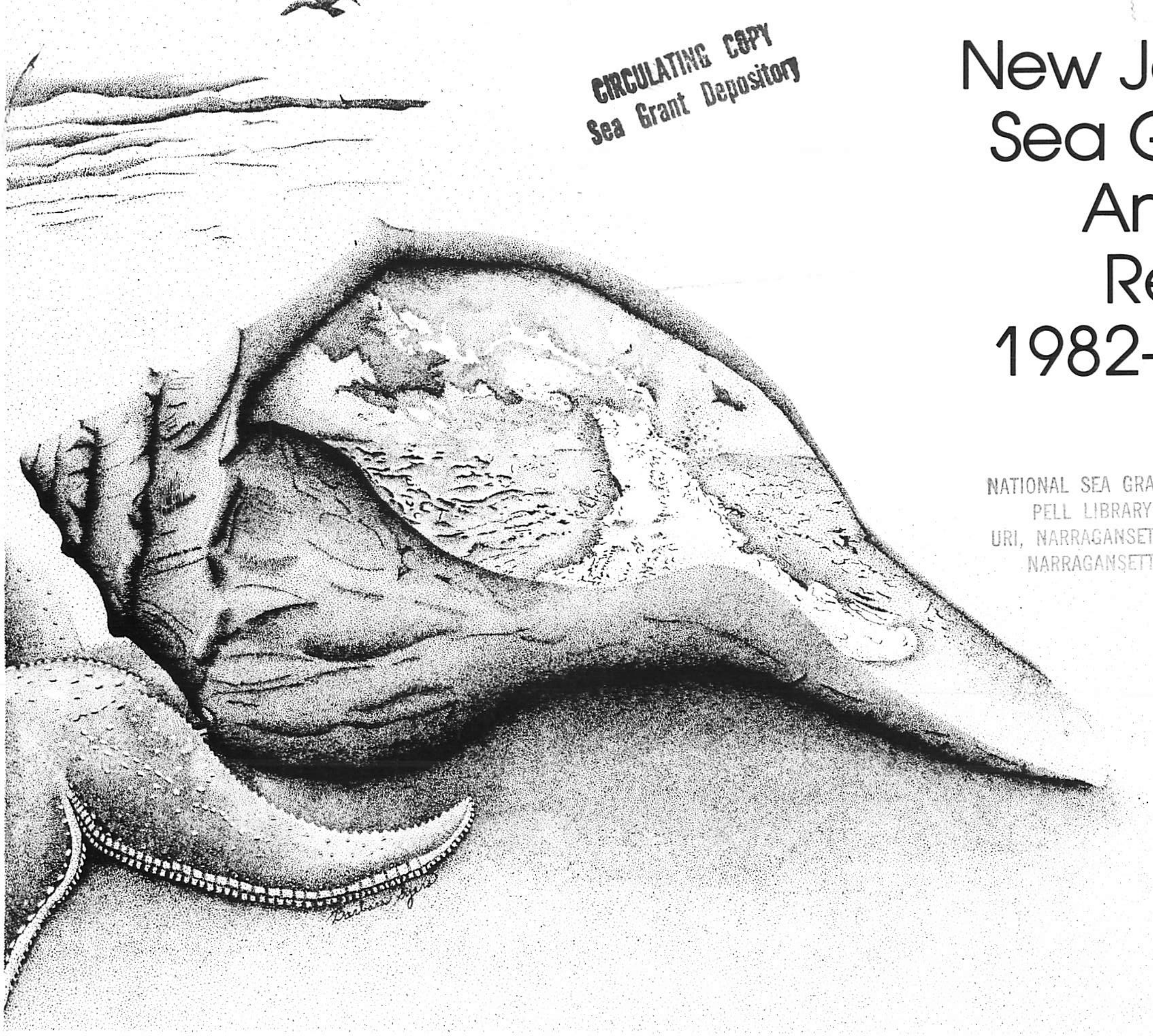

New Jersey Sea Grant Annual Report 1982-1983

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KOENEKE

INTRODUCTION TO THE NEW JERSEY SEA GRANT PROGRAM

Report of the Seventh Year 1982-1983

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The National Sea Grant College Program, through the education, research and advisory activities of the state Sea Grant programs, is a successful investment in the nation's marine resources. It is a model partnership involving the universities, the private sector and government at all levels. It is based on a national network involving strong local program input.

The Sea Grant Program is conducted nationally by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. Created by Congress in 1966, the program takes its cue from the historically-proven Land Grant agricultural tradition, namely the integration and articulation of research, education and outreach. In New Jersey, the Sea Grant Program continues to achieve the goals and objectives established by the National Sea Grant Program.

The New Jersey Sea Grant Institutional Program is managed by the New Jersey Marine Sciences Consortium, an alliance of 26 institutions of higher learning, a number of business and private organizations, and individuals interested in marine affairs. New Jersey Sea Grant's recently completed seventh year of activity in coastal and marine concerns are represented in this account.

During the 1982-83 Sea Grant year, New Jersey's program continued to address critical coastal problems and needs, conducting 13 research projects in four major categories: Fisheries, Northern Estuarine System, Coastal Processes, and Marine Education. Furthermore, the New Jersey Sea Grant Extension Service, the marine educational and informational arm of the Sea Grant Program and the Cooperative Extension Service of Cook College - Rutgers University, continued to provide excellent advisory services on a variety of coastal issues state-wide.

From the shallows of the Delaware Bay to the offshore canyon depths of the Atlantic Ocean—from Sandy Hook to Cape May—New Jerseyans are, in ever-increasing numbers, associating themselves with Sea Grant's leadership in addressing wise use, development, and protection of their irreplaceable marine resources.

Dr. Robert B. Abel
Director

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SEA DRAGON
BRICKTOWN, N. J.


ATLANTIC
QUEEN

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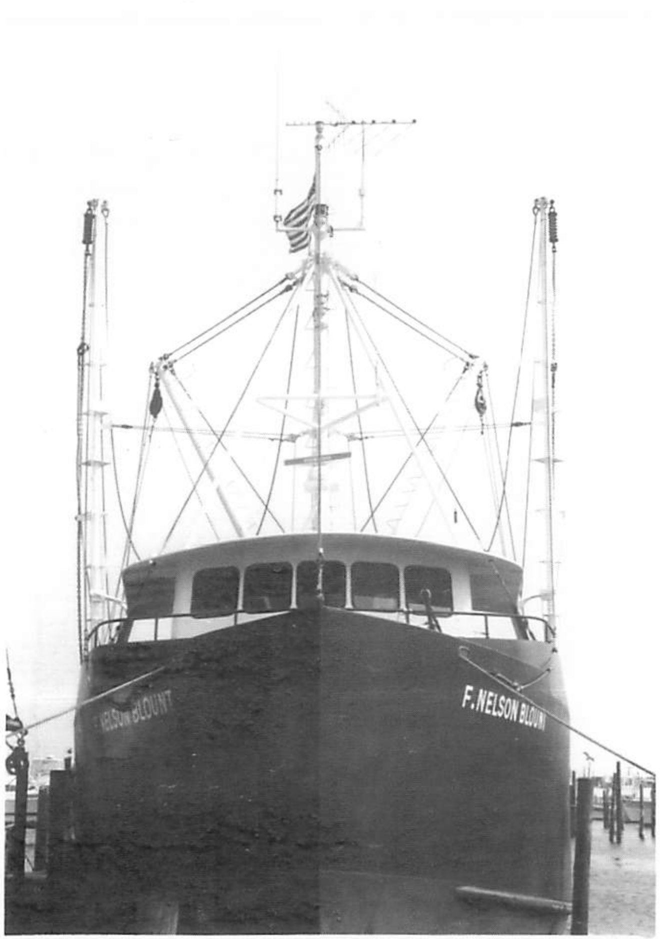
FISHERIES PROGRAM



Commercial fishing is easily one of New Jersey's largest, yet most overlooked, industries. Both finfish and shellfish are important to our commercial fishermen. Over 30 species of finfish and shellfish are harvested commercially in New Jersey including menhaden, whiting, ling, fluke, flounder, weakfish, bluefish, black sea bass, mackerel, tuna, tilefish, surf clams, hard clams, soft clams, oysters, scallops, mussels, lobsters and blue crabs. These species are harvested by a diversity of fishing gear including clam, crab and scallop dredges, trawl nets, gill nets, drift nets, seines, longlines, fyke nets, pount nets, traps, pots, rakes and tongs.

New Jersey's commercial fisheries rank among the most productive in the nation. For example, in 1979 New Jersey ranked ninth in the United States in pounds harvested landing over 189 million pounds of fish and shellfish with a dockside value of $53 million. The Cape May-Wildwood and Port Monmouth-Belford fleets ranked third and fourth in the nation, respectively, on a port pounds landed basis. New Jersey's fishing industry employs approximately 3,100 commercial fishermen operating 2,000 fishing vessels. These fishermen land about 75 million pounds of edible fish annually which carry a retail value exceeding $100 million dollars. The fishing industry also supports another 417 companies with more than 6,700 employees involved in processing, storing, shipping, and marketing fish and shellfish.

Introductions to the fisheries program in the past have stated that pollution continues to be the most critical problem affecting many elements of the New Jersey fisheries, and for this reason has received a high priority. Initial results of this priority research show that the problem has not been overstated; there is growing evidence that it may be even worse than originally defined.

It should be emphasized once again that the very large body of information available on pollution problems nationally does not contain sufficient data on the implications for survival of marine species—indeed, for key elements of the marine food web — in heavily contaminated areas, nor is there adequate information on concentration of toxic materials upward through the various trophic levels. The lack of data adequate for proper management or policy-making is not only a New Jersey problem; it is national.

With all of the above in mind, the New Jersey Sea Grant Fisheries Program has continued to investigate fish and shellfish resource problems in an attempt to find solutions or data that will assist optimal management, improvement, development, and utilization of those resources.

SUBLETHAL EFFECTS OF HEAVY METALS ON INTESTINAL ABSORPTION OF NUTRIENTS IN FISH FOUND IN NEWARK BAY/RARITAN AREAS

NEW JERSEY MARINE SCIENCES CONSORTIUM

A. Farmanfarmaian

Long-term health, growth, and therefore survival of finfishes and other fisheries resources of U.S. northeast coastal waters are threatened by the sublethal insidous effects of a variety of toxicants which find their way into these waters. They include heavy metals, agricultural pesticides, petroleum products, dispersants, detergents, PCBs, radionucleides, industrial acids, and nonspecific industrial and urban sewage residues. Most studies on the effect of toxicants on marine life have concentrated on acute species mortality and direct human health hazards involved in the accumulation and amplification of various substances, particularly heavy metals, in finfish and shellfish. More recently, attention has been directed toward the sublethal physiological, biochemical, and developmental effects of toxicants, particularly heavy metals, which debilitate the fisheries stocks by affecting development, growth, and ability to resist disease and environmental stresses.

Experiments conducted by Dr. Farmanfarmaian of Rutgers University have examined the effect of heavy metals on the absorption of essential nutrients, related these to the impairment of growth in laboratory and field populations of fish from pristine and contaminated areas, and explored the possibilities of mitigation measures. Specifically, the project attempted to address the following:

1. Compare the effect of heavy metal ($HgC1_2$, CH_3HgC1, $CdC1_2$ and $CoC1_2$) pollutants on the intestinal absorption of essential amino acids and calcium in fish from contaminated areas of the Hudson-Raritan estuary with those from relatively pristine areas in southern New Jersey and Buzzards Bay, Massachusetts.

2. Compare the growth, food conversion efficiency, general health, and survival of juvenile and adult fish in quantitative feeding experiments in which the total absorbed food and/or specific components, such as essential amino acids and calcium, can be quantitatively measured in two parallel series—with and without the inclusion of known levels of a heavy metal in the food.

3. Correlate morphometric measurements for the same year classes of fish from areas with known specific pollution to those in relatively pristine waters. Seek to establish relationships between these field studies and the laboratory studies described above with the aim of answering the question: Are the malabsorptions of the essential amino acids and calcium, caused by the presence of certain heavy metals in food, directly related to the growth, health, and survival of fisheries stocks in New Jersey and U.S. Northeast coastal waters?

4. In feeding experiments can the presence of minimal levels of selinium in the food mitigate against malabsorptions caused by Hg? Similarly, can the inclusion of moderate amounts of zinc protect against malabsorptions of calcium, which may be caused by the presence of Cd in food? Demineralization, weakened structure of bones, vertebral aberratons, and spinal deformities (lordoscoliosis) have a high frequently in fish exposed to Cd and other heavy metals. These deformities and loss of equilibrium impair swimming in fish.

5. Explore the chemical engineering possibilities of implementing the mitigation at sewage or industrial point sources of heavy metal toxicants.

In the past two years Dr. Farmanfarmaian's work demonstrated that Hg^{2+} ($HgC1_2$) in the concentration range of 0.25-10 ppm inhibits the intestinal absorption of the essential amino acid, L-leucine, in a variety of fishes including summer flounder, winter flounder, common killifish, striped killifish, toadfish, sea robin, and two species of sea urchins which are important food of fish and lobsters. The level of significant inhibition ranged from 10-80% depending upon Hg^{2+} concentration, the species, and the in vitro or in vivo design of the test. By contrast Ch_3HgC1 gave a lower percentage of inhibition observable only at 10 and 20 ppm. Preliminary studies also showed that Cd^{2+} is not as potent an inhibitor as Hg^{2+}, and Co^{2+} lies somewhere between Cd^{2+} and Hg^{2+}. The range of heavy metals used for the above studies included the levels reported in the gut of fish or in the natural food of fish in a neritic or benthic food chain. These levels are typically 100-1000 fold higher than those in the water column except near a point source where the water column is highly contaminated. By contrast the levels reported for the soft tissue of fish, and the invertebrates or small fish typically found as food in their guts, are of the same order of magnitude as the sediment.

When exposure to heavy metals in sea water or sediment are compared to exposure via contaminated food, the more important route for heavy metal accumulation, and consequent toxicity, is the intestine of fish. This is also true for fish larvae, crustacea, and molluscs. After exposure to contaminated food the gut lumen and wall have the highest level of divalent heavy metals when compared to other soft tissues. Heavy metals enter the intestine not only via food and drink but also via excretion through the bile duct.

There appears to be ample evidence for expecting high concentrations of heavy metals such as Hg^{2+}, CH_3Hg^{+}, Cd^{2+}, Zn^{2+}, and Co^{2+} in the intestinal lumen of fish in contaminated areas such as the Hudson-Raritan estuary. Since it has been demonstrated that some heavy metals inhibit the absorption of the essential amino acid L-leucine in fish, and others have implied that calcium absorption may also be impaired in the same manner, the question is *how prevalent and general are these malabsorptions in contaminated areas and to what extent do they actually interfere with normal growth of fish?* Results carried out with the summer flounder from Sandy Hook Bay (polluted) and Brigantine (pristine) in New Jersey, using 0.25 mM lecuine and a Hg^{2+} challenge at 0.5 and 10 ppm are presented in Figure 1. It can be seen that the normal rate of absorption of leucine is appreciably higher ($P<0.01$) in the pristine group. With the Hg^{2+} challenge both groups show significant ($P<0.05$) inhibition at 0.5 and 10 ppm Hg^{2+}, but the polluted groups shows more sensitivity at 0.5 ppm and equal sensitivity at 10 ppm with respect to leucine absorption.

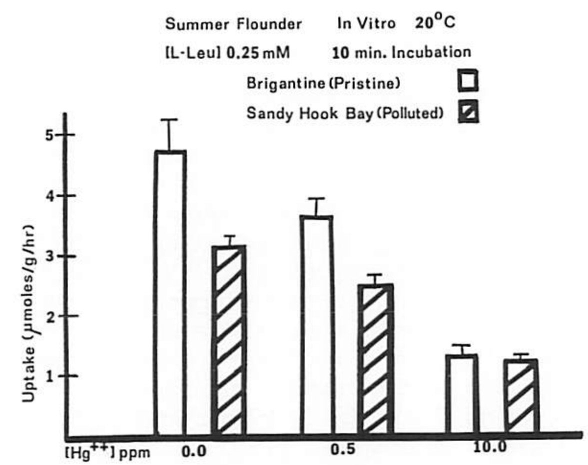


Figure 1. Uptake of Hg^{2+} in summer flounder from Sandy Hook Bay and Brigantine, New Jersey.

LIFE HISTORY AND POPULATION DYNAMICS OF TILEFISH

NEW JERSEY MARINE SCIENCES CONSORTIUM

C. Grimes and K. Able

In 1978 a study was initiated by Drs. Ken Able and Churchill Grimes of Rutgers University to develop the biological basis of management of tilefish, ***Lopholatilus chamaeleonticeps***, one of the most valuable edible finfish resources in New Jersey and New York. The overall objective of the study was to provide the biological basis for management of tilefish stocks in Mid-Atlantic Bight and southern New England waters. Through studies of stock identity, age, growth, mortality, reproduction, catch and fishing effort, and population dynamics, population models were constructed which enabled evaluation of the effects of different levels and strategies of fishing. Information from this study is presently being considered by the Mid-Atlantic Fishery Management Council for preparation of a tilefish management plan.

The tilefish, ***Lopholatilus chamaeleonticeps***, is a large (maximum size of 60 pounds and 120 cm) demersal species of the outer continental shelf, that occurs from Nova Scotia south to Surinam and throughout the Gulf of Mexico. They are abundant in the western north Atlantic from New Jersey to Cape Cod. Small commercial fisheries exist in the south Atlantic from Cape Hatteras to Florida.

Tilefish occur along a relatively narrow portion of the outer continental shelf and in submarine canyons at depths of approximately 170 to 240 m where temperatures are fairly uniform (approximately 9-14° C year round). They have been reported to occur around boulders and in "pueblo villages" in the steeply sloping sides of submarine canyons. Submersible observations by Drs. Grimes and Able during the summers of 1979, 1980 and 1981 have confirmed the above for selected portions of their distribution. However, observations indicate that the vertical burrows tilefish construct are probably the primary habitats throughout most of the area currently being fished in the Mid-Atlantic and southern New England area. Tilefish share these burrows with galatheid crabs, cancrid crabs, blackbellied rosefish, conger eels and others, forming a distinct community. Complex interactions may exist between tilefish and some associates. For example, galatheid crabs which occupy secondary excavations at the burrow margin, are a major food item for tilefish. The tilefish diet consists primarily of crustaceans, fishes, polychaetes and echinoderms.

A fishery for tilefish has existed in the Mid-Atlantic Bight since 1915, and in 1916 ten million pounds were landed in ten months. Since that time, landings have fluctuated between a few thousand pounds and about 8.0 million pounds. Since 1971 there has been a dramatic increase in commercial tilefish landings. In 1979 over seven million pounds of tilefish worth 3.7 million dollars were landed in this area. In 1979 and 1980 landings (approximately eight million pounds and worth 4.5 and 6 million dollars) exceeded all previous years except 1916. The catch is landed in Massachusetts, Rhode Island, New York and New Jersey but New Jersey has consistently recorded the greatest landings by far (58% of the total in 1980; according to the U.S. Dept. of Commerce).

Tilefish are taken commercially by longlines anchored and weighted to remain on the bottom. The submersible ***Nekton Gamma*** was used by Drs. Grimes and Able to evaluate the performance of longline fishing gear. Most hooked fish were in good condition; however, some fish were dead from gut hooking and sharks occasionally took hooked fish on the bottom. Seventeen percent of the catch was lost, apparently when longlines were retrieved and hooks pulled free from fish in burrows. Although the longline moved very little on the bottom, tilefish were attracted from a wider area than that transected by the longline. Bait predation by starfish and crabs resulted in 50% bait loss in four hours. Bait predation proceeded rapidly; all exposed baited hooks were preyed upon after three hours. Minimum soak time may be around two hours, and due to 100% bait loss from predation maximum useful time is eight hours.

Tilefish stock separation studies were accomplished using electrophoretic and morphological data. Samples from numerous locations within the Mid-Atlantic Bight (Hudson, Veatch, Block and Atlantis Submarine Canyons), South Atlantic Bight (off Georgetown, SC) and the Gulf of Mexico (off west Florida, Texas and on Campeche Banks) were examined. Results of electrophoretic analysis showed statistically significant differences in gene frequencies for both liver esterase and liver isocitrate dehydrogenase enzyme systems between northern (Mid-Atlantic Bight) and southern (South Atlantic Bight and Gulf of Mexico) populations. Morphological results also clearly showed differences between northern and southern populations, but clearly indicated that morphological variation was clinal (with no step clines) from north to south. These data suggest that Mid-Atlantic Bight tilefish populations represent one unit stock and that South Atlantic Bight and Gulf of Mexico populations be considered another stock, at least as a working hypothesis. However, the wide geographic separation of the latter two areas may necessitate managing them as two stocks. Because the electrophoretic results suggest that gene flow may occur between Gulf of Mexico and South Atlantic Bight populations, this should be done with cognizance that Gulf of Mexico populations could serve as a source of recruits to South Atlantic Bight populations.

Aging of tilefish was accomplished by using saggital otolith. Thin sections from the center of each otolith were microscopically valuated for age and measurements made from the central core to each annulus and the section margin. Ages determined from otolith sections agreed with ages determined from scales of the same fish. Marginal otolith increments analysis showed that bands were laid down at the same time (March-April) annually. The maximum age of females was 35 years for an 87 cm individual, while the oldest male was 28 years at 108 cm. The largest female was 95 cm at 29 years, and the largest male was 112 cm at 22 years. Calculations of lengths at annulus formation revealed growth of approximately 10 cm per year for the first five years, after which it slowed. The average female reached 55-60 cm at six years and thereafter grew more slowly than the average male. By eight to nine years the average male reached 65-70 cm.

Analysis of data to determine reproductive seasonality, maturity, sex ratio and fecundity were also completed. Analysis of visual staging data, ovum diameter distributions and gonosomatic indices, indicate that spawning occurs from May to October. Eggs are matured (1.30 mm diameter) and released in several batches per season; a typical (60 cm) female may release 1-2 million eggs per year. Sex ratio was skewed toward males at large size, but sex ratio does not differ from 1:1 for the population. Sex ratio was approximately equal until about 55 cm, when females began to predominate; and above 65 cm, males became increasingly preponderant. The unequal sex ratios most likely result from differential growth between the sexes and not from sex reversal as is the case in some fishes. Visual staging data suggested that most females matured at 52-57 cm and most males were 62-71 cm. However, histological studies of gonadal tissues suggested that both males and females were mature at 50-55 cm. Predorsal adipose flap size becomes sexually dimorphic in adult fish, with males developing enlarged flaps at about 65 cm. These findings may indicate that males delay spawning for as much as two or three years following physiological maturation. Taken together these results may indicate that participation in reproduction by males is under social control.

Length frequency data necessary to describe size/age structure of the fishery and estimate mortality were collected by randomly sampling over 13,000 fish from the commercial fishery. For comparison, other length frequency data from foreign trawl fisheries and the recreational fishery in Barnegat Light, New Jersey was obtained. Size/age structure, different size/age of recruitment, and dominant year classes have been described in the longline fishery and estimates of instantaneous total mortality have been made. Plots of length frequency data for the fishery show that substantial truncation in size structure has occurred since 1974. However, these data may indicate that the effects of fishing in truncating size structure may be fishing area specific.

Catch and fishing effort data was obtained from log books maintained by cooperating fishermen. Limited historical catch and effort data were also obtained from records kept by fishermen. An analysis of these data showed significant variations in catch-per-unit-of-fishing-effort (abundance index) with seasons and fishing areas. Results also suggested, although inconclusively, that abundance (catch-per-effort) up to 1978 had declined significantly since 1974. Furthermore, analyses suggest that seasonal variation in catch rates may be caused by stock movements (expansion and contraction) in response to seasonal changes in bottom water temperatures on the Mid-Atlantic and southern New England outer continental shelf. Movements suggested by catch rate and habitat information are consistent with seasonal expansion and contraction of 9-14°C bottom water covering the Mid-Atlantic and southern New England shelf at preferred depths (100-275 m) of tilefish.

To test this hypothesis, tagging studies were undertaken. Initially, studies concentrated on development of a suitable tagging technique. Conventional tagging methods were inappropriate for marking tilefish because mortality is induced by pressure and temperature change when these deep water fish are raised to the surface. A tag that detaches from conventional longline fishing gear to mark fish on the bottom was designed and successfully used.

Results of the tagging experiments suggest that tilefish are resident in the warm bottom water at Hudson Canyon year round, concentrate in a smaller area of warm water in late winter and spring (especially in the Veatch Canyon area) and may be completely absent from shallower waters adjacent to the more eastern canyons on Georges Bank (e.g. Oceanographer and Lydonia Canyon) when cooler waters are present there in winter and spring.

The tilefishery is an increasingly valuable and highly visible resource in New Jersey, and consequently, is receiving a high management priority as evidenced by the promulgation of a tilefish work plan by the Mid-Atlantic Fishery Management Council in August 1979 and requests by the National Marine Fisheries Service (NMFS) and the Mid-Atlantic Fisheries Council for tilefish management information. Despite the present low catches of tilefish in the South Atlantic Bight and the Gulf of Mexico the potential for an expanded tilefish fishery may exist in these areas. To this end, Drs. Grimes and Able are presently involved in investigations similar to those conducted in the Mid-Atlantic regarding the southern tilefish stock off the southeast coast of Florida. Plans are also being made to expand these studies into the Gulf of Mexico. It is hoped that by applying the techniques and information developed in studies of the Mid-Atlantic stock, a viable and well managed tilefish fishery may become established in these areas.

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SOCIOECONOMIC EVALUATION OF INNOVATIONS IN COMMERCIAL FISHERIES

B. McCay

A major part of the continuing research on the "human ecology" of New Jersey's commercial fisheries being conducted by Dr. Bonnie McCay of Rutgers University was a study of technological change among a group of fishing captains of Cape May County. The question asked in this study was how different aspects of the situations and perceptions of fishing captains are related to technological and other changes they planned to make. This study was motivated by widespread concern in New Jersey that commercial fishermen were not taking advantage of the opportunities that exist for fisheries development. Since the Magnuson Fishery and Conservation Act went into effect in 1977, foreign fishing off the coast of New Jersey has declined sharply. To some extent export markets for New Jersey fish have improved, and many persons believe that new opportunities, some of which require technological change in fish harvesting and handling, exist for the local industry. Accordingly, it seemed appropriate to inquire into the factors that accounted for technological changes among the fishermen. It must be noted, that no evidence of conservatism that had been attributed to local fishermen was found. Cape May County fishermen are and long have been very innovative and responsive to opportunities. In fact, this study took place after a five-to-six year period of rapid growth and expansion of Cape May fisheries and at the beginning of a new period of development, marked by the start of a directed fishery for summer squid (*Illex illecebrosus*) for export markets and increased use of purse seine technology for tuna.

The Cape May fleet works out of four docks in Cape May Harbor, a finfish dock at Otten's Harbor in Wildwood, and out of Sea Isle City. This area is referred to as "Cape May" in official reports. It is the largest fishing port on the east coast between New Bedford, Massachusetts, and Hampton Roads, Virginia, and vessels from other ports frequently visit Cape May when fishing Mid-Atlantic waters. According to the 1981 statistics published by the National Marine Fisheries Service, the leading species in terms of pounds landed were, in descending order, scup (porgy), weakfish, Atlantic mackerel, fluke, and sea scallops. (This study does not include surf clams and ocean quahogs, which are also very important to the Cape May fisheries). The vessels studied also caught large quantities of many other species, ranging from black sea bass to whiting. There is great seasonal and year-to-year variation in abundance of the different species, but the large number of species available to Cape May fishermen provide a kind of insurance against the inevitable ups and downs. Nonetheless, fishing is risky and uncertain. Accordingly, it tends to select for people who are able to take chances and work under uncertainty. Willingness to take risks is reflected in the responses Cape May captains gave to a set of questions concerning buying a new piece of equipment. Twenty-four captains (52%) said they would buy even if the chance of obtaining a satisfactory return were only 50-50.

The period 1975-1979 was a "boom" period for the Cape May fleet. Much of the boom rested on the rapid development of fishing effort and technological capacity in sea scalloping. 1979 landings were 6 times those of 1975 and over 22 times those of 1972. The decline of the Virginia winter trawl scup fishery also helped the Cape May fleet during this period, since it increased market demand. Decline in yellowtail flounder production in Mid-Atlantic and New England waters also helped the Cape May fleet, as market demand increased for a related product, fluke, long a specialty of New Jersey's otter trawl fishermen. Increased Cape May catches of mackerel were made possible by reduced foreign catches. These and other factors stimulated rapid technological development in the fishing fleet. Vessels today tend to be much larger, newer, more mobile and far-ranging compared to those of the early seventies. For example, within the otter trawl fleet, sizes have increased and hulls changed from wood to steel, reflecting a shift from day trawling (close to shore) to multi-day trawling trips.

The prosperity and changes of the boom period are reflected in data on the captains of the fishing vessels. A number of young men became captains during the 1975-79 boom. Accordingly, the average age of Cape May fishing captains is quite low. The average age was thirty-seven in 1982, and thirty for the group that became captains during the 1975-79 boom. Very few captains are over fifty. The boom period also resulted in changes in patterns of vessel ownership. Non-owner captains, once rare in New Jersey's fisheries, are now much more common, especially within the sea scalloping fleet, whose development has involved outside investors and owners. Kinship ties are fairly common, even among the captains in Cape May Harbor of whom 39 percent have kin who are also captains in the Cape May fleet. Fourteen of the captains in the study have close kin in their crews. While less than 30 percent of crew members stay with a particular vessel for more than three years, on the vessels in which there is a kinship tie between the captain and at least one member of the crew, the crew tends to be more permanent. Families that fish together, it appears, stay together. The highest turnover is found in the scallop fishery, especially on investor-owned vessels where captain turnover is common. The sea scallop fishery involves trips as long a fourteen days, compared to two to six days for trawlers, and difficult, dangerous work. Today, when large catches are more difficult to come by, crew turnover is even more of a problem.

Forty of the captains interviewed said they wish to maintain or increase their commitment to fishing. The other six wished to lessen their level of commitment to get out of the business, largely because of economic problems. The problem emphasized most by the captains who wish to maintain or increase their commitment is that of price, a chronic complaint of fishermen and in 1982 a real problem. Only 11% of the captains recalled that in 1975 or 1976 their returns from fishing were less than they had expected. However, in 1982 52% of the captains felt that their 1981-82 returns were less than expected, partly because of declining catches for some species and partly because of lower value when adjusted for inflation. The dockside buyers of fish have much greater knowledge of price than the fishermen and are sometimes viewed suspiciously, but this study found strikingly high levels of stability in fisherman-buyer relationships in Cape May.

In commercial fishing technological specifications depend heavily on the species sought, the form in which they are to be landed, and the planned duration and location of fishing trips. The Cape May fishermen seek to occupy particular "niches" in the commercial market, and their technology reflects this. The "niches" are species or mixtures of species sought. Vessels and harvesting gear, or "core" technology, and "augmenting" technology such as ice-holds, refrigeration, or on-board ice-making (to maintain fish quality) are heavily dependent on the niche. "Auxiliary" technologies, such as radar, loran, radio, and plotters, apply across the spectrum of fishermen. Examples of important innovations in "core" technology are midwater or pair trawling (with or without an electronic net recorder), the conversion of scallopers for bottom trawling (otter trawls), and the refitting of vessels with purse seines. In "augmenting" technology, growing concern for maintaining fish quality (to maintain market niches or enter new ones, e.g. for summer squid) is leading to growing interest in on-board refrigeration. Maintaining fish quality on board not only helps enter new market niches but may also make longer trips possible and allow captains to hold their catches for better prices. For "auxiliary" technology or equipment. Cape May fishermen have used and experimented with large varieties and are increasingly interested in satellite navigation, new radios, video depth finders, track plotters, etc. Cape May has a long history of technological innovation: one Cape May fisherman claims to be the first to use a depth finder, during the second World War.

Table 1 summarizes the number of technological changes per year from 1972 through 1981 among the vessel captains interviewed. These data should serve to dispel the notion that New Jersey fishermen are unwilling to change or accept new technological ideas. Comparable levels of innovation and change are not found among the fish buyers, although expansion of export trade is leading to plans for change in storage capacity, freezing equipment, handling methods, etc. The Cape May "docks" were able to absorb the fishing boom of the 1970s without technological change, and continued fluctuation in fish landings and prices works against widespread and significant change in their operations. The use of block ice, labor rather than machines, and other seemingly archaic methods by the "docks" is a prudent way to adjust costs to product volumes and markets. Fishermen, on the other hand, are more reliant on technology than on temporary manual labor to increase productivity, lower costs, and improve safety at sea. Their sets of incentives and requirements differ.

In the 1970s technology was adopted to exploit an opportunity, and correlations between the adjusted value of landings and data on the adoption of vessels, gear, and equipment between 1972 and 1981 are very strong. The boom years are over. The factors motivating technological changes are less evident. New developments have appeared on the Cape May scene: a summer squid season; new fishing docks; the conversion of several

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TABLE 1
SUMMARY OF TECHNOLOGY CHANGES,
FORTY-SIX CAPE MAY FISHING VESSEL CAPTAINS,
1972 - 1981

Year	Vessels Acquired	Refrigeration Changes	Gear Changes	Equipment Items-* First Year of Use	Total Changes
1971	1		3	40	44
1973			1	7	8
1974	2		8	41	51
1975	3		3	43	49
1976	3	1	7	47	58
1977	4		4	46	54
1978	9		10	81	100
1979	8		9	78	95
1980	10		7	84	101
1981	2	–	2	23	17
	42	1	54	490	587

*First year of use may pre-date captaincy.

trawlers to purse seining; plans for a new freezer facility. However, the past two years have been poor for Cape May fishermen. In this setting our study was undertaken.

The data collected showed a strong and significant correlation between planned fishing change and planned technological change. In other words, fishermen who plan to try a new fishery, perhaps a different species or in a very different location, are more likely than others to be considering technological changes. Technological change, along with fishing change, is thus part of a fisherman's search for a niche, a position as supplier of a species or mix of species from which he seeks a satisfactory return for himself. This was particularly true for core and augmenting technologies, but also for auxiliary technology (e.g. radio, depth finding, and other equipment).

In addition, this study found that those who express optimism about their future fishing prospects are less likely than those who are not optimistic to plan changes in fishing or technology.

Another attitudinal factor that helps predict technological and fishery change in the Cape May fishing fleet is how captains assess the relationship between the returns they expected and what they actually experienced. At the beginning of this study it was anticipated that fishermen who were dissatisifed with their current returns but were optimistic about the future would be the ones to plan changes in their fishing technology (vessels, gear, refrigeration, etc.). However, this proved not to be so. In this group those planning changes are balanced by those planning no changes. In the group who are optimistic and content with the relationship between actual and expected returns the tendency is to do nothing. It is those who are not optimistic about the future, particularly those with less than expected returns, who plan to make important changes.

What appears to be happening in the contemporary Cape May fishery is that everyday interplay of species availability, market influences, fisherman skill, resource, and effort differentials, and the vagaries of chance lead some fishermen to view the future with pessimism (or at least no optimism) and also cause some of these non-optimists to experience poorer returns than they had expected. These are the prime candidates for fishing and/or technological change. They are seeking new alternatives, trying to diversify in a period of greater economic setting, those who reetain some optimism about the future of the fishery they are engaged in, regardless of whether their returns are less than expected, are less likely to make plans to change either their technology or their kind of fishing. One might have expected them to plan technological changes that would lead to the intensification of their present fishery—doing it better—as was the general pattern during the boom years of 1975-79, but they are not making those plans. They are holding their own, having already intensified their technology and fishery in the past. If and when environmental, market, and other conditions lead them to give up their optimism, they too may begin to consider searching for new niches and planning technological changes.

NEW JERSEY
MARINE SCIENCES
CONSORTIUM

TOLERANCE TO CHRONIC EFFECTS OF POLLUTANTS IN NEWARK BAY AREA KILLIFISH

P. Weis, J. Weis, J. Bogden

Heavy metal tolerance can be acquired by both short-term physiological mechanisms and by long-term genetic selection. In view of their previous findings that *Fundulus heteroclitus* embryos from a polluted environment (Piles Creek - PC) are more tolerant to methylmercury (MeHg) than embryos from a cleaner habitat (Southampton - SH), Dr. J. Weis, Rutgers University and Drs. P. Weis and J. Bogden of UMDNJ, investigated the short-term component of tolerance in four experiments.

1. PC females were maintained in clean water to see if meHg tolerance of subsequent clutches would be reduced relative to intitial clutches. Data showed that tolerance, as measured by degree of embryonic abnormality produced by 0.05 ppm meHg, was actually increased in later clutches. SH females were maintained in PC water and in water with low levels of meHg to see if subsequent clutches would show an increase in tolerance, but no subsequent clutches were produced.

2. Tolerance of larvae which were pre-exposed to meHg as embryos was compared with that of littermate control groups which were not pre-exposed. Half the eggs in each clutch were treated with 0.02 ppm meHg in 30 ppt sea water at 24° C. After hatching, larvae were transferred in groups of 10 to 100 ml of sea water. Experimental groups were dosed with 0.05 ppm meHg and controls were untreated. Solutions were changed daily and dead larvae removed for up to 8 days. For each group an LT_{50} (Time to 50% death) was calculated and the mean LT_{50} for pre-exposed and non pre-exposed

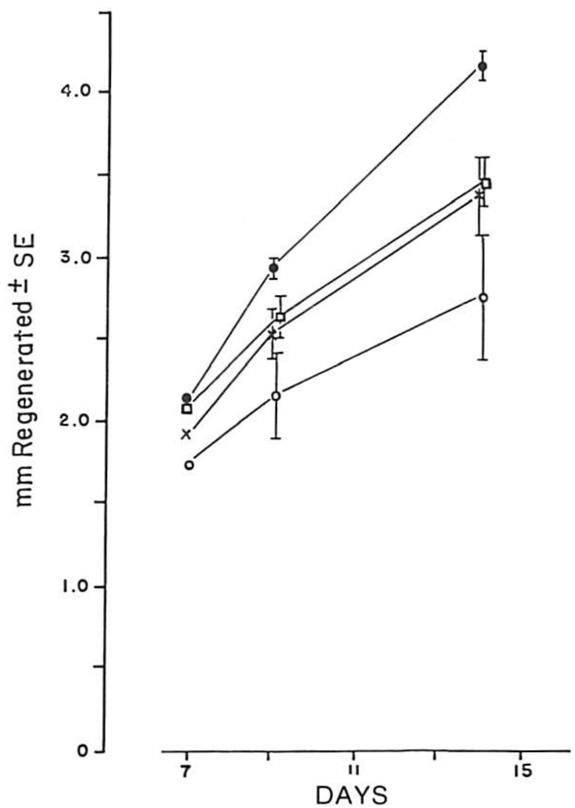

Figure 1. Pre-exposure effects on regeneration of F. heteroclitus caudal fins (mm + s.e.) □ = 0.0.1 meHg 0.05 meHg; x = control 0.05 meHg; = pooled controls (C C, 0.01 meHg C, and 0.005 meHg C). See text for explanation.

groups calculated. The pre-exposed groups were less, not more resistant (Table 1.)

3. Tolerance of adults pre-exposed to meHg was compared with that of those not pre-exposed in a fin regeneration assay. Pre-exposure was to 0.01 or to 0.005 ppm meHg for a week prior to amputation. After amputation of half of the caudal fin, experimental fish were maintained in 0.05 ppm meHg while controls were in clean sea water. Water was changed and redosed twice a week, and regeneration of the amputated fin measured twice a week for a two week period using a calibrated ocular micrometer in a stereomicroscope. While those pre-treated with 0.005 ppm and those not pre-treated at all were equally affected by the 0.05 ppm during regeneration, the fish which had been pre-exposed to 0.01 ppm showed a greater reduction in fin regeneration rate, indicating that they were less resistant (Figure 1.)

4. Tolerance of PC adults (Pre-exposed for their whole lives) was compared to that of SH adults in the fin regeneration assay. 0.05 ppm meHg slowed regeneration in both groups, but the SH controls grew at a much greater rate than PC controls, and PC experimentals had a very high mortality rate, indicating lower resistance. In 0.03 ppm meHg, SH fish showed an enhancement of growth (hormesis) not seen in the PC fish.

Therefore, no evidence for a short-term component to meHg tolerance in this species has been found, and it is likely that the observed embryonic resistance is genetic.

Embryonic Treatment	Larval Treatment	(n)	LT_{50}
Control	0.05 ppm meHg	22	5.32 + 0.31 (S.E.)
0.02 ppm meHg	0.05 ppm meHg	15	4.33 + 0.24*

*Significantly different by t - test, $P<0.001$.

Table 1. LT_{50} of *F. heteroclitus* larvae in methylmercury (meHg).

NEW JERSEY MARINE SCIENCES CONSORTIUM

BIOLOGICAL IMPACT OF AROMATIC HYDROCARBONS IN SOUTHERN NEW JERSEY COASTAL WATERS: EFFECTS OF NAPTHALENE AND TEMPERATURE ON OXYGEN CONSUMPTION OF MYSID SHRIMP

B. Hargreaves and S. Herman

An important step in modeling the ecological effects of oil pollution in New Jersey coastal waters is the evaluation of key species exposed to representative hydrocarbon toxicants. Mysid shrimp are the major food for many fish species which use the salt marsh lagoons as a nursery habitat. Drs. Hargreaves and Herman previously showed that the dominant mysid in this area, ***Neomysis americana***, is more sensitive to oil pollution than are most fish, and is especially sensitive during summer months when both mysids and fish are actively growing and reproducing.

When they exposed mysids to naphthalene (a typical aromatic hydrocarbon in petroleum products) at concentrations 10-100 times greater than that likely to be found in coastal lagoons and channels, the mysids died after several days. Naphthalene entered the body tissues rapidly during exposure to seawater containing low levels of the hydrocarbon. Within several hours after the onset of naphthalene exposure the concentration reached a plateau. Monthly tests of the lethal limit showed a marked increase in both sensitivity to naphthalene and accumulation in body tissues when water temperature exceeded 20°C, as it usually does during July through September. Although the tested concentrations would be present following an oil spill, and such an event could be expected to destroy a major source of food for fish, the effective concentrations were much higher than typical values in the field. The more significant implication of these findings was the effect of summer temperatures, and the suggestion that death was caused by a buildup of naphthalene in the tissues.

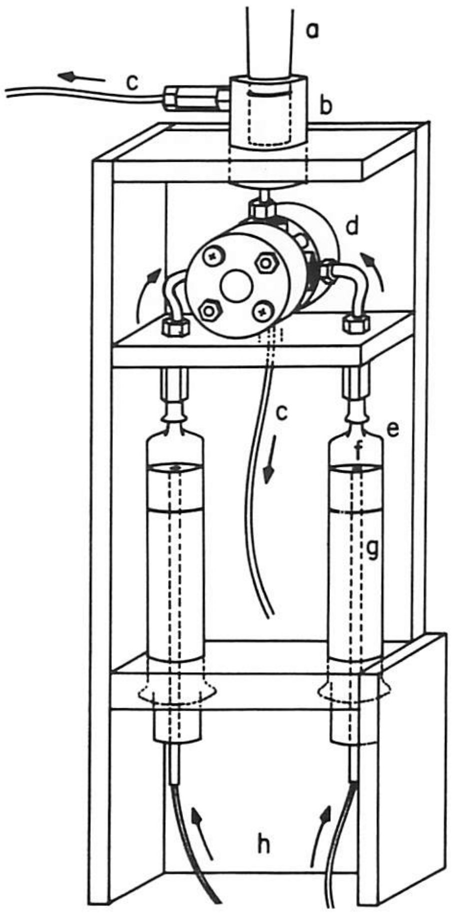

Figure 1. Continuous flow respirometer. a=oxygen electrode, b=oxygen measurement cell, c=effluent tube, d=four-way valve, e=10-ml glass syringe, f=1-ml animal chamber, g=teflon plunger, h=influent tubes from constant-head reservoir.

To assess the toxic effects of oil pollution at lower concentrations, and to further assess the role of water temperature and the accumulation of naphthalene, a sublethal test was developed to measure changes in respiration over 24 hours during exposure to naphthalene. Figure 1 shows the continuous-flow respirometer which was developed to analyze the response of individual mysids. It incorporated the gravity-feed toxicant/seawater reservoir developed in the previous year. The oxygen concentration was recorded for water flowing out of matched chambers, one of which (f) contained a resting mysid. Oxygen consumption was computed from the continuous record using brief intervals when the oxygen sensor was automatically calibrated.

Resting metabolism showed a slight daily cycle which was disrupted by low levels of naphthalene. Resting metabolism rose rapidly during the first few hours of exposure, reached a plateau in about 3 hours, and declined after about 12 hours for the highest toxicant levels (Figure 2). Metabolism also increased when mysids were tested at elevated temperatures to which they had been exposed for several weeks (Figure 3). The highest combination of toxicant and temperature was known to cause death after several days, but the other combinations represented sublethal conditions in which the mysids might survive indefinitely if food were supplied.

The estimates of resting metabolism appear to be sensitive indicators of stress in the mysids. The new respirometer gives lower and more accurate values for resting metabolism than previously used apparatus (for example, when small sealed chambers are used instead of flowing seawater). The published description of this method should prove useful to other scientists studying sublethal responses to toxicants in aquatic organisms.

A rise in resting metabolism in response to naphthalene exposure probably means that mysids are using more energy and are less efficient at growing and reproducing. The pattern of respiratory response to naphthalene over the first few hours is similar to the pattern of naphthalene accumulation in body tissues. This similarity suggests that the energy costs cuased by exposure to various oil pollutants might be predicted if the tissue concentrations are known. Since progress is being made in predicting tissue concentrations from water concentrations of various oil pollutants, the loss of energy to a population of mysids might be predicted eventually from cehmical analysis of water samples. The energy cost appears to be significant; the decline in resting metabolism observed after 12 hours (Figure 2) suggests that those mysids are running out of energy reserves. Although food available in nature would prevent the starvation suggested by Figure 2, mysids might grow more slowly or produce fewer offspring under such conditions. The implications for fish populations are hard to estimate, but fish species that cannot switch to other sources of food when mysids are scarce may decline in abundance.

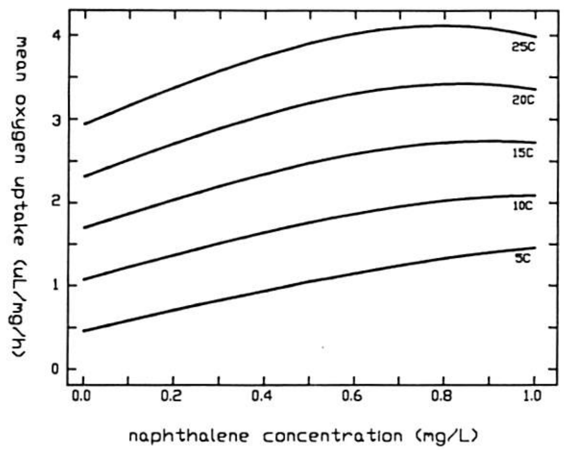

Figure 2. Neomysis americana. Resting oxygen consumption during the course of naphthalene exposure at 15° C, computed for an 11mm long female. Naphthalene concentration (mg/liter) is indicated for each curve.

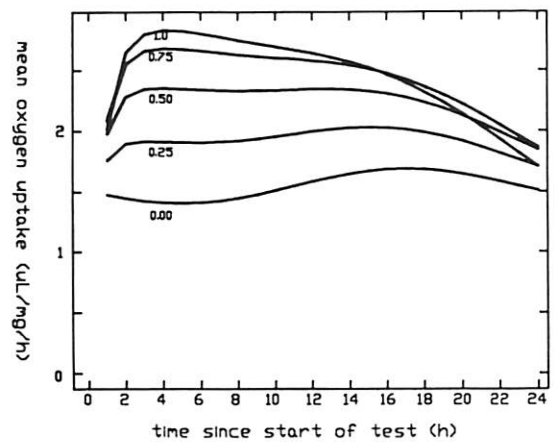

Figure 3. Neomysis americana. Resting oxygen consumption at different acclimation temperatures and naphthalene concentrations, computed for an 11mm female.

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IDENTIFICATION OF BIVALVE LARVAE: A MULTI-INSTITUTIONAL APPROACH

R. Lutz

New Jersey Sea Grant VII was the second year of a proposed 5-year project directed by Dr. Richard Lutz of Rutgers University. The primary objective of the effort is publication of a comprehensive manual for the identification of bivalve larvae and early postlarvae (through *routine optical* microscopic examination of the larval hinge apparatus) in estuarine and marine waters of the North Atlantic. This objective is being accomplished through a multi-institutional cooperative effort, involving 15 institutions (academic, federal and private industrial) along the various coasts of North America.

The many difficulties associated with accurately identifying bivalve larvae within the plankton have long hampered applied and basic research efforts in estuarine and open coastal marine environments. For example, as a result of existing practical barriers, detailed studies concerning spatfall predictions for aquacultural and fisheries management purposes have been extremely limited. Year-to-year fluctuations in larval abundance and juvenile recruitment are often not possible to define due to an inability of researchers to discriminate individual larval and early postlarval specimens. Similarly, it has been virtually impossible in routine plankton identification studies to unambiguously assess the impact of various environmental perturbations (natural "disasters", chemical pollutants, thermal discharges, oil spills, dredge spoil dumping, etc.) on the larvae of individual species of bivalves. While a few keys for larval bivalve identification do exist, their usefulness is limited and, at the present time, it is not possible to unambiguously identify the larvae of many bivalve species, particularly at the early (straight-hinge) developmental stages. This ongoing project offers an approach aimed at eliminating many of the existing obstacles to future research. The involvement in this project of a number of researchers at various institutions, who are presently culturing the larvae of numberous species of bivalves for other purposes, has proved to be an extremely cost-efficient means of achieving the goal of the proposed effort (i.e., publication of a practical identification manual).

Over the past two years of the project, larval and, in many cases, postlarval developmental sequences were obtained for the following 25 species of bivalves: *Mytilus edulis* (blue mussel); *Modiolus modiolus* (northern horse mussel); *Geukensia demissa* (Atlantic ribbed mussel); *Ischadium (=Brachiodontes) recurvum* (hooked mussel); *Crassostrea virginica* (American oyster); *Ostrea edulis* (European oyster); *Argopecten irradians* (bay scallop); *Placopecten magellanicus* (deep-sea scallop); *Mya arenaria* (soft shell clam); *Mya truncata; Spisula solidissima* (surf clam); *Mulinia lateralis* (dwarf surf clam); *Macoma maitchelli; Macoma balthica; Arctica islandica* (ocean quahog); *Arca noae* (common arc); *Genna genna* (gem clam); *Periploma leanum; Astarte castanea* (chestnut clam); *Pitar morrhuana; Diplothyra smithii; Ensis directus* (razor clam); *Nucula annulata; Nucula proxima; Mercenaria mercenaria;* and *Tagelus plebeius* (stout razor clam). Optical micrographic and/or scanning electron micrographic early life history sequences are being prepared for each of these species.

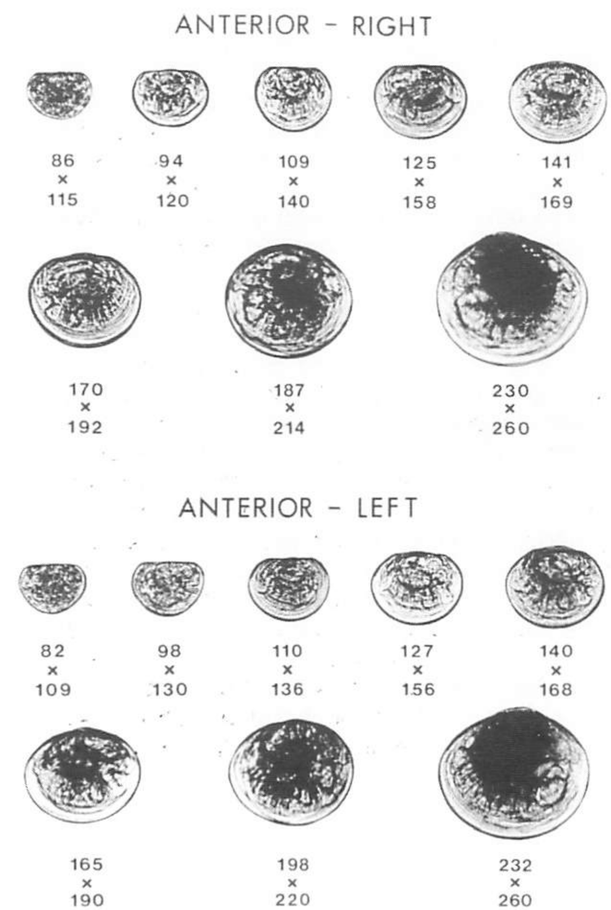
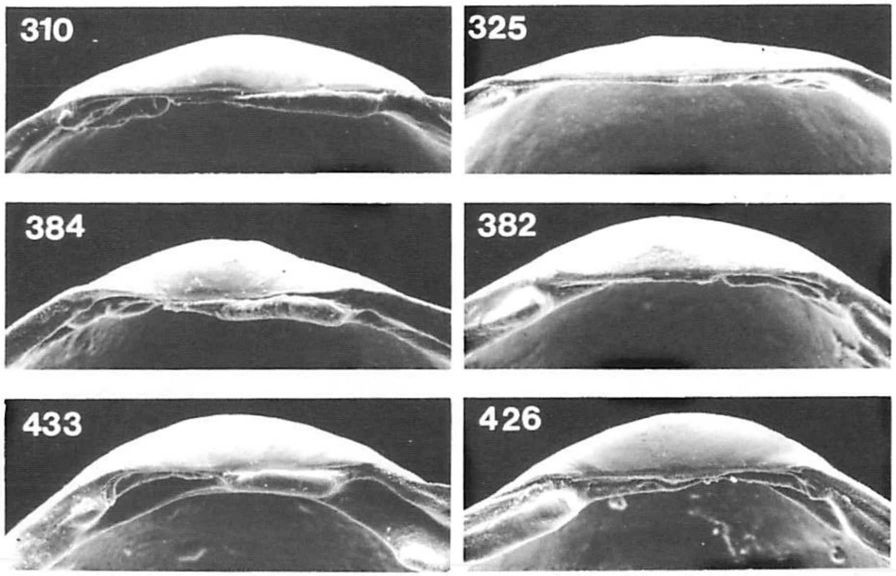


Figure 2. Photomicrographic sequences of the larvae of the ocean quahog, Arctica islandica, from the early straight hinge stage to metamorphosis. Height and length dimensions (um) are given below individual specimens.



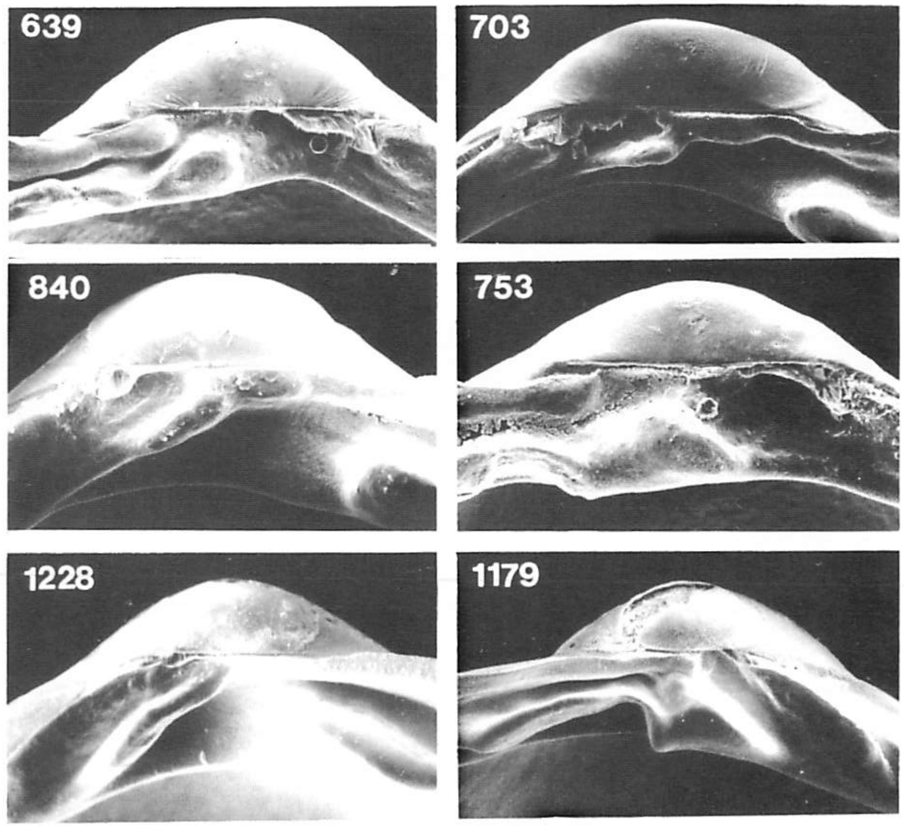


Figure 3. Scanning electron micrographic sequences of disarticulated shell valves of ocean quahog (Arctica islandica) postlarvae. Left valves on left side and right valves on right side. Numbers designate lengths of the shell in um.

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An invited paper entitled "Discrimination of Larval Bivalves in the Plankton: Aquacultural Implications for Predicting Spatfall" was presented at the annual meeting of the World Mariculture Society and twelve separate papers or abstracts have been published (or are currently in press) in refereed journals summarizing our results obtained to date.

A photographic format has been developed for presentation in the final manual of the ontogenetic sequences of the larval and postlarval stages. Figure 2 depicts the format to be used for optical micrographis sequences of larval stages, while Figure 3 illustrates the format for scanning electron micrographic sequences of the hinge regions of postlarval specimens. Both of the depicted sequences are of the ocean quahop, *Arctica islandica*.

NEW JERSEY SEA GRANT FISHING INDUSTRY STUDY: INFLUENCE OF WEATHER AND SEA STATE

NEW JERSEY
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R. Raguso and J. Del Greco

The individual fisherman has long been at the mercy of the whims of weather, with little more than sketchy, non-specific sector forecasts issued for his general area. Often, the forecasts were not specific enough for his parochial concern, and wind/wave parameters were averaged for the entire region, many times not representative of his locale. As a result, the "peril of the sea" was often very real for these navigators of relatively small craft on a large ocean. In contrast to large ocean vessels, fishing boats had to contend with waves of a height and length posing the threat of disaster. Obviously, it does the fisherman no good to hear or read a forecast for "moderate conditions" if a 55-foot long, 8-foot high wave will swamp his 45-50 foot vessel in an extreme corner of the forecast sector.

Some thoughts come to mind about this problem:

1. The National Weather Service is not chartered to provide specific, detailed offshore forecasts to industry segments. As a result, they are obliged to produce the general weather "discussions" currently being issued;
2. Equipment is committed to offshore work, often in the face of missing and/or incomplete weather data. This often results in equipment damage or loss due to weather-related "accidents";
3. Fishing boats are damaged or lost, people injured or killed, often with little weather data available prior to sailing: In 1981, the U.S. Coast Guard S.A.R. statistics show that, in 30 cases involving N.J. fishing boats over the canyon areas, $500,000 of property was lost. Eighteen of these cases, involving $250,000, occured when winds were over 20 knots. A summary of N.J. cases in 1981 also cites 63 lives lost despite Coast Guard efforts.
4. There must be more efficient collection, analysis and dissemination of data already available.
5. There must be continual follow-up, so that the final product can be refined, providing maximum benefit to the user.

With this study, Messrs. Raguso and Del Greco of Bendix Field Engineering Corp. intended to help those concerned with a relatively small area of the North Atlantic Ocean, and whose special weather information needs and requirements have, for the most part, gone unnoticed. Bendix weather advisories attempted to pinpoint the environmental parameters most important to the individual fisherman, enabling him to make those decisions having most impact on him. In addition, it was intended to fine tune the form and content of these advisories, and show the saving in fuel, reduction in weather damage, etc., gained through the prudent use of accurate, specific, timely forecasts in their area of interest.

Bendix began issuing offshore advisories through the N.J. Sea Grant Extension Service in June of 1981 on an experimental basis, and comments from the users were invited. Responses came in during September and October of 1981 and were overwhelming favorable: 15 fishermen cited a total of $18,000 in fuel saved by scrubbing a trip due to weather (average $1,200 per boat). More letters referred to "significant savings over many trips", but did not quantify the money saved.

Based on this positive response, Bendix proposed this study to identify the characteristics of the N.J. fishing industry, the weather-sensitivity of the fleet, and the economic benefits of a customized, responsive weather advisory service. Thanks to the efforts of the N.J. Sea Grant Extension Service (SGES), the benefit-study was funded by combining resources from N.J. Sea Grant, and Monmouth and Ocean Counties.

The mechanics of distributing the forecast were simple: Bendix meteorologists prepared the advisories Monday through Friday and sent a written transcript via telecopier in SGES Toms River office. The advisory was read into a recorder, and callers heard the recorded message. The forecasts were available 5PM through 8AM, excluding holidays and weekends.

The problems and benefits of a customized forecast designed to reduce the potential for loss over the offshore regions are illustrated by the following two cases:

The first case is the sinking of the fishing boat "JOAN LARIE III" on October 24, 1982. Here, the captain made the decision to sail, even though the forecasts accurately called for deteriorating conditions for the next 18-24 hours. While the prevailing weather at the time of sinking did not appear abnormally bad, calmer conditions might have enabled the boat to return to port safely.

While this was not a typical weather problem, the decision to leave port at that time might have contributed to the disaster.

The second case is a classic weather problem — one of the worst storms ever to hit this area — "The Blizzard of '83", February 11-12, 1983. Here, the accurate and timely forecasts of severe conditions, issued both by National Weather Service and Bendix, convinced almost all of the offshore boats to seek the closest shelter, averting a potential devastation of the fleet. Even so, a 90 foot boat out of Barnegat Light sustained damage off the coast of New Jersey. Two New Jersey-based boats required assistance to make shelter in Virginia during the storm; the assisting ship, about 600 feet long, sank in the storm off the Virginia coast, shortly after helping the fishing boats.

In just two cases, four fishing boats were involved in an "extremis" situation — one sank, one received damage, and two almost were lost, due to weather or its effects. Several hundred thousand dollars in equipment, in addition to the lives of the crew, were lost or imperiled in just those two incidents.

All the figures compiled in this study do not reflect the intangible deleterious effects of weather on fishermen: Their boats and equipment do not last as long as expected, and their careers are shortened by stress or injury related to severe weather. If these boats and men are not replaced, the remaining fleet must make up the lost volume, or the entire industry suffers. This could result in greater economic pressure to leave port to stay offshore in worsening weather, increasing even more the potential for damage or loss of the vessel and crew. Through intelligent use of forecasts, however, each fisherman could reduce his time spent in bad weather, preserving his boat and equipment, and increasing the length of his career and the amount of money he makes. In general, this would benefit the entire industry.

To summarize, over $11 million of operating costs could have been saved during the past year (1982-1983) through an accurate, timely offshore weather forecasting service, not including the savings in lost boats and crew, which could amount to thousands, even millions of dollars more.

Finally, there is the issue of long-range forecasting for the offshore areas. The results show that there is little difference in the 24-hour accuracy of the Bendix and National Weather Service (N.W.S.) forecasts. This is not surprising, since the forecasts were prepared independently by trained professionals in both houses, using the same data set.

Bendix shows a clear advantage, however, in issuing forecasts beyond 24 hours. Recently, the National Weather Service extended its offshore advisory to the 1000 fathom limit, which is roughly the canyon fishing grounds. This advisory gives good detail for 24 hours ahead, but only provides a general description of the expected position of major weather features, with a superficial treatment of wind/wave values for 48 hours ahead. While this is a step in the right direction, it does not appear to satisfy the operational needs of the fisherman. Since the Bendix experiment began in June 1981, through the end of the study in 1983, Bendix provided as much detail in the 48-hour outlook as was put into the 24-hour forecast.

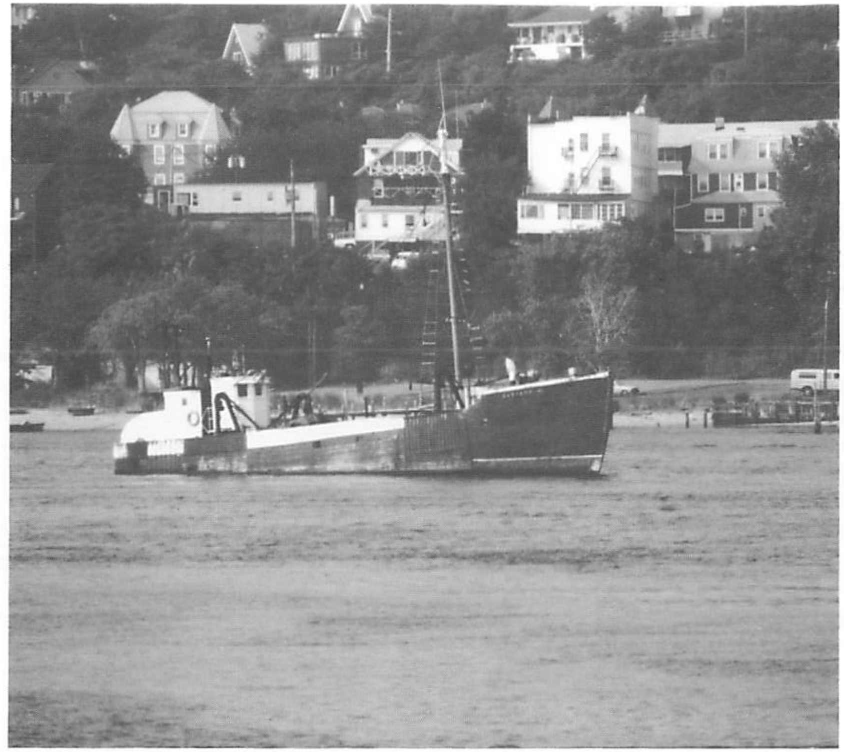
The concept (and reality) of a customized, targetted forecast received overwhelmingly favorable input. One symptom of this has been a complaint that weekend weather is not updated! To recap the views of fishermen, offshore forecasts should include:

1. *Wind:* Direction and speed. Apparently, both parameters are of equal importance. Fisherman almost unanimously say that E-NE winds are more troublesome than W-NW winds.
2. *Waves:* Again, direction of sea/swell is as important as height.
3. *Long Range Outlook (2-3 Days):* This is particularly important to the commercial fleet, but also helps the charter and recreational operator to plan ahead.
4. *Superstructure Icing:* This apparently is a greater problem close inshore during the winter than over the canyons.
5. *General Weather Synopsis:* Position of High and Low Center, fronts, etc., actual and projected movements and effects.
6. *Storm Warnings:* Prognosis of the effects of significant systems approaching the forecast area.
7. To a lesser extent, outlooks of Visibility, Air and Water Temperatures.

The forecasts should be updated regularly every 6-12 hours, with special bulletins for sudden, unexpected events, and the advisories should be available 7 days a week. Further, the area covered by each advisory should be reduced to cover a limited region (Baltimore Canyon to Block Canyon, e.g.); as stated before, the small size of the fishing boat calls for a bit more attentiveness to slight changes in wind/sea conditions than for a large ship.

The dissemination should be targetted for each area's concern — New Jersey fishermen generally go to one area, New York, Delaware, Rhode Island have other regions of primary interest to them. While the "big picture" is good, each fisherman should be able to receive a specific forecast for his fishing ground.

The results of this study are available to Sea Grant/Marine Advisory Service (M.A.S.) committees, National Weather Service Conference of forecasting priorities, national marine weather advisory groups, and all other interested parties, to promote a greater awareness of the problems and their possible solution, and help the individual owner/operator to make the *proper* decision for safety and efficiency quickly and confidently.



NEW JERSEY
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NORTHERN NEW JERSEY ESTUARINE PROGRAM

The Hudson-Raritan estuarine system receives flow from the Hudson, Raritan, and Passaic River drainage basins. All of these river basins are polluted from industrial and urban sources throughout their drainages; thus, the Hudson-Raritan estuary receives a major portion of the waste products discharged into the environment from the New York metropolitan area. In fact, of all the major embayments of the northeastern United States, the Hudson-Raritan estuary is considered the most heavily polluted.

Because the acute pollution of New Jersey estuaries is the state's most serious environmental problem, research into pollution sources, processes, and effects has been a Sea Grant priority since the program's inception. As indicated above, the northern New Jersey estuaries and bays are among the most heavily used and contaminated in the nation because they drain the vast industrial chemical and petrochemical complex of the most densely populated region of America.

Estuarine research conducted under the New Jersey Sea Grant Program continues to attempt to determine the source, nature, amount, location, and fate of heavy metals and other important pollutants in the northern New Jersey estuaries, and to assess the potential for constructive change.

To achieve this objective, the complex biology and chemistry of pollutant interaction with the marine environment must be understood if there is to be any hope at all of future interdiction of pollutant damage. But, further, where, how and when the pollutants move through the system also must be known to a degree that will permit prediction with relative precision.

Another objective of this program is to determine the impacts of heavy metals, toxic chemical compounds, and other pollutants on the estuarine ecosystem. This objective relates to determining the effects of pollutants at a fundamental level — how toxicants interact with and become part of the estuarine organic structure.

It is the goal of our Sea Grant estuarine research to yield data useful to environmental decision makers involved in management of New Jersey's complex northern estuarine complex. Furthermore, it is hoped that knowledge acquired through investigations of our polluted northern estuaries can be applied to other estuarine environments throughout the country.

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PHYSICAL OCEANOGRAPHIC STUDIES OF THE HUDSON-RARITAN ESTUARY

G. Mellor and R. Hires

This study by Drs. George Mellor and Li-Yauw Oey of Princeton University and Dr. Richard Hires of Stevens Institute of Technology was concerned with a numerical-observational physical oceanographic study of the greater New York Harbor region encompassing the Hudson and Raritan Estuaries, the Passaic, Hackensack, and East Rivers, Newark Bay and the Kills around Staten Island.

A time-dependent, three dimensional, finite-difference simulation of the Hudson-Raritan estuary was developed in the initial phases of the study. The calculation covered July through September, 1980 and included real tide and wind forcing and also time-dependent river and sewage discharges. Turbulence mixing coefficients in the estuary were calculated according to second moment, turbulence closure sub-model. Salinity contours showed formation of a complex pattern of eddies produced by the interaction of the unsteady, three dimensional velocity field with coastline and bottom bathymetries. These eddies are advected and subsequently mixed throughout the water column and are important physical elements in shear dispersion processes in the estuary.

The effect of wind on the vertical salinity structure was shown to be significant in shallow regions of the estuary. An up-estuary wind of magnitude 0.5 dyne cm^{-2} can turn an originally stratified estuary with an average depth of 5m into a well-mixed estuary. A down-estuary wind produces the opposite effect. Subtidal velocity and salinity fields were found to depend significantly on the wind forcing.

Salinity measurements along the Sandy Hook-Rockaway transect were made during August 20th and 27th, 1980. It was found that the model predicts well the details of the observed salinity distribution. Throughout the tidal cycle, the observations showed that unstably stratified water columns are created by advection of waters of different densities which subsequently mix. The observations also showed that the water becomes vertically homogeneous during a spring tidal cycle. These complex three dimensional flow structures and mixing events are predicted remarkably well by the model. There is also good agreement with the observed time-averaged circulation in Raritan Bay.

Next, the results from the time-dependent, three-dimensional numerical simulation of the Hudson-Raritan estuary covering the period August 1980 were compared with observations made during the same period by the National Ocean Survey. The comparison included: 1) comparison of amplitudes and phases of tidal constituents at four tide-gauge stations and five current meter stations in the estuary; 2) comparison of kinetic energy spectra; and 3) comparison of subtidal cross-shore current response to cross-shore and along-shore wind forcing at a meter location near the mouth of the estuary.

Model results generally compared well with observations. Discrepancies can be explained in part by the uncertainty in the open boundary specifications. Predicted M_2 phases at three tide gauge stations show significant improvement over the M_2 phases obtained from a two-dimensional, vertically integrated tidal model. The improvement is presumably due to bottom boundary layer resolution, and therefore, improved representation of bottom friction in the three-dimensional model. The horizontal diffusion coefficients are null in this model. The burden of horizontal dispersion is generally handled well by the model's adequate resolution of small scale advective processes. In the two-dimensional (x,z) rivers, the estimate is that horizontal dispersion due to vertical variability in velocity and salinity is correct; however, mixing by lateral variability is absent so that salinity intrusion is somewhat under-predicted. Explicit addition of horizontal diffusion in the 2-D rivers or lateral resolution would correct this.

Current responses to wind forcing in the estuary generally conform well to observed responses. The response is predominantly barotropic and is a result of balance between bottom friction, cross-shore sea surface slope and wind stress, modified by vertical velocity shear and density-induced baroclinic effects. Non-local sea level forcing from the self region is significant and its inclusion is expected to be important to a successful simulation of both the tidal and subtidal dynamics in the estuary. Non-local forcing was included in the present simulation study by specifying observed sea level at the mouth of the estuary.

Finally, results from the numerical simulation of the Hudson-Raritan estuary were used to analyze salt fluxes at three sections in the estuary. It was found that salt fluxes and volume transports in the estuary vary considerably over subtidal time scales of a few days to weeks and that an averaging time of at least 50 days is required to define a statistically stationary estuary. The sub-tidal forcing is due to local and non-local winds and neap-spring tide variation.

Various physical mechanisms account for the salt balance in the estuary. It was found that tidal trapping effects due to coastline irregularities contribute most to the salt balance at the Sandy Hook-Rockaway transect and at the Narrows. A two week osbervational record was analyzed to support this finding. In Raritan Bay transverse effects are important as are the effects of vertical velocity and salinity gradients despite the fact that the top to bottom salinity difference during the simulation period — a period of low fresh water flow — never exceeded one half of one part per thousand throughout most regions of the bay. In Raritan Bay this is due to the following factors: (1) the tidal r.m.s. current is weak ($<0.2\ ms^{-1}$); (2) the unsteady wind is important; and (3) there are no significant coastline irregularities in the bay, which would otherwise provide large scale, more intense horizontal eddies. It is concluded that a two dimensional, depth-integrated xy-t model, in which the horizontal dispersion coefficients are modelled empirically, will not perform well in this case.

It is clear that progress in understanding the sources, pathways and fates of pollutants in estuaries depends not only on a detailed knowledge of the biological, chemical and geological processes affecting these pollutants but also on an equally thorough understanding of the relevant physical phenomena. The goal from the beginning of these physical oceanographic studies has been to provide predictions of the variations in the physical environment, i.e., temperature and salinity, and predictions of the current distributions which serve to transport the pollutants within and across the boundaries of the Hudson-Raritan estuary. The application of this three dimensional numerical model to predict currents and temperature and salinity distributions to the entire New York Harbor region provides an unparalleled opportunity for synthesis of past, present and future physical oceanographic work in the estuary. In addition it provides the much needed physical framework for studies of pollutant transport within and through the modelled region.

NEW JERSEY
MARINE SCIENCES
CONSORTIUM

RELATIONSHIP OF SALINITY AND OTHER ENVIRONMENTAL PARAMETERS TO MICROBIAL TRANSFORMATIONS OF MERCURY IN ESTUARINE SEDIMENTS

R. Bartha

Most people associate mercury, the only metal that is a liquid at room temperature, with its use in thermometers. Less well known are the vastly larger scale uses of this unique metal by industry in electrodes, batteries, switches, paints, metal alloys, chemical catalysts and biocides. The last term refers to a group of mercury-containing organic compounds designed to kill pests, prevent spoilage of materials and the microbial fouling of surfaces. Unfortunately, the same properties that make mercury compounds effective as biocides also render them highly hazardous as environmental pollutants. For this reason, the use of mercury compounds as biocides has been severely curtailed in the United States, but numerous other uses of mercury are bound to continue. Some of the manufacturing wastes and products inevitably wind up as environmental pollutants. In addition, the burning of fossil fuels, particularly coal, releases cumulatively large amounts of mercury into the atmosphere from where it returns with precipitation to surface waters. Although a significant effort is made to minimize mercury pollution, it has been estimated that man's various activities double the annual release of mercury into the environment as compared to natural cycling processes. And while the release of the most hazardous forms of mercury has been curtailed, certain aquatic microorganisms possess the unwelcome ability to convert comparatively harmless forms of inorganic mercury into highly toxic methylmercury compounds. These tend to accumulate in fish and shellfish, and the consumption of methylmercury-tainted seafood caused fatalities and permanent impairments in two tragic poisoning incidents that occurred in Japan. Similarly dangerous situations in Scandinavia and in the United States were averted only by closing waters to fishing that became polluted by hazardous levels of methylmercury.

In view of the described situation, efforts to safeguard seafood resources from tainting with methylmercury need to be pursued on two levels. Environmental pollution by mercury, whatever its chemical form, needs to be minimized. For technological as well as economic reasons, progress in this direction is expected to be at best only gradual. Another promising abatement approach would be to learn how to control the activity of microorganisms that convert the relatively harmless forms of polluting mercury into the highly toxic and biomagnification-prone methylmercury compounds. This latter approach is being investigated by Dr. Richard Bartha and some of his graduate students at the Department of Biochemistry and Microbiology, Cook College, Rutgers University.

The methylation of mercury is a complex process that is either directly or indirectly dependent on microorganisms living in aquatic sediments. Mercury needs to be in a form that readily accepts methyl ($-CH_3$) groups. This form is considered to be the soluble mercuris (Hg^{++}) ion. Methylation of mercury may occur by one or more enzymatic mechanisms demonstrated in pure culture experiments. Alternately, the function of sediment microorganisms may be merely the synthesis of a methyl donor such as methylcobalamin that, in turn, methylates mercuris ions in a spontaneous chemical reaction. Not as yet known is, however, which of the above mechanisms are at work in aquatic sediments, and what is the relative importance of each process. Obviously, a precise knowledge of the mechanism(s) is essential for design of the most effective control approaches and Dr. Bartha's current efforts are directed at the unravelling of the mercury methylation mechanisms that are active in aquatic sediments. But even prior to these ongoing investigations, the work in Dr. Bartha's laboratory has identified important factors that influence the mercury methylation process and offer definite possibilities for its control.

The main experimental approach in this work involved the collection of sediment cores from various New Jersey salt marshes in a manner that minimized sample disturbance. The sediment samples were then transferred to the laboratory and were placed in reactor vessels that allowed both the monitoring and regulation of various environmental parameters such as temperature, salinity, pH, redox potential, etc. The sediment samples were spiked with low amounts of mercuric chloride, and conversion to methylmercury with time was measured by periodic analysis using electron capture gas chromatography. This technique is capable of detecting as little as 10 parts per billion of the methylmercury product.

To date, experiments of this type have demonstrated that methylmercury is formed at higher rates in sediments of low redox potential (-220 mV) and low salinity (0.2%). High redox potential (+110 mV) and salinity approaching the strength of seawater (2.5%) strongly supress mercury methyla-

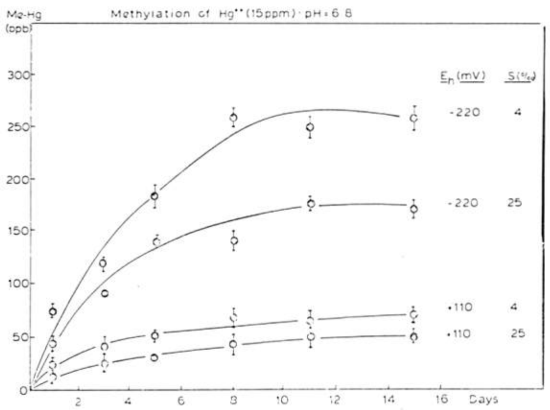


Figure 1. Methylation of mercury in sediments in relation to redox potential (E_h) and salinity (5%).

tion (Figure 1). High redox potential not only decreases methylation but also stimulates mercury demethylation activity. The inhibitory effect of salinity on mercury methylation was traced to the precipitation of mercuric ions by some of the anionic components of sea salts. Biocarbonate acts in this manner at both high and low redox potentials, causing a moderate inhibition of methylation. Sulfide, produced by reduction of seawater sulfate at low redox potential, ties up mercuric ions very effectively, resulting in almost complete suppression of methylmercury formation. Other anionic components of seawater did not influence the methylation process significantly.

The above laboratory experiments were correlated with analysis of collected field samples and have successfully explained why in some New Jersey salt marsh environments mercury pollutants are not methylated while in others they are. They resulted also in practical recommendations concerning cleanup procedures to be employed at a salt marsh site that is severely polluted by mercury. Continued investigations are expected to make additional progress towards the prediction and control of methylmercury formation in estuarine sediments, thus protecting both seafood resources and the health of consumers.

AN INTERDISCIPLINARY INVESTIGATION OF NITRIFICATION IN RARITAN BAY

NEW JERSEY MARINE SCIENCES CONSORTIUM

B. Deck, H. Ducklow, H. Simpson, and F. Cantelmo

Steps have been taken in the last several decades to improve sewage treatment in many areas of the country. In the northern New Jersey — New York region bordering the Hudson estuary and Raritan Bay, new sewage treatment plants have been completed, or are being expanded, to allow better treatment of the substantial amounts of sewage being discharged.

Within Raritan Bay and the Hudson estuary two processes contribute to oxygen depletion. The first process is the decomposition of organic material and is termed carbonaceous biological oxygen demand, or BOD. The second is nitrification, the oxidation of ammonia to nitrite and nitrite to nitrate, by the action of specific groups of bacteria. Oxygen demand from this process is called nitrogenous BOD. Large quantities of ammonia are present in sewage and most present methods of treating sewage are not effective in removing much of hte potential oxygen demand from this source. Most sewage management decisions have been aimed at reducing only the carbonaceous BOD in part because a lack of research has resulted in little concern being given to nitrogenous BOD, which calculations show can be a significant portion of the total BOD.

During this and the previous New Jersey Sea Grant year, Drs. Deck, Ducklow, and Simpson of Lamont-Doherty Geological Observatory of Columbia University have conducted a project to evaluate the role of bacterial nitrification in regulating the levels of oxygen and dissolved nitrogenous species in the waters of Raritan Bay and the lower Hudson estuary. During this project, rates of oxygen consumption and nitrification have been measured directly and also estimated by observing water column concentrations of nitrite and nitrious oxide (a by-product of the first step in the nitrification process). Ammonia is being supplied to Raritan Bay at the western end by the Raritan River and Arthur Kill in a region where the salinities are the lowest. Figure 1 shows that nitrite concentrations in Raritan Bay vary as a function of salinity with the highest nitrite concentration occurring at the lowest salinities within the bay. The linear trend of the data suggests that the majority of water in Raritan Bay is a mixture of low salinity western bay water, high in nitrite resulting from nitrification, and high salinity N.Y. Bight water low in nitrite. Figure 2 shows the concentration of nitrite as a function of nitrous oxide concentration. The data correlation is not extremely good because although both species are produced in the first step of the nitrification process, nitrous oxide is a gas and can leave the water column to the atmosphere during water column mixing and circulation in the bay. Figure 3 shows the strong inverse correlation in oxygen and nitrous oxide concentrations. Nitrification, as shown by high nitrous oxide concentrations is greatest where the oxygen is most depleted indicating a covariance in carbonaceous and nitrogenous BOD processes. Of note in figure 3 are the substantial number of data points with oxygen, concentrations greater than saturation (as shown by the circle, O_2-N_2O saturation at

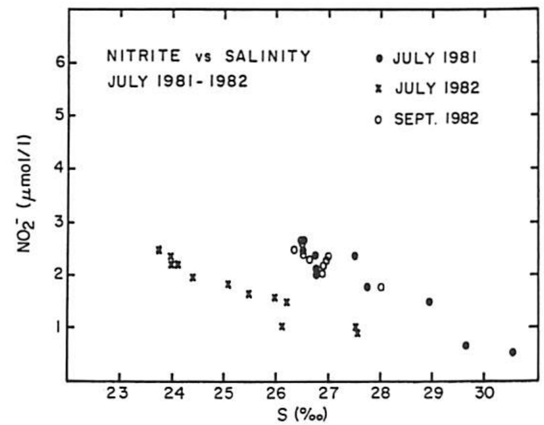


Figure 1. Nitrite concentrations in Raritan Bay as a function of salinity.

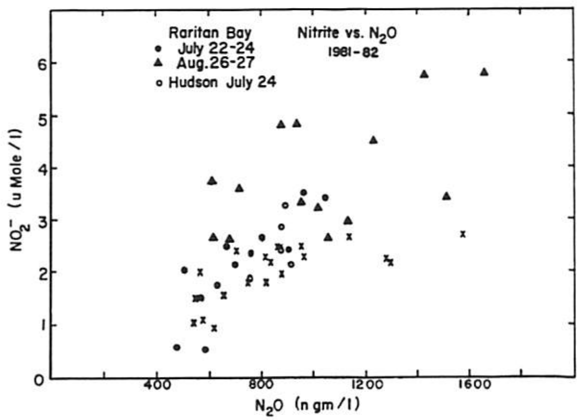


Figure 2. Nitrite concentrations in Raritan Bay as a function of nitrous oxide concentration.

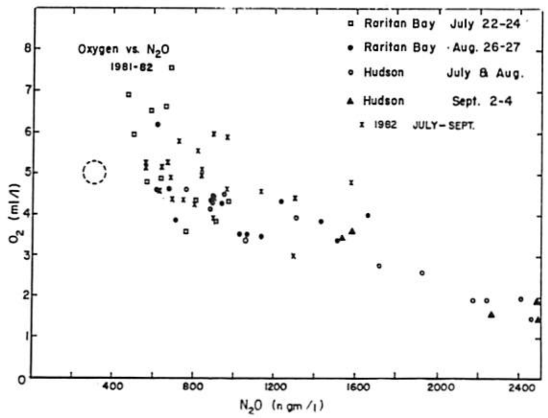


Figure 3. Inverse correlation in oxygen and nitrous oxide concentrations from Raritan Bay and the Hudson River.

temperatures and salinities in the bay) resulting from photosynethsis during algal blooms.

Incubation samples from the water column of Raritan Bay have been treated with several types of inhibitors to determine rates of oxygen consumption from carbonaecous and nitrogenous BOD and nitrite — nitrate production from ammonia oxidation. General results indicate that a major portion of oxygen consumption occurs in the first 5 days. Nitrification proceeds slowly in the first few days and rapidly increases after 5 to 6 days, consistant with the hypothesis a lag time is rquired for nitrifying bacteria to become established. Additional data indicates that the nitrification rate varies with location in Raritan Bay and may be very dependent on the circulation rate for water in the bay.

The substantial influence of the sediments and organisms within them on the nitrification process in Raritan Bay were investigated in this project by Dr. Frank Cantelmo of St. John's University. Bottom populations of small worm-and shrimp-like organisms living in estuarine sediments are collectively referred to as meiofauna. These organisms include the nematodes and harpacticoid copepods and range in size from .040 mm to .050 mm. The meiofauna are the most numerous multicellular animals and average populations of 40,000 per m^2 are commonly found in local estuaries such as Raritan Bay.

The influence of meiofauna populations on ammonification and ammonia oxidation rates has been investigated in incubated estuarine bottom water and sediment samples from Raritan Bay, Jamaica Bay and in model laboratory systems. By using selected inhibitors of ammonia oxidation (nitrapyrin) and nitrite oxidation (chlorate), it is possible to measure ammonia and nitrate accumulation in the incubated samples. Ammonification rates in water samples containing natural sediments with meiofauna are 3-4 times greater than either bottom water or sediment controls. In samples without nitrapyrin, the ammonia is rapidly oxidized to other nitrogenous species. Ammonia oxidation rates measured with chlorate indicate that there is some enhancement of nitrite production due to the presence of meiofauna, but the main influence of meiofauna appears to be related to ammonia regeneration.

In summary, findings of this study indicate that high rates of microbial nitrification do occur in Raritan Bay. This conclusion is supported by data on ammonia, nitrate, nitrite, and nitrous oxide distribution as well as measurements of nitrification rates themselves. This conclusion supports the hypothesis that Raritan Bay is an optimum environment for nitrification.

It has also been shown that nitrification is often more rapid in bottom waters than in top waters, and that benthic meiofaunal nematodes can stimulate nitrification. The shallow depths and largely muddy bottom of the Bay, with its rich meiofaunal population, and the high concentrations of ammonia imported from the Hudson and Arthur Kill probably explain the rapid rates that have been measured.

NEW JERSEY
MARINE SCIENCES
CONSORTIUM

COASTAL SYSTEMS PROGRAM

If one were to stretch out the coastline of New Jersey it would reach from Toms River to Denver, Colorado. A not inconsiderable distance of 1,792 miles. However, if all the citizens of New Jersey decided to go to the shore at the same time, only 15" of beach would be available to each. And that's not counting the thousands of out-of-state tourists who visit each year.

New Jersey has nearly 200 kilometers of beaches, most of them on fragile barrier islands where the population density during the coastal vacation season rivals most metropolitan areas. Relatively few of the state's beaches have been spared the indiscriminate, haphazard buildup which poses severe problems for coastal managers and the stability of the barrier beach systems.

With a program goal of developing the knowledge and methods to assist in the management and preservation of New Jersey coastal systems, the Sea Grant program has made substantial contributions toward problem definition, data accumulation and analysis, and even engineering improvement of tidal inlet management. Past coastal systems projects have addressed such critical issues as identification of hazard areas on barrier islands, tidal inlet responses to erosional forces, evaluation of beach nourishment techniques and practices, and testing of fluidization techniques for maintaining navigable channels.

Progress in understanding coastal processes has been good under the Sea Grant program because of the close coordination with coastal managers, and the ability of the researchers to take those findings to the resource managers. It is important that this progress continue; New Jersey's coast, after all, is the focus of tourism, the state's second largest industry and the livelihood of the state's coastal communities.

NEW JERSEY
MARINE SCIENCES
CONSORTIUM

SHORELINE CHANGE AND LAND USE AT TIDAL INLETS

K. Nordstrom

One of the purposes of this study conducted by Dr. Karl Nordstrom, Rutgers University, is to present a model of geomorphic change for shorelines adjacent to tidal inlets on developed barrier islands. The new model is presented to draw attention to potential stages in landform change which need to be tested with new information obtained from studies designed specifically for developed areas. Part of the rationale for this study is to show that models of change based on undeveloped inlets which are now used to describe these shorelines are not appropriate for study of developed systems.

There are 12 ocean inlets in New Jersey. Five of these are stabilized by jetties. Three inlets are not stabilized and have no development adjacent to them. The remaining four inlets, Great Egg, Corson, Townsend, and Hereford Inlets, are not stabilized by jetties, but the adjacent shorelines are developed. These four inlets (Figure 1) are the major focus of this study.

The inlet shorelines are very mobile (Figure 2) with annual rates of change as high as 95.2 meters. The high mobility of the shorelines near the inlets has discouraged (but not prevented) development, and there are portions of undeveloped land immediately adjacent to all of the inlets. Communities near the inlets have employed bulkheads and seawalls as shore protection. These structures affect sediment transport into the inlet and to the undeveloped shorelines near the inlet throat. These protection structures help to fix the position of

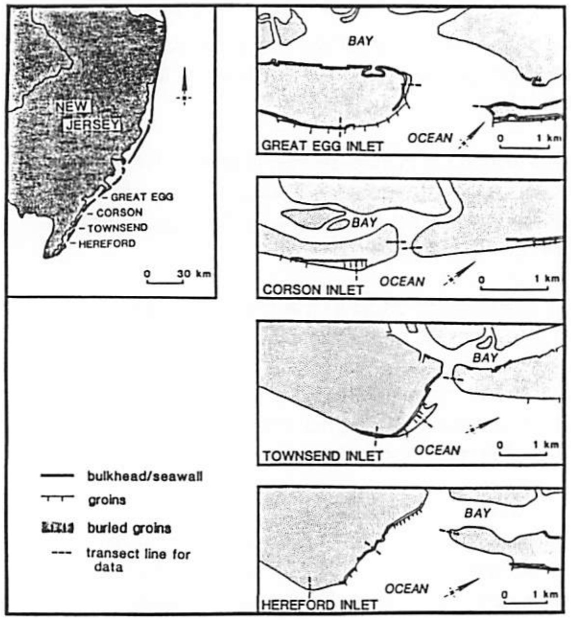


Figure 1. Unjettied tidal inlets on the developed ocean shoreline of New Jersey.

much of the inlet shoreline and reduce the quantity of sediment passing into the inlet from updrift. Because of these modifications, future changes at the unjettied, developed inlets will differ substantially in both rate and form from those which have been documented on undeveloped inlets and have occurred on the New Jersey inlets in the past.

One result of implementation of a large number of protection structures is a landward offset to the

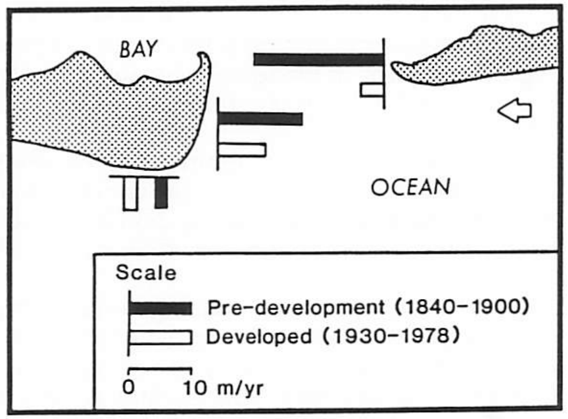


Figure 2. Average rate of shoreline change at unjettied, developed inlets.

sediment starved shoreline downdrift of the contact between protected and unprotected areas. There is now a pronounced shoreline offset updrift (north) of Hereford Inlet resulting from sediment starvation. The erosion at Hereford Inlet has occurred at a rate of 27 m per year over the last 9 years. Most of the 2 meter high dune has been eroded here and the beach is only about 5 meters wide. There is now little sand left in storage above mean low water downdrift of the groins.

Empirical evidence suggests that zones of sediment starvation caused by engineering structures may extend several kilometers downdrift of the terminal structure, and these starvation zones extend rapidly downdrift through time. These findings suggest that the zone of sediment starvation caused by the groins which are updrift of the four inlets either now includes portions of the ebb tidal delta or will include them.

Shore protection structures were not widely employed in southern New Jersey until the early 20th century when shoreline development began to take on major proportions. The effects of development on the configuration of the shoreline have only recently become noticeable, and the full effects are not yet apparent. Some trends are discernible, however, and the implications of these trends for models of future change can be assessed. Shorelines in the throats of the inlets (Figure 2) have been less mobile under conditions of development (after about 1935) than when largely undeveloped (prior to 1900). The rate of change on the shoreline updrift of the inlets has been greatly reduced.

There has been a slight increase in the mobility of the shoreline at the bulge downdrift of the inlets after development. There are no structures immediately updrift of these locations to interfere with delivery of sediment from the ebb tidal delta. Dramatic changes can be expected to occur on these beaches downdrift of inlets as a result of alterations to the ebb tidal delta. As the delta becomes affected by diminished sediment inputs from updrift, changes in delta form will cause erosion of downdrift beaches.

The conceptual model for shoreline change at developed inlets (Figure 3) is based on recent trends in the four unjettied inlets in southern New Jersey, extrapolated into the future. The existence of bulkheads and artificial dunes updrift of the inlet reduces the likelihood of breaching of the barrier island there. Even if a new breach is created, it is likely to be artificially closed to protect existing houses and community infrastructure. Thus, breaches will only occur in the unprotected portions of the barrier island. Once formed, a new

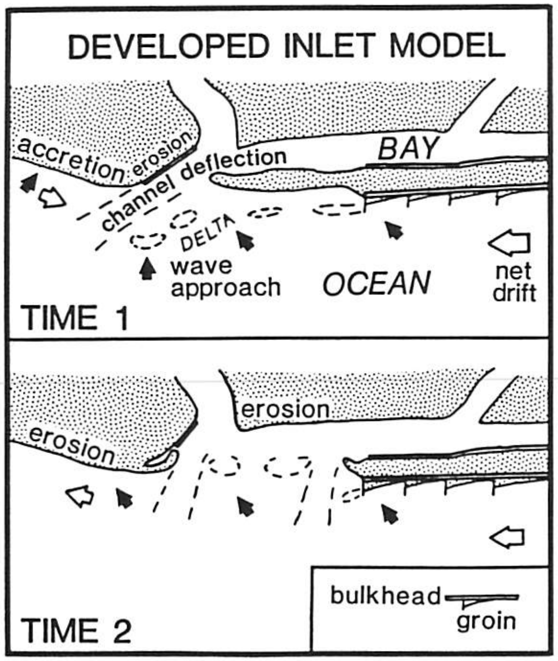


Figure 3. Conceptual model of shoreline changes on a developed inlet shoreline based on observations at New Jersey inlets.

breach is likely to remain open because there will be insufficient sediment in the longshore transport system to cause closure. The updrift barrier will not migrate downdrift because of sediment starvation. If a breach does not occur in the barrier island downdrift of the protected area, diminished sediment inputs will result in persistent erosion of the shoreline and the barrier will be eroded in place (Figure 3, Time 1). The eventual elimination of the unprotected portion of the barrier island will expose the marsh landward of it to ocean waves and the marsh will erode (Figure 3, Time 2). The zone of sediment starvation will eventually extend to the ebb tidal delta which will diminish in size. The value of the delta as a filter against storm waves will thus be diminished.

The new inlet will be wider than the previous inlet (Figure 3, Time 2). An increase in inlet cross section will be accompanied by shoaling of the main channel and the formation of secondary channels will be likely. There will be less sediment delivered to the updrift sides of the current channels, and downdrift deflection of the channels will be considerably reduced. The relocation of the main tidal channel from its downdrift position (in Figure 3, Time 1) will result in sediment starvation at the downdrift bulge, which, combined with higher wave energies there, will accelerate erosion (Figure 3, Time 2).

The shoreline in the inlet throat may undergo accertion initially because of the relocation of the ebb current channel updrift, but the long-term trend will be erosion because of diminished protection from ocean waves and diminished sediment inputs form the smaller ebb tidal delta.

The result will be the complete alteration of the barrier island system where structures are emplaced and the elimination of portions of the shoreline downdrift of the structures due to sediment starvation.

The model presented here is conceptual and it is only the initial stage of one of a series of scenarios which could be created. It is difficult to determine steady-state conditions when construction is still occurring and when the shoreline has not equilibrated to existing structures. Trends associated with development are conspicuous, however, and these can be used to anticipate future change. There is sufficient difference between the way shoreline change occurs under developed and undeveloped conditions to warrant a closer look at the effects of development.

NEW JERSEY
MARINE SCIENCES
CONSORTIUM

MARINE EDUCATION PROGRAM

The sea encompasses more than 70% of the earth. The ancestors of the many millions of inhabitants of lakes and forests emerged from the sea eons ago. The waters and the shore are barriers that are often violently attacked but seldom bridged. The ocean and beach zones are one of conflict and an arena for the development of unique lifestyles by species from both the land and the sea.

The 1,792 mile shoreline of New Jersey is, without question, one of the state's major natural resources. It is obvious that there is a pressing need to ensure the future of the beaches, estuaries, the inland waters and the living ocean that are so much a part of the Garden State. To meet this need will require wise use of these marine resources, as well as their intelligent development.

An early, positive exposure to our coastal resources is essential as a first step in educating the people of New Jersey about the value, beauty, and critical importance of these parts of their environment. Marine topics canalso be used to motivate learning in all subject areas, since the sea and its creatures have a fascination for most students which is often sadly lacking in their other studies. For these reasons, we need programs for everyone, not just future marine scientists.

The marine educational needs of New Jersey are many. New Jersey Sea Grant's goal is to provide comprehensive marine education programs tailored to the needs of New Jersey. Our programs are designed to educate citizens through pre-college, college and public programs aimed at those not involved with marine related fields.

SPECIAL STUDENT RESEARCH TOPICS ON NEW JERSEY MARINE AFFAIRS

NEW JERSEY MARINE SCIENCES CONSORTIUM

D. Morell

Princeton University's Center for Energy and Environmental Studies continues to support several university departments independent senior thesis and other independent student research projects related to marine affairs in New Jersey. By so doing, highly qualified Princeton students are encouraged to examine issues of marine science in New Jersey; and the quality of their research is enhanced. As a result, our knowledge about New Jersey's marine environment, the pool of individuals knowledgeable on this subject, and the number of students interested in marine careers also increases.

Student research may cover a wide range of coastal topics relevant to New Jersey, and students from any of the university's departments may apply. In each case, students requesting research support under this program submit a brief proposal and supporting budget to Dr. David Morell, the Principal Investigator.

Results of this activity are in the form of student research reports, primarily senior theses, but also include some doctoral dissertations, junior independent papers, and graduate or undergraduate student coursework papers. Where appropriate, these papers are reproduced as formal Working Papers or Reports of the Center for Energy and Environmental Studies, thereby available for wide distribution to interested users in government, industry, academia, environmental groups, and the public at large. To date, the Center has published 144 reports. Through this mechanism, new information about marine affairs in New Jersey should reach a broader audience.

This effort has been funded by New Jersey Sea Grant as a marine education project for the past three years. The following are the independent student research projects completed in the 1980-81 academic year (Sea Grant V) with some financial assistance from N.J. Sea Grant:

1. "Trace Metal Transport, Pollution and Estuarine Flocculation in the Raritan River," by Paul Bauman;
2. "Long Term Response of Beaches to Groin Structures on Northern Long Beach Island," by Sarah Kidwell;
3. "Citizen Activists and Hazardous Wastes: A Study in Extra-Bureaucratic Politics," by David Moldenhauer;
4. "Diagenesis in the Passaic Formation, New Jersey," by Charles West;
5. "The Life and Culture of the American Lobster: *Homarus americanus*," by David Siebert;
6. "The Thermal Degradation of EDTA, Oxalic Acid and Gallic Acid," by Edward Dillon.

Bauman's thesis won the Sea Grant student research award for 1981. His was only the second undergraduate award presented in fifteen years. It was one of seventy submissions that year.

The following are the independent student research projects completed in the 1981-82 (Sea Grant VI) academic year with some financial assistance from Sea Grant:

1. "1, 1, 1 - Trichloroethane Adsorption on Selected Clay Minerals" by Susan Wilkins
2. "That Noble Experiment in Urban Revitalization—Casino Gambling in Atlantic City: A Six-Year Impact Analysis" by Warren Lazarow

Most recently, during Sea Grant VII (1982-83), the following independent student research projects were completed with some financial assistance from Sea Grant:

1. Joseph Ryan, Geological Engineering, "Nutrient Behavior in the Raritan River Estuary, New Jersey".
2. Bradley T. Wendler, Department of Geological and Geophysical Sciences, "A Survey of the Raritan River Bottom Sediments".
3. Vivien Li, Master's Candidate, Woodrow Wilson School, "Regional Planning in the Hackensack Meadowlands and Along with New Jersey Coast".

NEW JERSEY
MARINE SCIENCES
CONSORTIUM

RESEARCH PAPERS IN MARINE LAW

A. Wypyszinski

Introducing a new substantive course into a law school curriculum is not easily accomplished, particularly from outside the institution. A large core of traditional classes such as evidence, torts, criminal law, and constitutional law, to name a few, occupy the greatest portion of the law school calendar and flexibility is extremely limited. Introduction of a new elective requires an interested faculty member, administration approval, and student interest.

Among the law schools affiliated with the New Jersey Marine Sciences Consortium (Rutgers University, Seton Hall University and Columbia University), the only course offering directly related to marine affairs is admiralty, a rather narrow specialty. There exist no survey courses addressing the broader areas of coastal zone law, fisheries management law, marine mammal protection, Law of the Sea, urban waterfront redevelopment, and the host of marine affairs issues generated by problems of allocation of relatively scarce resources in a heavily populated, urbanized region. The same applies generally to other law schools in the Mid-Atlantic region; although a seminar in Ocean and Coastal Management Law is offered at Villanova School of Law.

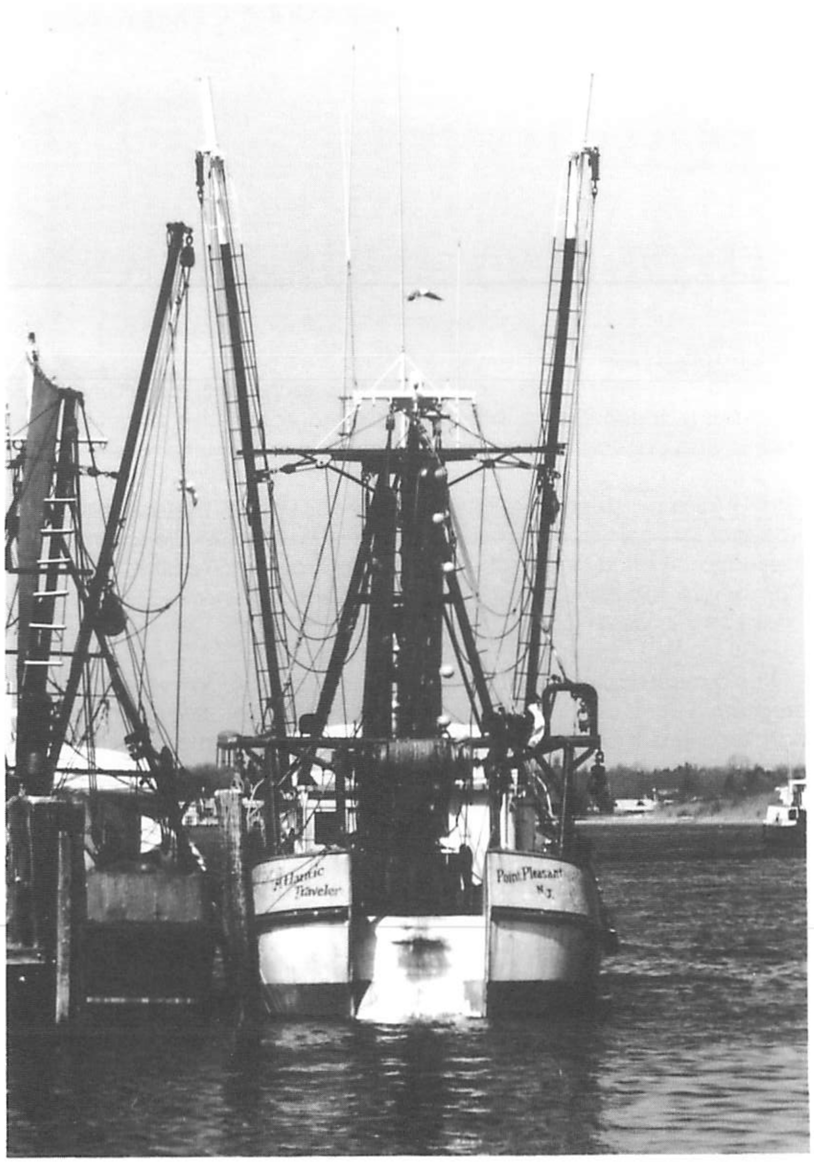
As a result, the legal community in the region contains very few individuals knowledgeable in or even aware of these subjects. It then follows that what ideally should be an area of interdisciplinary effort is lacking the legal element.

In order to stimulate legal research in marine affairs, hopefully with a focus on state or regional problems, the New Jersey Sea Grant Extension Service Coastal Law Specialist, Alex Wypyszinski, implemented a law student writing competition through the Sea Grant Program. The short-term objective is to identify to both students and faculty the New Jersey Sea Grant Program, the New Jersey Marine Sciences Consortium, and the important need for this type of research. Long-term objectives which could be accomplished by this program are provision of the impetus for development of a law school course offering in ocean and coastal law, as well as development of a better educated legal community; more aware of the legal issues and problems related to the many facets of marine affairs.

Legal writing is an integral part of a law student's education. Usually, a major written work or at least some evidence of facility in legal writing is a requirement for graduation. While the choice of topics is normally not extensive there is some flexibility. Established graduate law programs at the University of Washington and the University of Miami law schools require a major writing effort on a marine affairs topic. Furthermore, similar legal writing competitions presently exist in other areas of the law; e.g., the Letourneau Award given for the outstanding paper on a legal-medicine topic.

Papers submitted in conformity with the promulgated rules for this project are reproduced and distributed to members of the Student Awards Committee. This committe is presently composed of four attorneys, each a graduate of the Marine Affairs program of the University of Washington School of Law and each employed in some aspect of the marine affairs specialty. The committee chooses winners by consensus.

In 1983, the New Jersey Sea Grant Law Award was received by Mr. Robert M. Jarvis. Mr. Jarvis holds a B.A. (1980) from Northwestern University and received his J.D. in 1983 from the University of Pennsylvania. His original paper submitted in the competition was entitled "After Foremost Insurance Company V. Richardson Are State Anti-Pollution Laws Passed Pursuant to the Water Quality Improvement Act of 1970 In Jeopardy?" A revised version of this paper subsequently appeared in the Gonzaga Law Review (Vol. 19, No. 2 - 1983/84) under the title "Richardson V. Foremost Insurance Company: A New Opportunity for Industry to End State Regulation of Coast Oil Pollution?"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NEW JERSEY
MARINE SCIENCES
CONSORTIUM

ADVISORY SERVICES

More than one-sixth of New Jersey's land area is classified as "coastal." It is vitally important, therefore, to see to it that this fragile environment be protected, maintained, and conserved. The tremendous pressures placed on the marine related resources — the beaches, marshes, and estuaries — require careful and considered decisions concerning their multiple uses.

In 1976, a full decade following the inception of the federally-funded Sea Grant Program of the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, New Jersey joined the national effort. Under the Sea Grant Program managed by the New Jersey Marine Sciences Consortium, the New Jersey Sea Grant Extension Service (SGES) operates as part of the Cooperative Extension Service at Cook College, Rutgers, The State University of New Jersey.

With a methodology similar to the highly successful, experienced and visible land-grant agricultural program, SGES is a natural component of the Cooperative Extension Service. The tripartite philosophy of both land-grant and sea-grant is based on the integration and articulation of teaching, research, and extension. This is the unique feature of the educational programs and projects of the Extension Services, and responsible for their proven effectiveness in the application of research to practical situations in a relatively short time frame.

The goal of SGES is quite simple and direct: To inform the citizens of New Jersey and other user groups of the value of coastal resources and the need to promote the intelligent management of these resources.

Acting on the principle that only can an informed public act in a responsible manner, SGES facilitates the flow of information to assist in the maintenance of the quality of the marine environment as it accepts and responds to intensive use.

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NEW JERSEY SEA GRANT EXTENSION SERVICE

A. Wypyszinski

Short in number, long in enthusiasm, the Sea Grant Extension Service (SGES) completed another successful year during this reporting period. Uncomplicated as is its mission, complex is its administration.

SGES is the marine informational component of the N.J. Cooperative Extension Service at Cook College, Rutgers, The State University. It is, at the same time, the outreach arm of the N.J. Marine Sciences Consortium, headquartered at Sandy Hook. The Consortium is the manager of the New Jersey Sea Grant Program, funded by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. The major objective of SGES is to provide information to those who use New Jersey's coastal resources—commercially or recreationally—and to direct researchers connected with the Consortium to become more aware of problems faced by the coastal community.

At the close of the year, the coastal law specialist was appointed director of SGES, succeeding Robin Zimmer who elected to join a commercial aquaculture venture. The two marine agents remained at their respective stations at Cape May Court House and Toms River. The communications coordinator completed his first full year.

One of the major accomplishments this year was the coordination of efforts by the various industry components for harvesting, handling and developing squid products for overseas markets. There is also a domestic market that is receiving attention. Evaluations were conducted on the use of chilled seawater aboard vessels with refrigeration to maintain product quality.

An important project involved working closely with the National Weather Service and the Bendix Corporation in upgrading the offshore weather forecast system from 20 to 100 miles offshore. One reporting method (MAREP) utilizes fishermen themselves who radio to shore and report weather conditions in their immediate areas.

As an initial effort, the First Annual Cape May Seafood Festival was a success, much of it due to the work of our marine agent. Thousands of visitors became acquainted with the extent of our marine resources, and incidentally, with SGES. Up in the Toms River area, a few months later, the Fishermen's Forum addressed a variety of topics including, lobstering, fish quality, hard clam seeding and offshore meterology and oceanography. The educational sessions were augmented by a wide assortment of commercial exhibits.

Our bulletin series grew with the addition of a ***Fish Contaminants*** and ***Hard Clams*** exposition. The popular ***Gulf Stream Eddies*** was reprinted through the generosity of COFISH, INTERNATIONAL, Inc.

SGES initiated a new series of one-pagers entitled MARINE CUISINE. The first was ***"Fillet Fantastic"***, describing how to fillet properly; and another was ***"How To Shuck A Hard Clam—With Ease."*** A third one will contain a number of recipes, including a NEW JERSEY clam chowder. (New England and Manhattan chowders are about to receive some competition.) This effort is designed to assist local clammers in expanding markets for chowders.

Our first seafood marketing workshop was held, with about 50 retailers in attendance. Another is planned for the coming year, based on the positive experience of this one. Subjects addressed were: quality maintenance and sanitation; merchandising, advertising and in-store promotion; consumer attitudes and preferences. It is hoped that, eventually, a N.J. Seafood Retailers Association might be formed—to help retailers and consumers.

A logo and theme were developed to help promote the fishing industry of the state: NEW JERSEY FISH ARE FATHOMS FRESHER! Pins and bumper stickers were made available. Pressure sensitive labels were prepared for a Paris (France) International Food Show, scheduled for next year.

The quarterly newsletter of SGES, ***THE JERSEY SHORELINE***, was given a new graphic look. One of the feature articles, written by our coastal law specialist, on Legal Constraints in Aquaculture, brought a commendation from the late Edwin B. Forsythe, former ranking minority member on the Committee on Merchant Marine and Fisheries of the U.S. House of Representatives.

This has been an active, maturing year for SGES, serving its constituents in a variety of ways. With a staff of limited size, communications become extremely significant. It has worked well with other public agencies, such as the State Department of

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Agriculture, Department of Commerce and Economic Development, and the Department of Environmental Protection.

Whether face-to-face on the dock with a commercial fisherman, in a seafood processing plant, aboard a vessel involved in joint-ventures, in print, or before a TV camera, SGES is communicating. It is in these ways that SGES attempts to fulfill its duties and obligations in behalf of all those interested in the long-term health and vitality of New Jersey's irreplacable marine resources.

Who's On The Dock —

At present, the Sea Grant Extension Service consists of the following individuals whose expertise is available to provide educational and informational assistance to marine researchers, marine resource users, teachers, consumers and citizens throughout the state.

Alex Wypyszinski, Director/Coastal Law Specialist
Cook College, 201-932-9636
P.O. Box 231, New Brunswick 08903

Chester Teller, Communications Coordinator
Cook College, 201-932-9498
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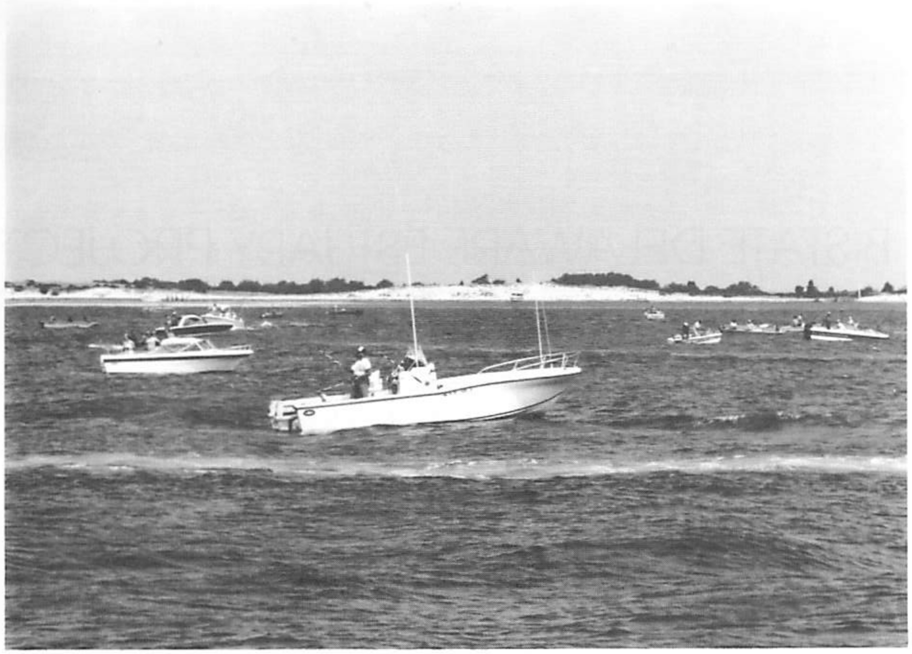
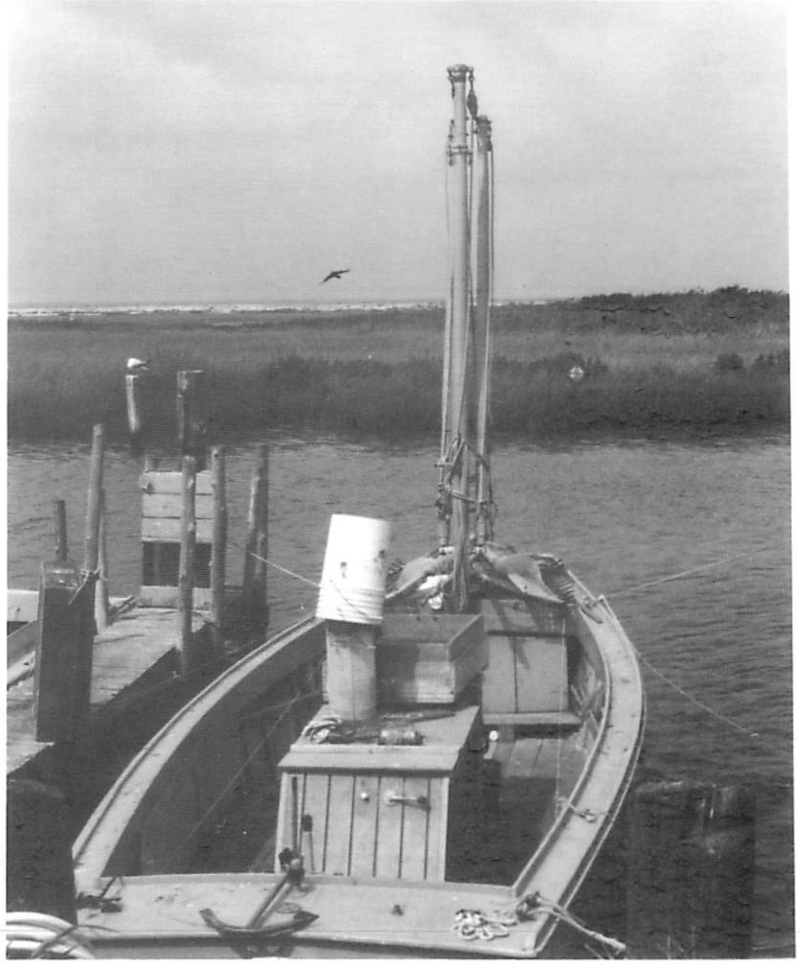
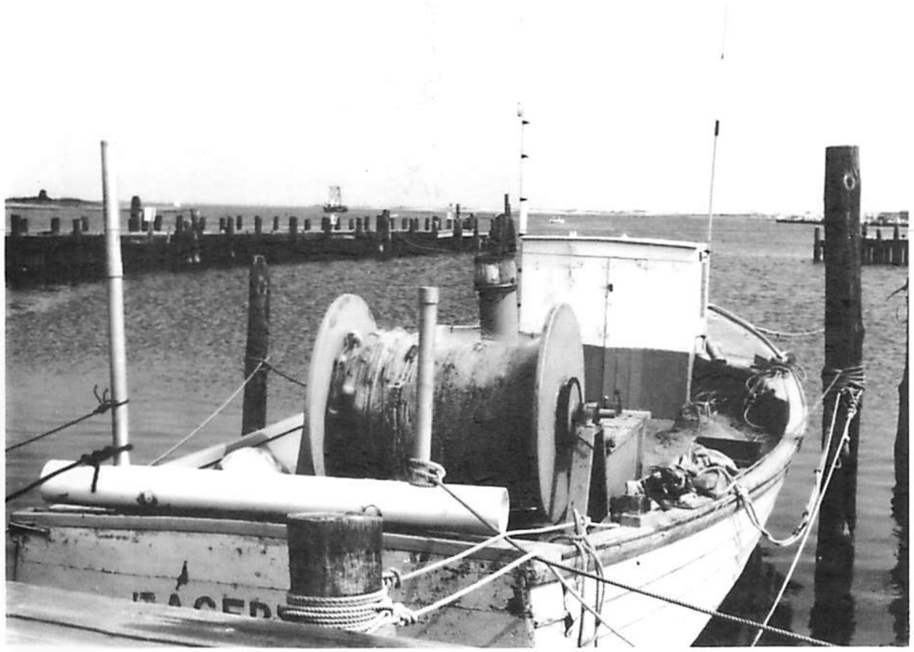
Gef Flimlin, Marine Extension Agent
Ocean County Agricultural Center, 201-349-1152
Whitesville Rd., Toms River 08753

Stewart Tweed, Marine Extension Agent
Cape May Extension Center, 609-465-5115
Dennisville, Cape May Court House

John Tiedemann, Marine Extension Agent
Southern Ocean County
Resource Center 609-597-1500
Recovery Rd., Manahawkin 08050







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BISTATE DELAWARE ESTUARY PROJECT

The estuary of the Delaware River is a body of water stretching in length about 115 nautical miles, of which about 65 miles is saline. The heavily populated upper end of the estuary contributes large amounts of municipal wastes (from about 5% of the United States population) and some industrial wastes. The broad, shallow lower estuary, surrounded by extensive salt marshes, supports healthy commercial and sport fishing as well as other recreational activities. The estuary, with a 55-foot natural channel 12 miles in from the mouth and a 40-foot dredged channel 90 miles from the mouth to Philadelphia, is a major transportation corridor and one of the largest ports in the United States. That the Delaware estuary functions as a major waste receptacle, a fishing ground, a recreational resource, and a transportation corridor is due to a quirk of nature in the way that the estuary works. For it to continue successfully to support such diverse activities requires both understanding the natural mechanisms of the estuary and responsible stewardship.

To better understand the estuary, a comprehensive study has been conducted by researchers from the University of Delaware College of Marine Studies and the New Jersey Marine Sciences Consortium (specifically Princeton University, Rutgers University, Stevens Institute of Technology, and Lehigh University). The Delaware River and Bay Authority (DRBA) issued a contract in 1982 to the College of Marine Studies of the University of Delaware and the New Jersey Marine Sciences Consortium in response to a proposal to conduct research on the Delaware Estuary. As a result of the DRBA support and prior support from the Office of Sea Grant of the National Oceanic and Atmospheric Administration (NOAA), the Bistate Delaware Estuary Project was begun. In addition to its association with the funding agencies, the Delaware Estuary Project became informally associated with research and monitoring efforts of the Delaware Department of Natural Resources and Environmental Control, the New Jersey Department of Environmental Protection, the four-state Delaware River Basin Commission, and the NOAA National Ocean Service. The result is an understanding greater than that which the Delaware Estuary Project or any one agency alone could achieve. Every effort has been made to place the Delaware Estuary Project in the pivotal position for research and information coordination on the lower Delaware Estuary.

DELAWARE BAY ESTUARINE RESEARCH PROJECT

The individual research components and principal investigators for the New Jersey portion of the Bistate Delaware Estuary Project are listed in Table 1. The following is a summary of the results of the New Jersey component of the project. The major goal of the Delaware Estuary Project was that a thorough understanding of the Delaware Estuary is essential for rational estuarine management.

By far the most important shellfish resource in Delaware Bay is the oyster. Dr. Harold Haskin of Rutgers University has been involved in considerable work on oysters and environmental conditions in the Delaware Bay for several decades. Dr. Haskin's work in the Delaware Estuary Project dealt with the oyster industry, oyster quality and the role of the oyster in the benthos of Delaware Bay.

The oyster industry, which has yielded up to two million bushels annually, is recovering from a period of low production resulting from mismanagement and the advent of a serious new disease (MSX) in the late 1950s. The continued pressure of MSX on the oyster population has required some changes in industry operations. Better understanding of requirements for consistent seed production and for consistent high meat quality on planted grounds will increase the production of market oysters. It is reasonable to expect that the current oyster production in Delaware Bay can be approximately doubled.

Although the Delaware Bay benthos has been considered by earlier investigators to be of low density and impoverished in comparison with other estuaries, Dr. Haskin's work indicates that the benthic assemblages on stabilized bottom are diverse and the population density compares with that in other highly productive temperate estuaries. In particular, the assemblage of species generally recognized as the oyster community is highly diverse and the production of oysters per unit area compares favorably with other oyster areas around the world. As evidenced by its shellfisheries, Delaware Bay is "healthy" and its benthic populations demonstrate a more than respectable secondary production.

One approach to investigating how an estuary works is to identify the most important animal species and to study their population dynamics and the patterns and underlying forces that determine population size. This approach was employed by Drs. Sidney Herman and Bruce Hargreaves of Lehigh University, to study the important components of the macrozooplankton in Delaware Bay. Drs. Herman and Hargreaves found that copepods were the most abundant organisms in the zooplankton, accounting for 94% by number in samples taken. While more than 30 species of zooplankton were recorded in the study, five species of copepods accounted for most of the recorded numbers. Two distinct regions of the estuary were evident, the upper low-salinity region and the lower high-salinity region. *Acartia tonsa* and *Oithona* sp. were the only abundant species distributed throughout the estuary; *Temora longicornis*, *Pseudocalanus minutus*, and *Centropages hamatus* were in the lower more saline region only. These latter three "marine" species were present only in winter and spring, while the other two were present most of the year. Overall, *Acartia tonsa* was the dominant copepod both geographically and seasonally. Copepods are important because they serve as a food source for many postlarval and juvenile fish.

Drs. Herman and Hargreaves also studied another important planktonic food item of juvenile fish, the mysids or oppossum shrimp. Mysids typically make up a large percentage of the invertebrates that live near the bottom. They are omnivores, feeding on phytoplankton, zooplankton, and detritus. Two species of mysid shrimp were observed in the estuary, *Neomysis americana* and *Mysidopsis bigelowi*. *Neomysis* was the most abundant mysid although *Mysidopsis* was nearly as abundant during the winter months.

The mean size of mysids was found to change seasonally. In spring, the peak consisted of large overwintered adults and their offspring; in late summer the peak consisted of small summer adults and their offspring. The mean size of individuals remained low through the summer and fall, rising from November through February as the young, released in the fall, grew and matured in cold water. The winter rise in population biomass is probably attributable in part to an increase in mysid numbers (from reproduction and perhaps migration), but mainly to growth of the individual mysids. In warm temperatures mysids grow and reproduce rapidly, but never reach the size of the overwintering animals. In addition to growth and reproduction, another important factor in the size of the mysid population is predation. Two periods of heavy predation were apparent, from late May through August and from mid-September through November.

Bivalve larvae are another important member of the macrozooplankton community. During the past year, Dr. Richard Lutz of Rutgers University, studied feeding habits of larvae of the commercially important bivalve species, the oyster *Crassostrea virginica*. These larvae have a 14 to 21 day planktonic phase during which they develop from fertilized eggs to eyed larvae. Most information about the natural phytoplankton diet of the larvae has been inferred from laboratory species. While these experiments provided necessary information on which species of phytoplankton are ingested and which promote rapid growth rates, they do not address which phytoplankton species the larvae feed on in nature. To investigate the phytoplankton component of the larval diet, Dr. Lutz conducted feeding experiments designed to use natural assemblages and densities of phytoplankton.

Comparisons of phytoplankton cell counts before and after feeding trials showed that populations of small cells (less than 10 microns in the largest dimension) declined more rapidly than larger forms. The larvae used in the experiments are known to have mouth diameters of approximately 10 microns. Larvae did not appear to be selecting particular cell types from the small phytoplankton fraction. The relative proportions of each of five small-celltypes (coccoid cells, centrate diatoms, pennate diatoms, flagellates, and dinoflagellate) remained approximately the same during larval grazing after correction for changes in control trials where no oyster larvae were present. A difference in larval feeding rate was noted when long and short trials were compared. The lower rate during prolonged exposure suggests either that larvae became satiated within 6 hours and fed slowly thereafter or (more likely) that larvae ceased feeding actively when phytoplankton levels dropped below a threshold concentration. The lack of selectivity by oyster larvae, and the demonstration of active feeding on natural assemblages (at least at starting concentrations), suggest that growth and development of oyster larvae are not limited by food availability in the Delaware Estuary.

As a contribution to the New Jersey portion of the DRBA project, Dr. Richard Bartha of Rutgers University conducted a preliminary survey of Delaware River and Bay sediments as to their total mercury and methylmercury contamination levels. In part, the survey was conducted to decide whether the contamination levels justify a more extensive study of the problem.

Mercury had been reported to have an average concentration of 0.73 ppm with some values greater than 1 ppm in the central Bay; this being attributed to concentration with the fine organic-rich sediment fraction. In his part of this study, Dr. Bartha found similar mercury concentrations (less than 2 ppm). Higher concentrations, about 5 ppm, were found in the upper bay near industrial sites; and 3 ppm in middle bay areas in accord with central-bay accumulation. Methylmercury was found to be a minor fraction of the total (less than 2 ppm) for all samples.

In order to better understand the physical oceanography fo the Delaware Bay and River, Dr. George Mellor of Princeton University and Dr. Richard Hires of Stevens Institute of Technology, undertook modeling studies of the area.

A two dimensional tidal model with very fine spatial and temporal resolution was developed by Drs. Mellor and Hires for the Delaware estuary. A significant feature is the inclusion of the neighboring continental shelf in the computational domain. The model has been shown to adequately predict tidal elevation and currents, although a comparison with NOS predictions suggests the possible absence of some physical mechanism from the model. Some important conclusions concerning open boundary conditions have been made as a result of this modeling effort. The effect of shelf boundary conditions located near the bay may result in significant changes in the calculation of residual currents around the bay's entrance.

In order to improve the management or to maintain the present condition of the Delaware Estuary, it was mandatory to first know the state of the estuary. There is a misconception that the Delaware Estuary is hopelessly polluted, leading some to suggest it be written off for recreational purposes and considered an industrial estuary. This is not so, and, in fact, there is every reason to believe that this body of water can be maintained and improved as a multiple-use estuary. The results of the research conducted in the Bistate Delaware Estuary Project provided an understanding of the Bay and are being considered by the DRBA.

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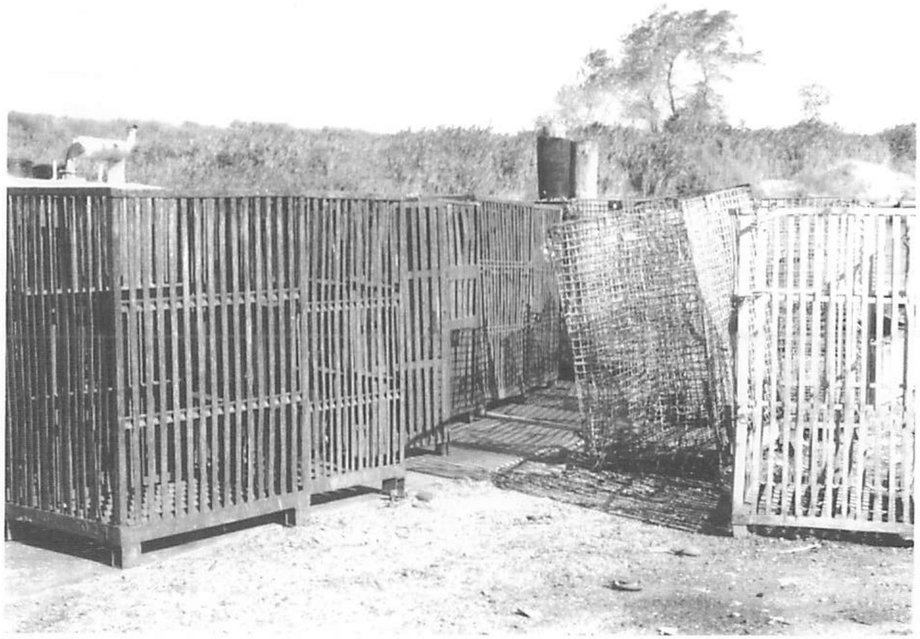
Oyster Quality on Delaware Bay Planted Grounds and Its Relationship to Environmental Factors. Harold H. Haskin & Walter J. Canzonier Rutgers University	Grazing by Shellfish Microplankton and Its Relationship to Primary Production in Delaware Bay. Richard A. Lutz Rutgers University	Physical Oceanographic Studies in Delaware Bay and River. George L. Mellor - Princeton University Richard I. Hires Stevens Institute of Technology
Preliminary Studies on the Macrozooplankton and Mysid Populations of Delaware Bay. Sidney S. Herman & Bruce R. Hargreaves Lehigh University	Relationship to Salinity and Other Environmental Parameters to Microbial Transformation of Mercury in Estuarine Sediments. Richard Bartha - Rutgers University	

Table 1. New Jersey Components of the Bistate Delaware Estuary Project, 1982-1983.

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SEA GRANT EXTENSION SERVICE

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MARINE SCIENCES
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PROGRAM SUMMARY

MARINE RESOURCES DEVELOPMENT

Living Resources

R/F-1
Sublethal Effects of Heavy Metals on Intestinal Absorption of Nutrients (Amino Acids, Sugars and Cations) in Fish Found in Newark Bay/Raritan Bay Areas.
Dr. A. Farmanfarmaian, Rutgers University

R/F-2
Life History and Population Dynamics of Tilefish, *Lopholatilus chamaeleonticeps*.
Dr. C. Grimes, Dr. K. Able, Rutgers University

R/F-7
Identification of Bivalve Larvae: A Multi-Institutional Approach.
Dr. R. Lutz, Rutgers University

Marine Law and Socio-Economics

R/F-3
Human Ecology of New Jersey Fisheries.
Dr. B. McCay, Rutgers University

Commercial Fisheries Technology

R/F-9
New Jersey Sea Grant Fishing Industry Study: Influence of Weather and Sea State.
R. Raguso and J. DelGreco, Bendix Field Engineering Corporation

MARINE ENVIRONMENTAL RESEARCH

Research in Support of Coastal Management

R/S-3
Shoreline Change and Land Use at Tidal Inlets
Dr. K. Nordstrom, Rutgers University

Pollution Studies

R/F-4
Tolerance to Chronic Effects of Pollutants in Newark Bay Area Killifish.
Dr. J. Weis, Rutgers University
Dr. P. Weis, Dr. J. Bogden, NJ Medical & Dental University

R/F-6
Biological Impact of Aromatic Hydrocarbons in Southern New Jersey Coastal Waters: Assessment of Toxicity by Chemical Analysis and Mysid Bioassay.
Dr. B. Hargreaves, Dr. S. Herman, Lehigh University

R/E-5
Relationship of Salinity and Other Environmental Parameters to Microbial Transformations of Mercury in Estuarine Sediments.
Dr. R. Bartha, Rutgers University

R/E-6
An Interdisciplinary Investigation of Nitrification in Raritan Bay.
Dr. H. Simpson, Dr. B. Deck, Dr. H. Ducklow, Lamont-Doherty Geological Observatory
Dr. F. Cantelmo, St. John's University

Applied Oceanography

R/E-3
Physical Oceanographic Studies of the Hudson-Raritan Estuary.
Dr. G. Mellor, Dr. L. Oey, Princeton University
Dr. R. Hires, Stevens Institute of Technology

MARINE EDUCATION AND TRAINING

College Level

E/T-2
Special Student Research Topics on New Jersey marine Affairs.
Dr. D. Morell, Princeton University

E/T-3
New Jersey Sea Grant Law Award
A. Wypyszinski

ADVISORY SERVICES

Extension Programs

A/S-1
New Jersey Sea Grant Extension Service
A. Wypyszinski

PROGRAM MANAGEMENT AND DEVELOPMENT

M/M-1
Program Administration.
Dr. R. Abel, Mr. R. Stevens, New Jersey Marine Sciences Consortium

NEW JERSEY
MARINE SCIENCES
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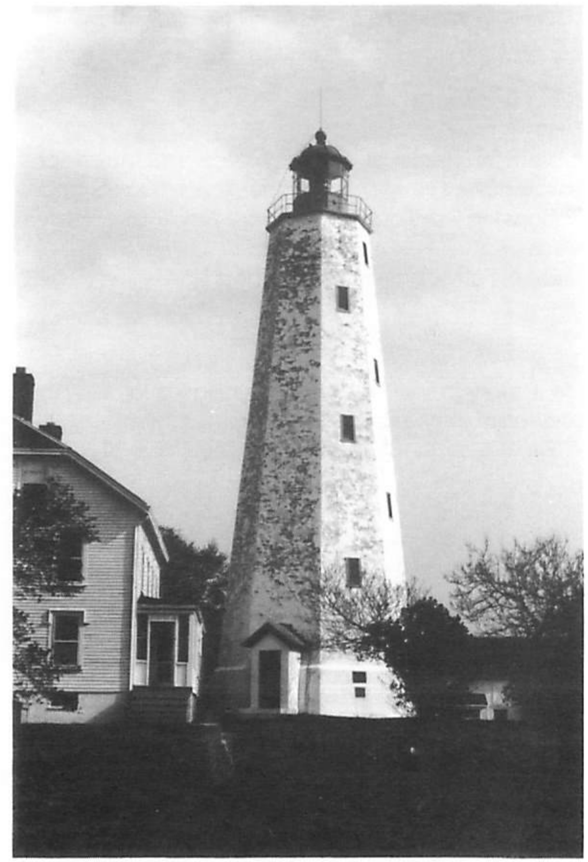
ACTIVITY BUDGET

ACTIVITY BUDGET SHEET (Summary Totals by Activity)

	NOAA Grant Funds	University Matching Funds
MARINE RESOURCES DEVELOPMENT		
Living Resources	88,200	45,700
Marine Law and Socio-economics	13,000	7,600
MARINE TECHNOLOGY RESEARCH AND DEVELOPMENT		
Commercial Fisheries Technology	17,500	15,560
MARINE ENVIRONMENTAL RESEARCH		
Studies in Support of Coastal Management	12,000	11,050
Pollution Studies	98,500	107,100
Applied Oceanography	24,000	19,400
MARINE EDUCATION AND TRAINING		
College Level	4,500	4,000
ADVISORY SERVICES		
Extension Programs	129,000	121,500
PROGRAM MANAGEMENT AND DEVELOPMENT		
Program Administration	133,300	48,400
TOTAL	520,000	380,310

	DRBA	University/ Sea Grant Matching Funds
BISTATE DELAWARE ESTUARY PROJECT		
New Jersey Component (NJMSC)	449,210	169,285



NEW JERSEY
MARINE SCIENCES
CONSORTIUM

ADMINISTRATION

NEW JERSEY MARINE SCIENCES CONSORTIUM ADMINISTRATION

Dr. Robert B. Abel
President, New Jersey Marine Sciences Consortium
Director, New Jersey Sea Grant Program

Mr. Richard S. Stevens
Associate Director, New Jersey Sea Grant Program

Mrs. Joan A. Sheridan
Vice President, Administration
New Jersey Marine Sciences Consortium

Mr. Alex W. Wypyszinski
Director, New Jersey Sea Grant Extension Service

ASSOCIATE MEMBERS

American Littoral Society
Marine Biologicals, Inc.
Oceanic Society
Public Service Electric and Gas Company
The Wetlands Institute

MEMBER INSTITUTIONS OF THE NEW JERSEY MARINE SCIENCES CONSORTIUM

Atlantic Community College
Brookdale Community College
Burlington County College
Columbia University/Lamont-Doherty
Geological Observatory
Cumberland County College
Fairleigh Dickinson University
Glassboro State College
Hudson County Community College
Jersey City State College
Kean College of New Jersey
Lehigh University
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Montclair State College
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NOTES

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