and were the highest since 1979. Research vessel survey indices in 1989 indicate a marked increase in abundance in the Northern stock due to strong recruitment from the 1988 year class, but little change in abundance of the Southern resource where stock size have been relatively low since 1986.

Red Hake

USA 1989 commercial landings from Subareas 5 and 6 were 1,558 t, a record-low, and 10% less than in 1988 (1,738 t). Landings from the Gulf of Maine - Northern Georges Bank stock in 1989 were 776 t [-10% from 1988], while landings from the Southern Georges Bank - Middle Atlantic stock totalled 782 t [-11% from 1988]. In both stocks, fishing mortality is low and stock levels have increased recently due to good recruitment from the 1985 and 1988 year classes.

Atlantic Herring

USA landings from Subarea 5 in 1989 were 40,542 t, about the same as in 1988 (40,394 t). Landings from the Gulf of Maine stock in 1989 were 40,386 t, the highest annual catch since 1981. Gulf of Maine spawning stock biomass has increased markedly in recent years [doubling between 1986 and 1989] and is currently relatively high [i.e., comparable to SSB levels observed in the late 1960s]. Stock size has increased due to strong recruitment from the 1983 year class and reduced fishing mortality rates, particularly on juvenile herring. Landings from Division 52 were 156 t in 1989,

primarily from Subdivision 5Zw (137 t). There has been no directed herring fishery in Subdivision 5Ze since the collapse of the fishery in 1977. There is evidence of continuing recovery of the Georges Bank population based on research vessel survey results. Herring landings in Subarea 6 in 1989 were 125 t, 76% lower than in 1988 (511 t).

10. Atlantic Mackerel

USA commercial landings in 1989 from Subareas 5 and 6 totalled 14,634 t, 19% higher than 1988 (12,257 t), and the highest USA annual catch since 1949. Total stock biomass [Subareas 2-6] has been increasing since 1980 and is now comparable to the record-high levels observed in the late 1960s. 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 1989 from Subarea 5 and 6 were 3,121 t, 50% higher than 1988 (2,083 t), but still the second lowest USA commercial catch since 1980. The 1989 catch was about equally divided between Subarea 5 (1,750 t) and Subarea 6 (1,371 t). Research vessel survey indices in 1989 increased sharply due to strong recruitment from the 1988 year class.

12. Squid

USA landings of long-finned squid, Loligo pealei, from Subareas 5 and 6 increased from 19,038 t in 1988 to a record-high 23,402 t in 1989 [+23%]. Of the 1989 USA total, 47% of the landings (10,929 t) was from Subarea 5 and 53% (12,473 t) from Subarea 6. Survey abundance indices in 1989 indicated that stock abundance approached record-high levels.

USA landings of short-finned squid, Illex illecebrosus, from Subareas 5 and 6 increased from 1,958 t in 1988 to 6,802 t in 1989, primarily due to improved market conditions. All but 96 t of the 1989 catch was taken in Subarea 6. Survey abundance indices in 1989 indicate that Illex abundance still remains at a relatively high level.

13. Sea Scallops

USA commercial landings from Subareas 5 and 6 increased from 13,198 t (meats) in 1988 to a record-high 14,519 t in 1989. Compared to 1988, Georges Bank [Div. 5Z] landings (5,824 t) declined by 5%, Gulf of Maine [Div. 5Y] landings (644 t) rose by 22%, while Mid-Atlantic [Subarea 6] landings (8,051 t) increased by 23%.

USA commercial CPUE indices declined in the Georges Bank and Gulf of Maine regions in 1989, but increased slightly in the Mid-Atlantic fishery. The 1989 Georges Bank CPUE index was the lowest since 1985 [and the third lowest on record], while Mid-Atlantic CPUE in 1989 was the second highest recorded since 1980. Total USA scallop effort [days fished in all areas] in 1989 increased 21% from 1988 and was a record-high.

Abundance indices from the USA 1989 sea scallop survey indicate that scallop abundance in the Mid-Atlantic area remains at a record-high, while scallop abundance in the USA sector of Georges Bank has declined to a record-low. In the Mid-Atlantic resource, strong 1982-1985 year classes have been followed by an exceptional 1986 cohort. On Georges Bank, strong 1982-1984 year classes have been followed by much weaker 1985 and 1986 cohorts.

B. Special Research Studies (Subareas 4-6)

1. Environmental Studies

- a) Hydrography. Analysis of bottom current meter data in the inner New York Bight has revealed a strong association between wind velocity and bottom currents, especially currents up and down the Hudson Shelf Valley. Further analyses are being conducted on other forcing functions.

Reports of conditions in shelf and slope waters off the northeastern U. S. in

1988 were prepared, dealing specifically with the position of the shelf/slope front, movements and paths of warm core Gulf Stream rings, and the temperature structure along a transect in the New York Bight.

The 13th annual report of surface water masses present and receiving wastes at the 106-Mile Dumpsite (38 40' -39 00'N, 72 00' - 72 05'W) was prepared from Satellite AVHRR data spanning 1988. Slope water was involved 59% of the time, shelf water 18%, and warm core ring water 23%.

Oceanographic surveys (temperature and salinity) of the inner New York Bight were conducted in June and August. These observations were in support of a multi-year study of the changes occurring in the inner bight following the cessation of sludge dumping at the 12-Mile Dumpsite.

An oceanographic survey (temperature and salinity) of Georges Bank was conducted in the fall of 1989 in support of research on the resurgence of herring spawning on the bank.

A report was issued describing the oceanographic conditions on the northeast continental shelf during 1986 as observed on four surveys of the shelf region.

- b) Zooplankton. During 1989, two studies of the effect of environmental variability on the abundance and distribution of a dominant copepod species Calanus finmarchicus were completed. Information from the ten-year MARMAP data base for the Northeast Continental Shelf ecosystem was used to model the annual cycle of abundance and to identify years of significant departure from the long-term data base. Correlation analysis was used to examine relationships between C. finmarchicus abundance and environmental variables including wind stress, stratification, chlorophyll, and temperature. The strongest correlations were negative between water temperature and copepod abundance with the higher abundance correlated with periods of lowest mean water column temperatures in spring. A second study using the same data base demonstrated that the principal determinant of the geographical occurrence of C. finmarchicus on the Northeast Continental Shelf is also temperature. Information gained from these analyses are the basis for efforts to develop indices on the state of the environment of the Northeast Continental Shelf ecosystem. Approaches being considered include multivariate analysis of the MARMAP data set, measures of standardized anomalies from a long-term mean based on the continuous plankton recorder Ship-of-Opportunity Program and composite indices based on deviations of ecologically important parameters from their long-term means.

The automated plankton analyzer, which uses image analysis to count, measure, and identify zooplankton was upgraded. The new system is based on an IBM PC-AT and used an inexpensive frame grabber board. The major advantage this system has over the old is its ability to be used in a flow-through mode, in which the sample is pumped through an imaging chamber viewed by the camera. This technique, now being completed in a cooperative project with University of Rhode Island scientists, allows for more accurate and efficient sample handling.

Scientists in the Plankton Ecology Investigation, working in cooperation with Australian researchers, published a study on the age structure of Antarctic krill in Polar Biology. Chemical and morphometric techniques (both manual and image analysis based) were used to show that the population was probably made up of six different year classes of adults.

The year 1989 marks the 29th year of monitoring plankton and environmental conditions across the Gulf of Maine and the 14th year of monitoring the New York Bight. The survey uses the Hardy Continuous Plankton Recorder (CPR), expendable bathythermographs (XBT's), and surface water samples

- c) Phytoplankton. A report was published on the regulation of phytoplankton growth by chemical water quality in the coastal and shelf region between Cape Hatteras and the Gulf of Maine. Enrichment bioassays were made on over 400 water samples collected in five surveys spanning an annual cycle. The assay results suggest that nitrogen, potentially, was the most important growth-limiting nutrient region-wide and year-round. The results also suggest that phosphorus had considerable importance, and that silicon and vitamin B₁₂ occasionally were

limiting. The potential regulatory importance of phosphorus apparently was less consistent, temporally and spatially, than that of nitrogen. Phosphorus limitation was detected primarily in just two of the collections, from March and July surveys. In the March collection it was evident predominantly in the inshore samples, but in the July collection its incidence was approximately the same among samples from inner, mid and outer shelf. Inhibitory water quality was prevalent in two of the summer collections, particularly in samples from inshore locales. The cause of this inhibition has not been identified but it was not associated with nutrient concentration. It is possible that adverse water quality was an important growth regulator at these times and locales, at least for phytoplankton species having sensitivities analogous to that of the assay organism.

A report was published which discusses the need for increased investigation of the detrimental biological effects of phytoplankton blooms. Many phytoplankton blooms increase productivity in the ecosystem in which they occur and cause no apparent harm. There has been increased recognition in recent years, however, of the important and complex detrimental effects some blooms can have on the marine biota and human health. This, and mounting evidence that the incidences of blooms and related problems are increasing world-wide, suggest that greater focus is needed on the aspect of bloom effects. The overall importance of bloom biological effects becomes more appreciable if their diverse types and environmental significance are considered. The report, therefore, provides a general summary of the various major consequences of some phytoplankton blooms on components of the marine biota and/or humans, including paralytic shellfish poisoning, neurotoxic shellfish poisoning, ciguatera poisoning, diarrhetic shellfish poisoning, ichthyotoxicity syndrome, and oxygen insufficiency. Some occasional or unique consequences of particular blooms, and the various known roles of allelochemicals produced by phytoplankton also are compiled.

Data were collected from surface waters and at depth to follow the annual cycle of chlorophyll and algal blooms in the inner New York Bight. Phytoplankton fluorescence, temperature and conductivity of near surface waters were measured in the inner New York Bight and/or Raritan Bay at least once a week from late February through December using a computerized shipboard underway system. Data were collected continuously (averaged over 0.75 km) in the surface water (1 m) along the track of the RV KYMA during 101 day-long surveys. The greatest number of cruises took place between April and September 1989. Starting in late March, weekly monitoring of the vertical distribution of chlorophyll *a*, nutrients, phytoplankton, temperature and salinity within the water column began, at a station located at the head of the Christiaensen Basin. In addition, concentrations of chlorophyll *a* were measured, monthly, at surface and mid-depth from April to September at locations within and around the "12-mile" dumpsite.

Researchers from the NEFC collaborated with New Jersey Institute of Technology (NJIT) by gathering sea truth chlorophyll data to calibrate remotely sensed images taken using NJIT's airborne high resolution (< 1m) ocean colour sensor. A computerized system installed onboard the RV KYMA was used to record, continuously, phytoplankton fluorescence, temperature and conductivity of surface waters in the Hudson-Raritan Estuary. These readings along with discrete samples analyzed for chlorophyll content are being used to calibrate the ocean colour images.

- d) Ichthyoplankton The second year of field work for an ongoing study to measure the changing status of Atlantic herring and sand lance in the Georges Bank/Nantucket Shoals/Massachusetts Bay area was completed. Monthly cruises were completed in October, November, and December to: (1) determine the distribution, abundance and production of larvae; (2) collect larvae of herring and sand lance for growth increment analysis; (3) index spawning biomass of the target species; and (4) provide herring larvae from throughout the study area to DMR, Maine for elemental and image analyses. Monthly cruises will continue through April 1990. Samples are being processed by the Polish Sorting Center. Results are expected by late summer of 1990. Fecundity studies on both herring and sand lance are an integral part of this initiative. Results from 1988 cruises indicate that herring spawned on Georges Bank for the first time since 1978, but the most intense spawning activity was centered in Massachusetts Bay

to Nantucket Shoals. Recently hatched larvae were most abundant near Cultivator and Georges shoals on Georges Bank.

- e) Benthic Studies Monthly benthic macrofauna surveys were completed as part of a study of recovery of a former sewage sludge dumpsite (discussed under Environmental Quality). Data analyses of benthos from 1978 - 1985 collections throughout the Northeast U.S. continental shelf was begun. Laboratory studies were used to assess the potential for predation on juvenile bivalves by estuarine shrimp and mud crabs; a paper was published on roles of the shrimp as predators and prey. A guide to enhancing estuarine molluscan shellfisheries was also completed. This manuscript makes recommendations on ways to improve shellfish habitats and surveys of beds, and advocates use of shellfish production specialists to lead the work and interact with fishermen and managers. One suggestion is that piles of waste shell (from surf clam oyster and ocean quahog fisheries) can be spread on the bottom to reduce predation on the clams. Shell piles were deployed to test their effectiveness in reducing predation.

Three papers were submitted for publication during the reporting period. Both are the result of collaborative efforts with investigators from several agencies and institutions. One was done in cooperation with the Department of Marine Resources, State of Maine, and the Bigelow marine Biological Station at Boothbay Harbor, Maine on the distribution, abundance and behaviour of sea pens (*Pennatula* spp.) in the Gulf of Maine. The second, dealing with residence time of organic carbon in deepsea benthos, was done in cooperation with investigators from Texas A&M, IFREMER, Univ. Washington, City College of New York, Memorial Univ. of Newfoundland, and NMFS. The third was concerned with the dynamics of polychaetes associated with contaminated sediments in the N.Y. Bight.

A paper dealing with the quantitative composition and distribution of macrobenthos of the New England continental shelf ecosystem was completed. It is currently undergoing in-house review.

- f) Environmental Quality. The field sampling of an intensive monitoring study of the 12-mile sewage sludge dumpsite in the New York bight was completed in November. Monthly biological, chemical and physical measurements had been made since July 1986, prior to and continuing through the dumping phaseout in late December 1987. The Second Annual Report (coverage to December 1988) was published. Preliminary data analyses suggest that changes which may reflect some recovery have occurred since the cessation of dumping.

Sediment quality increased significantly (reduced metal contamination, increased redox potential) in the vicinity of the "12-Mile" sewage sludge dumpsite. Concentration of heavy metals in the top centimetre of sediments from the study area have diminished to levels found 5 cm deeper.

Seabed oxygen consumption levels at the most active dumping locations dropped precipitously after phaseout began and have gradually decreased to background levels with cessation. Values of dissolved oxygen in bottom water have not been less than 2.6 mg/l since the beginning of phaseout -- before then, values less than 0.5 mg/l regularly occurred in summer. Fecal coliform counts have dropped well below those observed during active dumping and are lower than in many estuarine shellfish harvesting areas. Some of the coliform reduction is attributed to year-round chlorination of industrial wastewater which was expanded in 1986 from warm month treatment only.

Benthic macrofauna studies have shown no clear response of species richness of other community variables, but species density of an indicator polychaete has decreased 100-fold near the sludge impact area. Biomass in timed trawl catches have been dominated by little skate, winter flounder, ocean pout, spiny dogfish, and rock crabs. Total biomass decreased during the dumping phaseout and the ratio of fish to invertebrates increased. Differences among three reference stations have diminished. There is an indication that reduction in the incidence of certain pathology indicators (finrot and cysts) occurred during the interval of study. Preliminary results of organic contaminant analyses on hepatic tissue of lobster and winter flounder collected from the area of the "12-mile" sewage sludge dumpsite in 1987-88 indicate that PCB concentrations

were higher in animals collected near the sewage sludge dumpsite than in animals collected at a reference station 10 km away. PCB concentrations in lobster hepatic tissue were higher than in winter flounder at both collection sites. No firm conclusions about hydrographic, chemical, or biological responses can be made until rigorous interdisciplinary data analyses are completed.

In 1984, the 106-Mile Deepwater Municipal Sewage Sludge Disposal Site was designated to receive sewage sludge from the New York City-New Jersey metropolitan area. Phased relocation of dumping from the inshore 12-Mile Dumpsite in the New York Bight apex to the offshore 106 MDS began in March 1986; by December 1987 all ocean-dumped sludge from the NY-NJ metropolitan area, (about eight (8) million metric tons/year) was being disposed of there. A pilot study was conducted in June 1989 to assess the feasibility of monitoring the effects of sewage sludge disposal at the 106 MDS using mid-water fish to detect sewage sludge-derived contaminant metals.

Preliminary results indicate, metal concentrations in samples of lantern fish (*Myctophidae*) collected at the DWD106 dumpsite were found to be more concentrated than in samples collected outside the dumpsite area. A report on the pilot study is available. A second, extensive survey will be conducted during August, 1990 to corroborate these findings. In addition to metal analyses, concentrations of organic contaminants will be measured.

2. Fish Biology Studies

- a) Migrations and Stock Identification. Stock identification research utilizing digital image analysis methods on scale samples from juvenile and adult winter flounder from inshore waters north and south of Cape Cod, Massachusetts has begun. Results indicate that the DIA method will probably be useful in distinguishing individuals from separate stocks along the coastal waters of the northeast.

- b) Age and growth. Approximately 29,000 age determinations were completed for 15 species of finfish and shellfish.

Biological studies of geographic variations in growth of yellowtail flounder, *Limanda ferruginea*, in the northwestern Atlantic, and the population biology of witch flounder, *Glyptocephalus cynoglossus*, in the Gulf of Maine-Georges Bank region were completed.

A preliminary age validation study for white hake, *Urophycis tenuis*, has been completed.

Technical memoranda describing the history of maturity sampling and classification schemes used during NEFC bottom trawl surveys, and guidelines for estimating lengths at age for 18 northwest Atlantic species were published.

A bibliography of the sea scallop, *Placopecten magellanicus*, was prepared.

Vertebrae and meristics from 56 sharks were collected to further our ongoing studies of age and growth of important species of North Atlantic sharks. In addition, the recapture of any tagged sharks injected with tetracyclines will help to validate age estimates from rings in the vertebrae.

- c) Pathobiology. The annual Chesapeake Bay oyster disease survey was conducted at seventy one (71) sampling sites scattered throughout the Maryland portion of Chesapeake Bay. A serious oyster pathogen *Haplosporidium nelsoni* "MSX" was detected in only 10 of the 1350 animals examined for this disease, and was not associated with any oyster mortalities. There was a significant increase in the number of sample locations found to be positive for the oyster disease "DERMO" *Perkinsus marinus*. This disease has spread to almost every oyster bed in the bay with it being detected in 68 of the 71 samples. Almost 50% of all oyster tissues cultured were positive for "DERMO". The salinity of the bay was generally lower this year in all areas sampled compared with the previous two years, and mortality was lower this year in spite of higher prevalences of "DERMO".

This massive diagnostic effort was completed on more than twice the number of animals diagnosed in previous surveys and in a much shorter time (3 months compared to 6 - 12 months in previous years). This improvement can be attributed to the use of haemanalysis instead of the standard paragon section examinations, good organization, and an expanded, well trained team of scientists and technicians.

- d) Physical and Genetic effects of Pollutants. A major three-year report on the assessment of reproductive success in winter flounder, Pseudopleuronectes americanus, from Long Island Sound and Boston Harbor was completed this year. This report presents the results of a study conducted by the Milford Laboratory of the NEFC on various physiological, biochemical, and genetic aspects of the reproductive biology of the winter flounder. Additional analytical chemistry measurements and pathological evaluations were completed by scientists from other NEFC laboratories.

The results of this complex, multidisciplinary study show a variety of lethal and sublethal indicators of reproductive failure in flounder collected from areas adjacent to heavily populated and industrialized centers, especially off New Haven, Connecticut and Boston, Massachusetts. These results will be later factored into a life-cycle model of flounder populations in New England waters to evaluate the combined effects of environmental degradation and exploitation on the recruitment of young flounder into the general population.

The blood chemistry of the American lobster, Homarus americanus, was followed over the individual stages of the molt cycle. Premolt hemolymph concentrations of calcium, chloride, inorganic phosphorus, magnesium, potassium, sodium, total protein, and osmolality were significantly differed from those of postmolt. Variations in glucose could not be correlated with ecdysis. These findings establish a baseline for hemolymph ion concentration throughout the molt cycle of the American lobster. This enhanced understanding of lobster blood chemistry provides the groundwork for better monitoring of disease and pollutant impact on this species.

The potential for the heavy metal pollutant cadmium to enter the food web via incorporation into phytoplankton biomass was investigated under controlled laboratory conditions. Cadmium-tolerant strains of three microalgal species were cultured with cadmium in the growth medium and fed to young post-set clams and oysters. Cadmium contents of the algae were determined to be within the range that may be encountered in polluted coastal waters. Effects of algal-borne cadmium upon oysters, Crassostrea virginica, included mortality and cessation of growth, whereas hard clams, Mercenaria mercenaria, survived exposure to the same cadmium-contaminated algae, but did not grow. Inimical effects were proportional to the amount of the metal present in the algal diet. The finding that phytoplankton-borne cadmium interferes with growth of young post-set mollusks at sublethal exposures may explain some population-level pollutant effects upon commercially important bivalves. Moreover, a direct advantage, in terms of fishery resources, to reducing cadmium discharges is suggested.

Vibrio anguillarum is a bacterial species frequently associated with diseases of marine fish. Those fish which survive infections will produce specific antibodies against the bacterium and will retain them in their sera for a period of several weeks to several months. Assays for antibodies in the sera of 832 winter flounder from Long Island Sound revealed that 16% of the fish had been exposed recently to this pathogen.

- e) Research Vessels Surveys. In 1989 the NEFC conducted routine spring and autumn bottom trawl surveys from Cape Lookout to Nova Scotia during March-April and September-October, respectively. In addition, the NEFC conducted one sea scallop survey between June and August and one surf/clam-ocean quahog survey in June-July.
- f) Population Studies and Multispecies Modeling. The feasibility of developing a Population Dynamics Workstation using newly developing computer hardware and software was evaluated, and a project begun to develop a prototype. The goal is to develop an integrated set of software tools on a high level microcomputer

workstation that is tailored for population dynamics studies. A systematic review of critical and desirable tools is being conducted, and a prototype workstation will be constructed that includes tools for relational data bases, statistical analysis, graphic display, mapping, routine fishery stock assessments, line transect analysis, and stochastic simulation. The prototype will be constructed on a workstation running the UNIX operation system using X-Windows protocol. Existing computer programs will be used where available, and integration will likely be done using UNIX shell scripts and the programming language APL.

A preliminary model was developed to evaluate trophic interactions between herring, mackerel and sand lance. Analysis to date has shown that the population explosion of sand lance during the 1970's is consistent with the hypothesis that predation by mackerel was the dominant factor regulating the sand lance population.

Several analyses were completed on the changes in the aggregate structure, biomass and production of fish stocks on Georges Bank and in the Gulf of Maine over the past 30 years. It was shown that excessive fishing effort was the principal cause of the significant population fluctuations observed since the 1960's.

Programming was completed for a preliminary stage of the Georges Bank multispecies model and initial testing of the model was begun. Analysis of the NEFC food habits data base was continued with emphasis on developing inputs for the model.

- g) Food Habits Studies. More than 15,000 stomachs of piscivorous species were examined at sea on the spring and fall groundfish surveys in 1989. Spiny dogfish, silver hake and cod were the principal fish predators sampled, and in the autumn survey the most common fish prey observed were sand lance, 0-group herring (15-19 cm) and 0-group silver hake. Herring eggs were also observed in a variety of species (but especially cod) on Georges Bank and along the coast of Maine. Additional emphasis was placed on sampling skate stomachs, to augment the data base on this part of the increasing elasmobranch biomass on Georges Bank.

Another joint bottom trawl/submersible cruise was conducted in August 1989 on 0-group gadid ecology on NE Georges Bank. About 2800 stomachs of potential 0-group predators were examined, and 0-group cod were observed chiefly in larger cod, sea raven, long horn sculpin and thorny skates. Several hundred 0-group gadids were also preserved for laboratory stomach analysis.

Computer audits were completed on a backlog of 15 summer cruises on Georges Bank for the period 1984-1987. This series will provide key information on summer distribution and abundance of 0-group gadids, and predation on the 0-group (nearly 28,000 stomachs examined in this series)

3. Marine Mammals

Research into line transect sighting survey methodology and into harbor porpoise distribution and abundance continued, providing additional information on their distribution in late summer and suggesting that the effects of ship avoidance may be substantial. Technicians aboard commercial fishing vessels are obtaining data on the frequency of harbor porpoise by-catch, as well as the by-catch of other species in trawl and drift gill net fisheries. Analyses have begun on the fine scale spatial and seasonal distribution of marine mammals in the Gulf of Maine and the Mid-Atlantic Bight, in an effort to identify patterns that may be useful in controlling by-catch. The increasing need for marine mammal research was reviewed, and planning completed for creation of a new research group of four scientists and two technicians, the Northwest Atlantic Marine Mammal Investigation.

4. Fishing Power and Gear Selectivity

Analyses of the five paired towing experiments, designed to compare the relative fishing power between R/V's ALBATROSS IV and DELEWARE II, is near completion. A draft

paper will be prepared during the first half of 1990.

5. Apex Predators

- a) A survey of sharks and other apex predators was conducted aboard NOAA ship Delaware II (Cruise DE II 89-03) from 18 April - 1 June 1989 along the U.S. Atlantic coast from Tampa, Florida to Block Canyon, southwest of Cape Cod, Massachusetts, from the 15 to 1000 meter isobaths.

A total of 723 fish representing 32 species was caught on 137 longline sets. Nineteen species were sharks and 13 species were teleosts (or rays). Five hundred and eighty-eight fish (81%) were tagged and released, ninety-four (13%) were brought aboard, and 41 (6%) were lost at the rail. The overall catch per unit effort (CPUE) was 5.0/100 hooks. The CPUE for sharks was 4.4/100 hooks (640 sharks on 14,522 hooks) and sharks represented 88% of the total catch of which sandbar sharks were the most common (48%), followed by scalloped hammerhead (16%), blue (8%), and tiger sharks (5%). The catch of other species included swordfish (10), bluefish (14), sting rays (22), and dolphin (*Coryphaena hippurus*) (10). The lowest CPUE (0.6 fish/100 hooks) was in the Gulf of Mexico where 23 longline sets (2490 hooks) yielded only sixteen fish (10 sharks). The overall CPUE in the area from the Dry Tortugas to Beaufort, North Carolina was 2.1 fish/100 hooks (245 fish on 11,184 hooks). The highest CPUE (10.5 fish/100 hooks) was on the third leg of the cruise in the area from Beaufort, North Carolina to southern New England. Results in this region were 509 fish on 4,851 hooks. The overall CPUE values are preliminary and contain biases in that there were repeat longline sets at some stations where good catches of sharks were made.

- b) Tagging Studies. A total of 588 sharks representing 17 species were tagged and released. Of these, 64 were brought aboard, measured, and injected with a small amount of the antibiotic oxytetracycline prior to release. The most common species tagged were sandbar (321), scalloped hammerhead (93), blue (50), and tiger sharks (3). Two of the ten swordfish caught were alive and were tagged and released.

6. Fisheries Economics

Individual vessel time-series data bases were developed and analyzed over 30 variables to reveal economic and spatial-temporal effort patterns within and over years. Sea sampling data bases were designed. A preliminary vessel entry/exit study was completed. Profiles of vessel gear and fishery switching were produced. A Primer on appropriate methods of allocating fish resources to competing uses and a critique of "Economic" arguments for allocation were submitted for publication. An analysis of a shift in the U. S. demand for seafood was also completed.