

Northwest Atlantic



Fisheries Organization

Serial No. N2089

NAFO SCS Doc. 92/15

SCIENTIFIC COUNCIL MEETING - JUNE 1992

United States Research Report for 1991

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 Science Center of the National Marine Fisheries Service (NMFS).

**1. Atlantic Cod**

USA commercial landings from Subarea 3-6 decreased 4% from 43,563 t in 1990 to 42,108 t in 1991. Compared to 1990, landings in Subarea 4 decreased (62 t vs 209 t), landings in Subarea 5 declined (41,615 t vs 43,026 t), and Subarea 6 landings increased (341 t vs 321 t). No landings were taken from Subarea 3 in 1991 although 7 t were taken in 1990.

Landings in 1991 from the Georges Bank fishery [Div. 5Z + 6] totaled 24,176 t, 14% lower than in 1990 (28,193 t). Total stock biomass has been relatively stable since 1986 due to above-average recruitment from the 1985, 1988 and 1990 cohorts. Spawning stock biomass in 1991 was near the long-term average.

Gulf of Maine [Div. 5Y] landings in 1991 were 17,780 t (a record-high) and 17% greater than in 1990 (15,154 t). Total and spawning stock biomass of Gulf of Maine cod attained record-high levels in 1990 and 1991 due to strong recruitment from the 1986 and 1987 year classes. More recent year-classes, however, have been below-average and stock abundance is therefore expected to decline in the future.

**2. Haddock**

USA landings from Subareas 3-6 in 1991 declined to 1,837 t, a record-low, and 629 t less than in 1990. Landings from Georges Bank [Subdiv. 5Ze] decreased 30% from 2,001 t in 1990 to 1,395 t in 1991. Abundance of the Georges Bank stock continues to remain at a record-low level. Landings from the Gulf of Maine [Div. 5Y] haddock stock in 1991 were 430 t, unchanged from 1990 (433 t). Commercial CPUE and research vessel indices in 1991 indicate that Gulf of Maine stock abundance remains at an historically-low level.

**3. Redfish**

Subarea 4

USA landings of redfish from Division 4X totaled only 4 t in 1991.

Subarea 5

USA landings of redfish from Subarea 5 declined from 588 t in 1990 to 525 t in 1991, marking the twelfth consecutive year of decline. Landings in 1991 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 present fishery, although one or more moderately strong year classes produced in the mid 1980s are expected to recruit to the fishery during the mid-1990s.

4. Pollock

Subarea 4

USA landings from Subarea 4 decreased from 213 t in 1990 to 68 t in 1991.

Subarea 5

USA landings from Subarea 5 in 1991 were 7,797 t, 16% less than in 1990 (9,330 t), and the lowest annual catch since 1973. USA commercial CPUE has trended downward since 1983, although slight increases occurred in 1989 and 1990. USA commercial fishery age composition data indicate that the 1985 and 1986 cohorts (both of average size) dominate the landings. No increase in stock size is expected in the immediate future unless recruitment improves.

5. Yellowtail Flounder

Subarea 5

USA landings in 1991 were 7,436 t, 47% lower than in 1990 (13,992 t). Landings from the Georges Bank stock declined to 1,784 t in 1991 from 2,740 t in 1990. Landings from the Southern New England stock declined 51% from 8,008 t in 1990 to 3,910 t in 1991. In both stocks, landings in 1991 were dominated by fish from the 1987 year class. This cohort has been fished down and is not expected to dominate future landings. Subsequent recruitment in both stocks has been poor, and hence stock abundance and landings are expected to decline even further in the next few years.

Subarea 6

Landings declined from 359 t in 1990 to 325 t in 1991.

6. Other Flounders

USA landings of flounders [other than yellowtail flounder] from Subareas 3 - 6 in 1991 totaled 21,963 t, 32% higher than in 1990. Compared to 1990, landings from Subarea 3 declined to zero (0 t vs 10 t); landings from Subarea 4 decreased by 6 t (8 t vs 14 t); landings from Subarea 5 increased by 36% (17,498 t vs 12,869 t); and landings from Subarea 6 rose by 20% (4,457 t vs 3,728 t). Winter flounder (34% of total), summer flounder (21%), American plaice (19%), windowpane flounder (17%), and witch flounder (8%) accounted for 99% of the 'other flounder' landings. Winter flounder landings increased 13% between 1990 and 1991, summer flounder increased by 16%, American plaice rose 74%, windowpane flounder increased 89%, and witch flounder landings increased by 22%. Survey indices for nearly all of the 'other flounder' stocks were either stable or increased in 1991.

7. Silver Hake

USA commercial landings from Subareas 5 and 6 in 1991 were

16,541 t, an 18% decline from 1990 (20,197 t). Landings from the Gulf of Maine - Northern Georges Bank stock declined to 6,050 t (-5% from 1990), while landings from the Southern Georges Bank - Middle Atlantic stock (10,491 t) fell by 24% from 1990. Biomass levels in both stocks appear to be relatively low.

8. Red Hake

USA 1991 commercial landings from Subareas 5 and 6 were 1,673 t, a 4% increase from the near record-low 1990 catch of 1,610 t. Landings from the Gulf of Maine - Northern Georges Bank stock in 1991 were 743 t (-7% from 1990), while landings from the Southern Georges Bank - Middle Atlantic stock totaled 930 t (+15% from 1990). In both stocks, fishing mortality is low and substantially higher catches could be supported.

9. Atlantic Herring

USA landings from Subarea 5 in 1991 were 47,576 t, 6% lower than in 1990 (50,761 t). Landings from the Gulf of Maine (Div. 5Y) in 1991 were 46,052 t, the third highest annual catch since 1981. Gulf of Maine spawning stock biomass has increased continuously since 1982 and is currently near the high SSB levels observed in the late 1960s (i.e., over 200,000 t). Stock size has increased due to strong recruitment and reduced fishing mortality rates, particularly on juvenile herring. Landings from Division 5Z in 1991 were 1,524 t, primarily from Subdivision 5Zw (913 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 and reports of incidental catches by commercial vessels. Herring landings in Subarea 6 in 1991 were 985 t, nearly double those in 1990 (494 t).

10. Atlantic Mackerel

USA commercial landings in 1991 from Subareas 5 and 6 totaled 26,945 t, 15% lower than in 1990 (31,804 t), but still the second highest USA annual catch. Total stock biomass (Subareas 2-6) has been increasing since 1980 and is presently at record-high levels (> 2 million t). Rebuilding of the stock has resulted from low fishing mortality rates coupled with outstanding recruitment from the 1982 year class and relatively strong recruitment from the 1984-1988 cohorts.

11. Butterfish

USA landings in 1991 from Subareas 5 and 6 were 2,160 t, 7% lower than in 1990 (2,319 t), and the second lowest USA commercial catch since 1978. About 58% of the 1991 catch was taken in Subarea 5 (1,257 t), while 42% was taken in Subarea 6 (903 t). Research vessel survey indices indicate that stock abundance is relatively high due to recent strong recruitment.

12. Squid

USA landings of long-finned squid, Loligo pealei, from Subareas 5 and 6 were 19,392 t, 25% higher than in 1990 (15,470 t), and the second-highest ever. Of the 1991 USA total, 41% was from Subarea 5 (7,907 t) and 59% from Subarea 6 (11,485 t). Survey abundance indices indicate that stock abundance remains moderately high, although lower than the very high levels observed in 1988 and 1989.

USA landings of short-finned squid, Illex illecebrosus, from Subareas 5 and 6 in 1991 were 11,929 t, a record-high,

and 2% greater than in 1990 (11,667 t). Of the 1991 USA total, 2% was from Subarea 5 (260 t) and 98% from Subarea 6 (11,669). Survey abundance indices indicate that Illex abundance continues to remain at a relatively high level.

13. Sea Scallops

USA commercial landings from Subareas 5 and 6 in 1991 were 17,113 t (meats), nearly identical to the record-high 1990 catch (17,174 t). Compared to 1990, Georges Bank [Div. 5Z] landings (9,464 t) decreased 7%, Gulf of Maine [Div. 5Y] landings (605 t) increased by 5%, and Mid-Atlantic [Subarea 6] landings (7,044 t) increased by 9%.

Abundance indices from the USA 1991 sea scallop survey indicate that scallop abundance in the USA sector of Georges Bank has increased to near-record high levels, while scallop abundance in the Mid-Atlantic area has declined from the record-high levels of the late 1980s. On Georges Bank, recruitment of the 1988 year class is very strong. In the Mid-Atlantic area, recruitment of the 1988 cohort appears to be only about average.

B. Special Research Studies

1. Environmental Studies

(a) Hydrographic Studies

Hydrographic surveys of the Georges Bank region were conducted in January, February, November and December in conjunction with a study of the recovery of the herring stock on Georges Bank. Additional hydrographic surveys of the entire shelf region from Cape Hatteras to the Gulf of Maine were conducted in spring (March-April) and fall (September-October) in connection with bottom trawl surveys of the fish stocks.

Two studies of the variability of water properties in the Middle Atlantic Bight were published. In the first the variability in salinity of the shelf waters for the period 1977-1987 was described and related to changes in both local precipitation and coastal runoff, and more distant sources of variability - in the outflows from rivers in the Gulf of Maine and from the St. Lawrence River system. The second study documented variability in the volume of shelf water in the Bight, on both seasonal and interannual time scales.

Reports were compiled for 1990 summarizing the water column structure across the New York Bight and the Gulf of Maine. A report also was issued containing oceanographic observations in the inner New York Bight collected in support of a three year (1987-1989) study of changes at the 12-Mile Dumpsite after the cessation of sludge dumping.

A study of changes in the springtime distribution of fish stocks on the northeast continental shelf in relation to environmental conditions during the period 1968-1989 was completed. Significant temperature changes occurred during the study period and a number of stocks appeared to have shifted their distribution north-south or between shallow and deeper waters to partially compensate for the broadscale temperature changes.

Hydrographic surveys of the Northeast Shelf ecosystem between Cape Hatteras, NC and Cape Sable, NS were resumed during 1991 as part of the MARMAP/EMAP ecosystem surveys. The objective of this monitoring is to assess the impact of changing biological and physical properties of the NE

Continental Shelf ecosystem which influence the sustainable productivity of the living marine resources. Key parameters measured were: water column temperatures, salinities, chlorophyll and nutrient concentrations, Ichthyo- and zooplankton composition, abundance, and distribution; underway near surface chlorophyll concentration, temperature and salinity; and standard weather observations. Full surveys are conducted four times per year, with two or more additional coverages achieved over the area during the spring and autumn trawl surveys. These latter cruises at this time do not include chlorophyll and nutrient measurements.

Monthly water column temperature and surface salinity monitoring between Boston and Cape Sable, and from New York towards Bermuda using ships of opportunity (SOOP) continues. The Gulf of Maine series reached sixteen years in 1991--the Middle Atlantic Bight series, seventeen years.

(b) Plankton Studies

Zooplankton and net phytoplankton surveys of the Northeast Shelf ecosystem between Cape Hatteras, NC and Cape Sable NS were resumed during 1991 as part of the MARMAP/EMAP ecosystem surveys.

Monthly zooplankton and net phytoplankton monitoring between Boston and Cape Sable, and from New York towards Bermuda using ships of opportunity (SOOP) continues. The Gulf of Maine series reached thirty-two years in 1991--the Middle Atlantic Bight series, seventeen years.

The Plankton Ecology Investigation participated in sample collection during the Herring Recovery cruises for 1991 collecting samples of the prey field during the autumn and early winter on Georges Bank and adjacent waters. These samples are undergoing processing at the Plankton Sorting Center in Szczecin, Poland. In other areas of research the Investigation conducted midwater sampling at the vicinity of the DWD 106 site with plankton nets and an IKMT to sample the midwater community. These samples are being analyzed to determine the trophic relationships between the copepod community and the midwater fishes resident in waters near the dumpsite to evaluate the possibility of contaminants entering the bottom of the food chain and being translated to commercially exploited fish stocks. The Investigation has also continued in the development of its image analysis based plankton identification system. Significant progress has been made in developing flow-through capabilities for the laboratory based system that were reported on at the Santa Fe NM ASLO meeting. The system was used to evaluate changes in the structure of the plankton community resulting from the migrations of schools of mackerel into the southern Georges Bank area and demonstrated a significant change in the size and species composition between before and after the arrival of the mackerel schools. The image analysis system has also been tested as a sea going component of the Video Plankton Recorder in cooperation with Cabel Davis and Scott Gallager of WHOI. Two trial cruises of the system were conducted in the autumn of 1991.

The Northeast Fisheries Science Center completed the fourth year of a study to measure the changing status of Atlantic herring and sand lance in the Nantucket Shoals/Massachusetts Bay/Georges Bank area by tracking interannual changes in the distribution

and production of larvae. Six cruises were conducted at monthly intervals from October 1991 through March 1992. The program includes fecundity estimates on mature females collected during the late summer and early autumn period and the preservation of some larvae in ethanol for otolith and biochemical analyses. Samples from the 1991-1992 spawning season are being processed at the Polish Sorting Center in Szczecin. Preliminary observations indicate that the principal spawning grounds of herring remain on Nantucket Shoals with less significant spawning occurring in Massachusetts Bay and on Georges Bank as far east as Cultivator Shoals. By December, larvae are spread throughout the study area. The 4-year study has yet to produce evidence of major spawning concentrations of herring occupying the historical spawning beds on eastern Georges Bank. Sand lance larvae remain extremely abundant around Nantucket Shoals and, to a lesser extent, over central Georges Bank in January, or about two months after the peak abundance of herring larvae.

(c) Benthic Studies

Sampling and analysis continued in a study of benthic macrofauna responses to phaseout of sewage sludge dumping in the inner New York Bight. Thirty-nine months after dumping ended, only limited recovery was evident; numbers of species in the area most affected by sludge approached those at a reference site, but the faunal assemblage remained sparse, with little resemblance to the reference area fauna. Strong relationships have been found between species richness and certain chemical parameters, e.g., redox potential. There were large decreases in sediment organic carbon and coliform bacteria in the water column in the area that had been most affected by sludge dumping.

A study was initiated of the relative value of different inshore habitat types to juveniles of resource fish species in the Hudson-Raritan Estuary. Biweekly beam trawl surveys will be supplemented by other sampling and cage studies to compare growth and abundance of species such as scup, sea bass, winter and summer flounder in several vegetated and unvegetated habitats.

Assays suggested that chemicals other than nutrients may explain the apparent exclusion of the PSP dinoflagellate, Alexandrium tamarense, from Great Bay, NJ. Attempts also continued to purify a culture of the species responsible for "brown tide" in Long Island waters; a pure culture is needed to determine factors promoting the blooms.

Participation began in NOAA's Damage Assessment and Restoration Program. DARP is designed to meet legal mandates to assess damages to natural resources from releases of oil and hazardous materials, recover damage costs from the responsible parties, and restore or replace damaged resources and habitats.

Manuscripts were completed on: a) ten-year changes in bottom invertebrate assemblages of the New York Bight; b) new species of lumbrinerid polychaetes encountered in benthic sampling on the Northeast shelf; c) the history of fisheries of Raritan Bay; d) the life and works of Ernest Ingersoll, one of the earliest writers on U.S. shellfisheries (late 1800's); and 5) ways to farm shellfish beds to minimize resistance from environmentalists.

A comprehensive report, 'Quantitative composition and distribution of the macrobenthic fauna of the New England region', has been completed. The report is based on samples collected in the region from Maine to Long Island and provides: a) measures of macrobenthic standing stock, b) taxonomic composition of the fauna, c) maps of the general features of the macrobenthic fauna and d) relationships between depth, organic carbon content and abundance.

(d) Other Environmental Studies

Habitat Studies. A new line of research has been initiated to investigate the role of habitat in fisheries productivity. Through survey and experimental methods, we will identify critical habitats necessary for recruitment of several valuable LMR target species, such as winter and summer flounder. Effects of habitat degradation on biological impairment and fisheries production will be estimated. Emphasis is on early life stages and juveniles, which can be readily studied and are likely to reflect population level effects. The objectives are to characterize habitat-types, determine species utilization, and to measure habitat quality. Results of these efforts can be used to quantify the effects of habitat loss and will provide insight into habitat restoration measures that might be employed to rebuild fish stocks.

The approach is to use available side-scan data, ROV surveys, and grab samples to create detailed maps of the physical nature of habitat types in areas of interest. Periodic trawling is used to assess abundance of fish, macrobenthic organisms, and vegetation. These data will enable insight into the key ecological relationships of the target species. Specific mark-recapture experiments will be employed to determine fish movement. We will then apply measures of habitat quality such as growth, food habits, condition indices, gross pathology, and physiological or biochemical measures to fish collected at each site.

DWD-106 Survey. In 1991, the only ocean disposal site in the United States designated for dumping of sewage sludge was the 106-Mile Deepwater Municipal Sludge Dumpsite (106-Mile Dumpsite) off the coast of New Jersey. As part of a cooperative study between the Environmental Protection Agency and the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, was engaged to study the impact of sludge dumping on marine organisms at and near the 106-Mile Dumpsite.

The data reported here are from one year of study and preliminary. A second year of sample collection was expanded to include collection and analysis of sediment. A two-year data base will be more amenable to rigorous statistical evaluation.

In 1990, two cruises were conducted to collect pelagic organisms (midwater fish and plankton) and epibenthic megafauna (bottom-dwelling organisms) at designated stations for chemical analysis. Directed collections from deep canyon areas were made for tilefish (Lopholatilus chamaeleonticeps) and lobsters (Homarus americanus) for chemical analysis and determination of the prevalence of shell disease (chitinoclasia) and chemical analysis, respectively.

Shelf stations had lower diversity but higher abundances of crustacean zooplankton than stations more offshore. Midwater fish genera varied, but the following species of Myctophidae were the most prevalent: Benthoosema glaciale, Lobianchia dofleini, Ceratoscopelus maderensis and Hygophum hygomii. The assertion that midwater fish feed on copepods and thus are appropriate sentinels of chemical contamination of the food chain was confirmed by the analysis of stomach contents of myctophid specimens.

The distribution of metal concentrations in midwater fish in 1990 showed elevated levels of individual metals in groups of fish from isolated stations over a large area. Values were lower than those measured in a preliminary study in 1989. Similarly, metal levels found in plankton samples from the dumpsite area were not highly elevated nor were they the highest concentrations found. The distribution noted in 1990 was probably related more closely to natural variability than to the effects of sludge dumping.

Organic contaminant concentrations were lower in plankton than in midwater fish. There was no apparent similarity in the organic contaminant distribution pattern between plankton and fish. The highest total pesticide level (1.4 ppm, wet weight) was noted in L. dofleini, but this finding was based on a composite of five fish. The small sample mass available for analysis, however, precluded any definitive interpretations of the data.

The principal epibenthic megafauna species collected were finfish: blue hake (Antimora rostrata), rattails (Coryphanoides carapinus, Coryphanoides armatus and Nezumia bairdii), cutthroat eel (Synaphobranchus kaupii) and halosaur (Halosaurus macrochir). With other species of finfish and invertebrates, a total of 817 specimens were collected for potential chemical analysis. Concentrations of Cu, Cd, Pb and Ag in nine species (352 specimens) analyzed were generally at or below the limits of detection; Zn, Fe, Mn were detectable but not elevated in any specimens. Mercury was found at low concentrations in most fish muscle samples; highest concentrations were in blue hake and cutthroat eel, with mean values ranging up to 2.74 and 2.24 ppm (dry weight), respectively.

Metals in muscle of 30 tilefish collected from the commercial fishery were generally low or below the limits of detection. Metal concentrations in liver tissue were generally higher than in muscle, with the exception of mercury which was somewhat lower. Mean Cu and Cd concentrations in liver were 17.1 and 11.1 ppm dry weight, respectively.

Metal concentrations in 129 lobsters (with or without shell disease) collected from the commercial fishery were comparable. Metal concentrations in muscle were low or below the level of detection, with the exception of mercury (up to 3.5 ppm, dry weight, in one specimen). Mean concentrations of Cd, Cu and Ag in hepatopancreas (liver) were as high as 82.0, 1,939 and 15.5 ppm (dry weight), respectively.

Megafaunal finfish generally contained relatively high concentrations of chlorinated pesticides and PCB's in their livers. Concentrations in individual blue hake and rattail specimens ranged widely, but



several fish had concentrations of total pesticides well over 100 ppm (Max = 135 ppm), and PCB's in the range of 20 to 25 ppm (dry weight). Halosaurs had much lower concentrations, with mean total pesticides ranging from 1.1 to 2.1 ppm and PCB's from 0.5 to 2.3 ppm. Predominant pesticides were a-chlordane and t-nonachlor, while predominant PCB's were the highly chlorinated congeners (total Cl 5's, Cl 6's and Cl 7's). Polynuclear aromatic hydrocarbons (PAH's) occurred at trace levels in both liver and muscle tissue.

Tilefish, the only commercially important deepwater finfish sampled, had lower levels of organic contamination than other megafaunal finfish analyzed. Total mean pesticide concentrations in liver tissue were about 0.5 ppm; PCB concentrations were similar.

Lobster hepatopancreas tissue had concentrations of total pesticides ranging from 0.12 ppm to 14 ppm and PCB's from 0.75 to 3.5 ppm. A comparison of organic chemical contaminant concentration in lobsters with and without shell disease revealed no significant differences. Analysis of muscle tissue from selected lobsters revealed low concentrations (~0.1 ppm) of contamination in edible flesh.

Shell disease prevalence in 8,844 lobsters collected from the commercial fishery at eight canyon locations ranged from 7.30% at Norfolk Canyon to 10.7% at Hudson Canyon. Females had more lesions than males. Prevalence of shell disease appeared to be greatest at Hudson Canyon. This finding should be interpreted with caution, however, as other factors such as age, size, stage of molt, and past migrations may be involved. Of 3,470 lobsters examined by observers on commercial fishing boats as part of an ongoing fisheries survey, an overall shell disease prevalence of 1.82% was found. Data collected on three bottomfish survey cruises by the Northeast Fisheries Science Center disclosed a shell disease prevalence of 6% (499 lobsters examined).

The Environmental Assessment group is continuing a bottom trawl survey of the Raritan/Lower/Sandy Hook Bay system. Major habitat types in this stressed estuary are being characterized in terms of their value to commercial and recreational species. There are areas of mud, shell and sand as well as natural and dredged channels. The trawl survey of randomly stratified stations, in conjunction with a small-mesh beam trawl fished concurrently, is designed to determine the functional value of the various habitats to finfish and megainvertebrate communities throughout the year. The area still functions as a nursery for a number of inshore fishes, as well as a feeding and spawning area for seasonally active species. This effort will result in species data from about 480 stations per year and will provide a basis for determining biomass and community change by comparison to historical surveys.

An adjunct study is designed to determine the seasonal variations in feeding habits of blue, rock and lady crabs, decapod crustaceans which dominate the invertebrate fraction of the catches.

Study results of a three-year monitoring of the phaseout and cessation of sewer sludge dumping at the 12-mile site in the New York Bight were highlighted in a two-day symposium. All cooperative scientists participated and a symposium volume is being prepared comprising peer-reviewed manuscripts of findings.

2. Biological Studies

Studies on Antibodies in Winter Flounder from Polluted Sites. The sera of 832 winter flounder, Pleuronectes americanus, from Long Island Sound and Boston Harbor were analyzed for antibodies against a panel of eight bacterial pathogens. Antibody titers were determined by agglutination reactions against formalin-fixed bacteria. The presence of antibodies (rather than non-specific agglutinins) was confirmed by treating representative sera with 2-mercaptoethanol, an antibody-disrupting reagent. To avoid a temperature effect which could bias comparisons of antibody levels between the 10 sites of fish capture, serum titers were divided into two groups: (1) those from fish captured at temperatures above 5° C and (2) those from fish captured at 5° C or less. Site comparisons for both temperatures indicated that total antibody levels are generally proportional to the estimated degree of pollution at the site. In other words, for winter flounder, the presence of higher mean antibody levels (against selected bacteria) signifies residence in anthropogenically degraded environments.

Effects of Prorocentrum on Bivalve Mollusks. Collaborative studies with the Laboratory for Maine Animal Health, which is located at the Marine Biological Laboratory at Woods Hole, MA, but affiliated with the University of Pennsylvania, investigated effects of the dinoflagellate Prorocentrum upon bivalve mollusks. Observations of a natural bloom of Prorocentrum in Long Island Sound in 1987 suggested that this dinoflagellate may have been associated with growth rate decreases in hard clams. Laboratory experiments were therefore conducted to test the survival and growth of post set hard clams, Mercenaria mercenaria, and bay scallops, Argopecten irradians, when exposed to two Prorocentrum isolates that were cultured and fed alone or in combination with a known good-food alga. Hard clams did not grow in six weeks when fed one Prorocentrum isolate, even with the combined diet. In contrast, clams fed only the nutritionally appropriate alga, and the combined diet including the other Prorocentrum strain, grew well. This confirmed our field observations with hard clams.

Scallops exposed to the Prorocentrum isolate that inhibited clam growth experienced rapid mortality of 100% in 1-4 weeks. Affected scallops were examined for histopathological effects by collaborating researchers. Extreme degradation in the digestive diverticula, coupled with systemic hemocyte-clot formation suggested the effects of a molluscan enterotoxin. Standard mouse bioassay of concentrated cells from the Prorocentrum culture revealed no evidence of a mammalian toxin in this dinoflagellate. These findings introduce a new factor that may affect distribution and recruitment patterns in molluscan populations; phytoplankton blooms that do not produce mammalian toxins may, nonetheless, disrupt shellfisheries activities.

Studies on the Immune Systems of Winter Flounder and Atlantic Salmon. In vitro studies on the immune systems of winter flounder and Atlantic salmon were conducted after administration of exogenous cortisol by intraperitoneal implantation. Implanted fish were exposed to exogenous cortisol for a period of 30 days, and it was observed that the ability of their splenic lymphocytes to produce antibody in vitro after stimulation by TNP-LPS and TNP-KLH antigens was significantly diminished when compared with control fish that received dummy implants. In the case of Atlantic salmon, cortisol administration for 17 days resulted in a number of the experimental animals developing a fungal infection caused by Saprolegnia sp., an opportunistic pathogen frequently present in aquaculture systems. Thus, it was possible to demonstrate that the

"stress" related hormone cortisol was capable of suppressing the immune systems of these two fish species as has been previously described for other teleosts.

Winter Flounder Pollution Model. Reduced data sets (unpublished) and descriptive graphs on 10 study sites including Long Island Sound (LIS) and Boston Harbor stations over a six-year period (1986-1991) were provided for a winter flounder pollution model. This includes data on egg size, early and late embryo mortality, and on larval mortality as measured at the end of yolk absorption (this latter data for '91 season only).

Larval mortality measured at the end of yolk absorption demonstrated that survival to this developmental period is only one-third that measured for late embryos. As few as 25 each of 100 spawned eggs of a pool of LIS winter flounder survive as externally normal larvae. Another 5-7 of these can be expected to have internal malformations of developing organ systems, leaving only 15-20 to undergo juvenile metamorphosis.

If our 1991 samples of LIS winter flounder are representative, as many as one-third of all females sampled as sexually mature fail to leave any offspring. As few as 15% of the females produce potentially metamorphosing larvae. From the perspective of intrinsic embryo/larval mortality alone - excluding extrinsic causes as predation - the genetically effective size of the LIS winter flounder population is much less than abundance of spawning females would indicate. If the Shoreham '86 site in Long Island Sound which had low egg/embryo mortality is used as a control or standard, one-half this reduction of genetically effective population of female spawners may be attributed to pollution. The significance of this will depend on other stressors which act as selective agents, and/or fishery quotas.

Larval and juvenile surveys of LIS winter flounder initiated in 1991, also are being conducted in 1992. In conjunction with the Undersea Program at the University of Connecticut, a remotely-operated vehicle (ROV) is being used to explore potential LIS spawning areas for winter flounder. A field bag/cage study also is being conducted to measure the influence of site on pre-hatch winter flounder mortality. Preliminary analyses indicate little difference thus far between sites for percent immature eggs and egg size. Separate egg cultures in the laboratory were sampled for embryo and larval mortality as part of the continuing series on reproductive success. In addition, eggs of individual females were exposed in the laboratory to Milford and New Haven site-collected water all the way to juvenile metamorphosis. Last year's success in this trial rearing of flounder eggs to the juvenile stage set a precedent for this initiative.

Blue Hake Biological Analyses. Genetic analyses consisting of a chromosome mutation assay (micronucleus test) and a measure of thymine dimers (SCG assay of DNA damage to single cells) are underway from blue hake collected on a 1991 cruise to the 106-Mile Deepwater Municipal Sludge Dumpsite specifically for these and other samples including chemistry. Samples for estimating DNA damage will be measured employing a fluorescence component of an image analysis system.

The incidence of micronucleation in blue hake samples examined to date has been rather low. A preliminary analysis of 57 of 78 fish showed a background level of .03%. While no significance can be attached to the data until analyses are complete, it appears that six fish had levels significantly higher than the background. None of the fish with elevated blood micronucleus levels were

closely associated with DWD-106 in a geographical sense, but may have been in areas of influence.

Oyster Disease Studies. Cooperative efforts with the Maryland Department of Natural Resources Fall Oyster Survey have continued. The 1991 survey of the Maryland portion of Chesapeake Bay assessed 75 natural oyster bars. Histological analysis of tissues collected from 30 oysters at each location showed that two major oyster diseases were affecting almost every population sampled. The disease Perkinsus marinus "Dermo" was found in over 90% of the sites sampled and at prevalences of 50% or higher in over 75% of those populations. Prevalence levels of the parasite MSX Haplosporidium nelsoni had increased significantly with levels of infection reaching 50-70% in oysters from several of the sites in the lower portion of the Chesapeake Bay. This is a substantial increase over the 20-35% infection levels reported at the same locations in 1990.

Soft-shell Clam Sarcoma Studies. Histocytology data for 1991 showed that prevalences of sarcoma disease in adult and juvenile soft-shell clams followed that patterns established in previous years with prevalences of sarcoma declining from 78% in December of 1990 to 40% and 32% in March and July respectively. Samples collected in September increased, as expected, to 66% prevalence of the sarcoma. Extremely high mortalities of soft-shell clams were reported by local watermen. Clams collected during that period showed high prevalences of chlamydia-like organisms in the duct and tubules of the digestive diverticula of the clams, along with an equally high number of hemocytic lesions in the gills of these clams. The high mortalities observed this summer were attributed to "heat stress syndrome" which was, perhaps, aggravated by the presence of sarcoma and/or parasites.

Blue Crab Disease Studies. The 1991 blue crab winter dredge survey collected a total of 221 crabs from 21 areas of Chesapeake Bay. Each crab was dissected with various tissues prepared for histologic examination. Inflammatory lesions were seen in 25% of the crabs with an additional 9% having hemocytic nodule formation. Trematode metacercariae infected 7% of the crabs with 40% of the metacercariae hyperparasitized with a haplosporidian. Diseases found which have been associated with mortalities of crustaceans include viruses (5%), microsporidia (10%) and one crab with a blood ciliate similar to Paranophrys sp. This parasite was detected in 4% of the crabs examined in last year's survey.

Biotechnology. Monoclonal antibody research has resulted in the production of two monoclonal antibody panels. One panel is capable of distinguishing species of oysters, scallops, and other molluscan shellfish. The other panel is capable of distinguishing most salmonid species. Work is continuing on the development of the salmonid panel to allow identification of all salmonid species. In addition to the antibody panels, anti-fish and anti-crustacean antibodies with generalized specificities have been developed. Research has also been initiated on the development of specific monoclonal antibodies for the identification and quantification of prey species in stomach content samples and the development of monoclonal antibodies to "female specific" serum proteins in Winter Flounder.

PSP Toxins in Atlantic mackerel. In more than three years of sampling we continue to find toxins in the livers of mackerel throughout the Northwest Atlantic range of this migratory species. Toxins have not been detected in the edible muscle or gonad tissues. We have continued to examine mackerel to document patterns of toxicity in this

species using high performance liquid chromatography (HPLC) and bioassay methods. Toxin profiles as revealed by HPLC have been characterized.

PSP on Georges Bank. In 1989, paralytic toxins were observed in all important molluscan shellfish species on Georges Bank resulting in the closure of the surf clam fishery and an advisory to fishermen concerning potential toxicity in scallop roe (roe-on product) and in various mollusc species encountered as by-catch. While the source of this widespread toxicity has not been identified it is assumed to have been derived from toxic phytoplankton blooms occurring within recent years on the bank. More recently, the neurotoxic compound domoic acid has been detected at low levels in these same offshore areas. Monitoring for these shellfish poisons is being carried out under contractual agreements and analytical methods for their detection are under study.

Biotoxins in marine mammal prey. Preliminary examination of selected species known to contribute to the diet of protected whales, dolphins and seals of the Northwest Atlantic have been carried out. Using HPLC and mouse bioassay, American sand lance, Atlantic herring, Atlantic mackerel and longfin and shortfin squid have been examined for paralytic toxins. To date, only Atlantic mackerel has been positively identified as a potential source of such toxins. This species was implicated in humpback whale mortalities in 1987-88. Toxicity has been detected in the livers of juvenile as well as adult mackerel (year classes 1+) providing an opportunity for toxin vectoring to a variety of large and small predacious mammals.

Food Chain Studies. At-sea examination of 15,000 fish stomachs was conducted on spring, summer, and autumn bottom trawl surveys during 1991. More than 30 species were included in the sampled species but principal focus was given to fish predators including spiny dogfish, silver hake, and cod. Major fish prey of these three species were herring, mackerel and silver hake (age-0), with herring being pre-dominant. Very few sandlance were observed in the stomachs of these species.

Sorting and identification of gut contents was completed on nearly 1500 preserved mackerel and herring stomachs from an April/May 1990 predation study on Georges Bank, and these data are being analyzed in relation to bongo samples of the zooplankton prey field taken concurrently on the same experiment. In addition about 4000 mackerel and herring stomachs were examined during the spring of 1991 on the Foreign Fisheries Observer Program (FFOP) to supplement similar data collected on the 1990 FFOP. Analysis of the feeding selectivity patterns derived from the intensive Georges Bank feeding study in 1990 together with the broader geographic patterns of feeding of migrating mackerel obtained on the FFOP, is expected to provide significant new insight into the nature of mackerel feeding behavior in the Middle Atlantic Bight and Georges Bank regions, including the potential for predation mortality on larval fish.

Age and Growth. Approximately 27,000 age determinations were completed for 12 species of finfish and shellfish.

Reports describing the growth of larval tuna in the Gulf of Mexico, and the growth and maturation of coastal winter flounder were completed.

A report describing maturation of 19 important species, including cod, haddock, witch flounder, yellowtail flounder, and others was prepared.

Cod and haddock otoliths and scales were exchanged and an ageing workshop was held with Canadian biologists in a

continuing effort to maintain comparability of age determinations between the two countries.

Apex predator Studies. A total of 6902 fish representing 34 species of sharks, 13 species of teleosts, and 7 species of rays were tagged in 1991. The majority were blue sharks (3818), sandbar sharks (789), tiger sharks (537), dusky sharks (313), and blacktip sharks (213). Anglers accounted for 72 % of the total releases followed by commercial fishermen (15 %), NMFS and other biologists (7 %), R/V Geronimo biologists (6 %), and NMFS Fisheries Observers (<1%). Fish were released by taggers representing 7 countries: United States, Italy, Portugal, Spain, England, Netherlands, and Ireland.

During 1991, 413 sharks and teleosts were recaptured. Blue sharks (174), tiger sharks (98), and sandbar sharks (78) were the most commonly returned. This is the largest number of fish ever recaptured since the beginning of the Program in 1962. The returns came from fish tagged by anglers (60 %), commercial fishermen (22 %), NMFS and other biologists (15 %), and Observers (3%). Recaptured fish were originally caught on rod and reel, longline, handline, trawl net, gill net or tagged free swimming. The sources of the recaptures were primarily commercial fishermen (63 %) and recreational anglers (35 %). Returns came from vessels from the following 16 countries and island territories: U.S. (362), Canada (18), Mexico (10), Spain (7), Japan (3), Italy (2), Venezuela (2), and 1 each from Barbados, Cuba, Ivory Coast, Portugal, Trinidad, Bermuda, Faroe Islands, Yugoslavia, and the Dominican Republic.

From April 23 to June 7, 1991 the API staff conducted a longline survey aboard the RV Delaware II along the Atlantic coast between Miami, FL, and southern New England. This cruise repeated a 1989 survey in the same region, during the same season, using the same fishing methods. A total of 539 fish, representing 31 species, were caught on 140 longline sets. Eighteen species were sharks and 13 species were boney fishes or rays. Sharks represented 82% of the catch. Three hundred and three fish (56%) were tagged and released. The most common species tagged were blue, sandbar, scalloped hammerhead, and tiger sharks. Biological samples for reproductive studies were collected from 89 sharks of 21 species. Samples of vertebrae for our age and growth work were obtained from 142 sharks. Examinations of 78 stomachs from 15 species of sharks were made for ongoing studies of food habits.

Marine Mammals. The endangered North Atlantic humpback whale population has been the subject of a series of research projects over the past several years, both within the Gulf of Maine and more generally across the North Atlantic and in the Caribbean. The NMFS is nearing finalization of an Endangered Species Act Recovery Plan for this species. Projects on the distribution, habitat requirements and on maintaining a centralized photographic catalog were supported this year. Overall coordination of research on this species is needed to ensure that the status of the species is considered in the appropriate spatial context, and especially that the complex breeding and social behavior of this species are properly accounted for. A series of international meetings were held among scientific researchers with both a common interest and active projects studying this species. A two year field project was begun that involves sampling all known winter and summer grounds for both photographic ID and biopsy sampling for estimating total and regional abundance, and for genetic studies. The study will be conducted by project scientists from several countries.

The endangered North Atlantic right whale population has been the subject of an intensive, coordinated, multi-institution study since 1986 which focuses on detecting

changes and causes of changes in the population size. The overall coordination of this study has facilitated the organization of individual identification and sighting survey data that had been collected by numerous organizations over the past decade, and the integration of that data into comprehensive data bases. Additional studies will be required to implement an Endangered Species Recovery Plan.

A study conducted under contract to NEFSC by the Center for Coastal Studies, Provincetown, MA for the Habitat Requirements project of the North Atlantic Right Whale Program has focused on measuring the prey concentrations in Cape Cod Bay that are exploited by right whales, with the goal of developing a model of habitat requirements of these animals. Additionally, during their studies the identity of animals using the Bay is monitored. The focus of studies was on further understanding of the fine scale distribution of zooplankton, both vertically and horizontally. The vertical depths of surface patches along slicks or frontal areas, which are used by right whales feeding on the surface, of roughly 15 cm appear to be important to right whales, as do horizontal distances of roughly 40 m. width of these patches are on the order of meters to tens of meters.

An additional present concern, as yet not completely defined, is the possibility of habitat degradation in Massachusetts and Cape Cod bays due to a Boston sewage outfall now under construction. Discussions center on timetables for levels of treatment.

The harbor porpoise in the Northwest Atlantic has been subject to levels of by-catch in a sink-gill net fishery in U.S. and Canadian waters for several years. The levels of by-catch may be biologically significant. To determine the significance of the by-catch, studies are conducted to estimate total abundance, and to determine seasonal distribution patterns, especially relative to the distribution of fishing activity and fishery resource species. This information is synthesized along with estimates of total by-catch and estimates of vital rates to determine the biological significance of the by-catch, and to determine possible approaches to reducing by-catch levels.

Marine Mammal Surveys. a) A 40 day marine mammal sighting survey was performed in the Gulf of Maine - Bay of Fundy - Scotian Shelf area during July 22 to August 30, 1991. The primary species of interest was the harbor porpoise. Line transect sighting procedures involving 2 independent teams on the same vessel were used to determine both the estimated density and the percent of animals missed on the trackline. To investigate if harbor porpoise were avoiding the vessel 25x power binoculars were used to search for animals beyond the normal sighting range. Also there was an investigation into whether inland bays can be surveyed using a 16-foot rigid hull inflatable boat as the observation platform in a line transect survey. Using the above procedure, preliminary results indicate there are more animals in the Gulf of Maine area than were previously thought.

b) Also within this project, between 03 and 17 August, a 48-foot vessel with a 4-foot draft was used to conduct a line transect sighting survey in the shallow inshore bays and harbors of Maine, from Port Clyde, ME to the Canadian border. This allowed a determination to be made of whether porpoise density varied between the shallow inshore waters and the adjacent offshore waters. After 553 nautical miles of trackline and using standard blocked analysis of variance statistical techniques, the results indicate that the estimates of absolute density made in waters adjacent to the coast may be used to estimate harbor porpoise abundance in the coastal bays and harbors of Maine.

c) Marine mammal survey conducted June 5 - July 16, 1991, aboard NOAA Ship Chapman. Area of operation was principally shelf edge waters between 100 and 1000 fathom isobaths from Cape Hatteras to Georges Bank, with some lines out to the Gulf Stream North Wall across warm-core rings and through the Great South Channel. Primary objectives of the cruise were to: 1) investigate fine scale distribution and habitat utilization within warm core rings, canyons, and shelf edge break, 2) determine if the distribution of marine mammals is continuous between several major canyons and the Gulf Stream Wall, especially beaked whales, 3) conduct line-transect population surveys along the shelf edge break and out to the Gulf Stream Wall, and 4) determine how the composition of marine mammals species varies latitudinally and between the shelf edge and Gulf Stream Wall habitats. The cruise covered 4032 kilometers of trackline and a total of 56 marine mammals and 8 sea turtles were sighted.

d) Aerial surveys were conducted during late August to mid-October by NEFSC and SEFSC between Cape Hatteras, North Carolina and Georges Bank, including the Gulf of Maine to assess the abundance and distribution of cetaceans and sea turtles. Bottlenose dolphins (*Tursiops truncatus*) was a principal focus of the survey due to the 1987 die-off. The survey design duplicated the Cetacean and Turtle Assessment Program surveys (CeTAP 1982), but also included survey blocks beyond the 2000 m isobath. The survey utilized 2 twin engine aircraft that provided good trackline visibility. Each transect was flown at an altitude of 750 feet and a true ground speed of 110 knots. A total of 19 survey blocks were completed during the 45 day survey window. Sea conditions, as well as fog, prevented completion of 4 areas off Cape Cod, Massachusetts. Data analysis is underway.

e) An aerial survey of the Gulf of Maine, Bay of Fundy, and the Scotian Shelf was conducted from October 12-24, 1991. The principal objective was to resurvey the area following the NEFSC shipboard harbor porpoise survey to look for shifts in their distribution and abundance with season. The NOAA Twin Otter was used and standard survey techniques were employed. Over 4000 kilometers of track line were covered and observers had 120 sightings of 890 animals and eight species. Data analysis is currently underway.

### 3. Gear and Selectivity Studies

An investigation designed to determine the relative fishing power of trawl doors currently used during bottom trawl surveys, with doors used prior to 1985 continued. Preliminary analyses of all data collected before June 1991 were completed. Results to date suggest significant differences in terms of weight and/or numbers for several species, and for all species combined. Preliminary coefficients and confidence intervals were calculated. Three trawl door cruises were conducted during 1991. The first cruise was conducted during January 23-31, aboard the R/V DELAWARE II (96 stations were completed), on Georges Bank. The other 2 cruises were conducted during November 16-22, aboard the R/V DELAWARE II, and during December 2-20, aboard the R/V ALBATROSS IV at specific sites in U.S. and Canadian waters in the Gulf of Maine. Sixty seven stations were completed during the November cruise; 147 were completed during the December cruise.

Analyses of data designed to investigate the relative fishing power of the R/V's ALBATROSS IV and DELAWARE II were completed. Species specific differences were noted for several species, and for all species combined in terms



of both weight and number. Coefficients and confidence intervals were calculated. A working document presenting the results was completed. A formal paper is being prepared.

4. Miscellaneous Studies

The Economics Investigation provided reviews on "Policy Guidance on Access to Fisheries" and published journal articles on existence values, structural change in preferences for seafoods, and common arguments used to influence fishery allocations. A study of individual vessel fishing behavior was presented at an international symposium and a system for providing by phone short term price information to fishermen was established.<sup>2</sup>