SEA GRANT

UNIVERSITY OF NEW HAMPSHIRE • UNIVERSITY OF MAINE

# SEA GRANT 1979

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# UNIVERSITY OF NEW HAMPSHIRE

# UNIVERSITY OF MAINE

# SEA GRANT ANNUAL REPORT

# 1979

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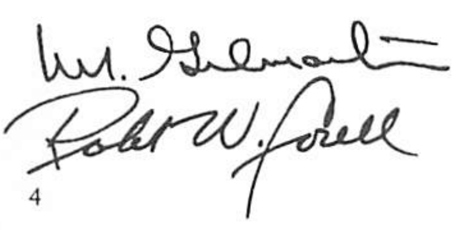
## Directors' Message

As we look back at the 1979 research, education, and advisory activities of the UMe/UNH Cooperative Institutional Sea Grant Program, we find ourselves reviewing more than just another program year. We stand at the close of a decade — a very significant decade for man's developing relationship with the sea. The Fisheries Conservation and Management Act; the discovery of self-contained undersea ecosystems at the rifts between continental plates; the United Nations Conference on the Law of the Sea; a new surge of offshore oil and gas exploration; the Coastal Zone Management Act; and during those years there was a dramatic resurgence of interest among the people of New England in the value of the ocean's resources. The 1970s were studded with historic events whose effects on the ocean domain promise to be felt well into the 21st century. Finally, the close of the 1970s marks the coming of age of the UMe/UNH program. On January 1, 1980, it was officially raised to the status of Sea Grant College Program, the fourteenth in the nation.

We therefore step back at this moment to review our 1979 efforts and to look at them in a larger oceanographic context. We feel strongly that the work we have done must inform our future work, so as we serve our region, our progress compliments that of other Sea Grant programs throughout the country. Clearly then, Sea Grant will be felt as a whole even greater than the sum of its parts.



# Introduction

Wise use and conservation of marine resources throughout the nation was of primary concern as the National Sea Grant College Program was born. The Program was organized so research being done on a problem in one part of the country would be available as similar problems were being addressed on another coast. At the same time, however, respect for the concept of home rule, so cherished in New England, was also built into Sea Grant from its inception. Recognizing that a prime concern in one coastal area may not be the most critical in another, Sea Grant's founders resisted establishing research directions at the federal level. Rather, each local program would, they decided, shape its own research and extension

## Living Marine Resources

The ocean means different things to different people. Along some stretches of the U.S. coast, it is the seashore, the primary economic drawing card for a booming recreation industry. Elsewhere the ocean is regarded as the seat of vast energy stores, concealing beneath its floors some of the earth's richest deposits of fossil fuel. Where ocean-going commerce holds primacy, the sea is first and foremost a highway for trade.

But northern New England's traditional dependence on the sea has — from the days of the great whalers on downward — centered around living marine resources. It is not surprising, then, that living marine resource studies are well represented in UMe/UNH Sea Grant research.

If one were asked to name the great milestones in the history of our nation's fishing industry, technological advances would likely spring first to mind. Improvements in harvesting equipment or in the vessels themselves — as classic as the switch from wind to steam power, or as recent as the introduction of electronic fish-finding devices — seem obvious candidates. Further thought suggests more subtle but also far-reaching developments such as innovations in seafood processing and preserving. But all these are dwarfed in impact by an event of the 1970s which is neither scientific nor technological in nature — the passage of the Fisheries Conservation and Management Act (FCMA).

By the early 1970s, the U.S. fishing industry was in a state approaching alarm. The total fishable biomass off our coasts had dropped drastically; for example, on Georges Bank, one of the world's richest fishing grounds, fishable biomass between 1968 and 1975 had plummeted as much as 60% by some estimates. The annual decline in landings of many important species was raising doubts as to the ability of their populations to rebound, and heavy foreign fishing off U.S. coasts made the problem impossible to control.

The government response was the Fisheries Conservation and Management Act of 1976 which claimed U.S. management authority over fisheries within a 200-mile contiguous zone, and placed the U.S. fishing industry under a complex management scheme. Some people believed that the FCMA would give U.S. fishermen open season on unlimited stocks. Those beliefs quickly proved unfounded. Instant abundance did not result, and the Act mandated that the level of fishing effort be regulated in accordance with the projected stock populations. For the first time, the stocks — the resource — came first.

Generally speaking, as the estimated populations increase or decrease, so will the quotas, and likewise the granting of entry into the fishery to new vessels, the duration of season for individual species, and other regulatory mechanisms through which the FCMA is implemented. State and local management structures are being created for the similar protection of shellfish and other marine species. Through management the fish stocks are protected from future irreversible losses, but what of the industry itself? Until and unless the stocks rebound, the fishing industry appears to be at the mercy of the vagaries of nature.

## Marine Environmental Research

Along with an awakened sense of the critical importance of fisheries conservation has come a new awareness of the fragility of the marine environment. The two are parts of a single and recent lesson — that vast resources are not infinite resources. Why is this lesson a recent one? Because, of all the environments on this planet, the oceans are the last to show the effects of our mistreatment of them. The air we breathe, the land which produces our crops, and the fresh water we drink offer evidence of human mismanagement. The marine environment's degradation is more easily measured in decades than in years, by virtue of its size and our lesser interaction with it. Unhappily, reversing damage to the marine environment is also a proportionately slower and more difficult process.

Only within the past ten years, the U.S. Environmental Protection Agency has built a body of legislation designed to safeguard the health of the marine environment. Some acts, such as the Marine Protection, Research, and Sanctuaries Act, were specific to the marine environment; others, (e.g. the Toxic Substance Control Act) were more generic, but nonetheless promised great impact on the ocean's environmental quality. Most influential of all, the Coastal Zone Management Act of 1972 provided powerful incentives for states to manage their coastal zone development in accord with certain minimum standards. Even beyond U.S. borders, the 1970's were a decade of unprecedented action for marine environmental protection. In 1975, for example, ocean dumping came under international purview with the Convention on the Prevention of through ongoing dialogues with the marine communities of its region, always being conscious, however, of how its work might benefit other parts of the country.

Therefore, it is crucial that local programs balance regional needs with a perspective on the long-range goals of Sea Grant, the recent history of man's relationship with the sea, and current national and international marine issues. The goals of Sea Grant in northern New England are best understood in the context of three major areas of activity: living marine resources, marine environmental research, and marine advisory services and education.

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Marine Pollution by Dumping of Wastes and Other Matter.

Such acts of law helped bring to light how little is really known about the marine environment. Faced with managing activities in the near-shore and coastal zones, regulators felt keenly the lack of data predicting what the impacts of those activities might be. So Sea Grant researchers became actively involved in efforts to fill the gaps in knowledge of how the marine environment responds to the whole range of man's activities.

In comparison to the rest of coastal New England and the Mid-Atlantic states, Maine and New Hampshire are in the infancy of coastal development. Rather than an excuse for ignoring environmental concerns, however, Sea Grant regards this as an opportunity to preserve our coastline in a relatively pristine state.

## Marine Advisory Services and Education

With tens of thousands of miles of coastline, a world-ranging naval force, and a leading position in international trade, our country's stake in marine affairs can hardly be overstated. The consequences of today's decisions in the ocean domain will be felt powerfully for decades, perhaps centuries.

In a democracy, such decisions are made — directly or indirectly — by the populace. Just as the success of American democracy hinges on a literate citizenry, wise decisions affecting ocean resources depend on what Sea Grant's founders chose to call "marine literacy". This country had neglected, the founders pointed out, to give the ocean its rightful place in its educational system, both in general studies and in specialized training to produce professionals in marine disciplines.

There was an obvious need for a link between the scientific and marine communities if the former was to serve the latter. Unlike many other funding agencies, Sea Grant does not regard it as sufficient that a research project be scientifically interesting, that it hold promise for advancing scientific knowledge. To pass muster, a project must — among other things — demonstrate its relevance to the needs of the region's marine community. Otherwise, it seemed perfectly conceivable that Sea Grant and its constituents could begin thinking along different lines, drifting further apart until the research, whatever its scientific value, became irrelevant to the concerns of those it existed to serve.

Sea Grant's founders met these two challenges by modeling their program after the very successful Cooperative Extension Service created by the earlier Land Grant Act. The twin forces of Sea Grant education and advisory services together constitute a feedback loop, keeping the program abreast of marine issues of regional importance, channeling research results in useable form to those who stand to benefit from them, and training marine specialists and building marine literacy through curricular and informal public education.

# LIVING MARINE RESOURCES

# Fisheries Dynamics

The Fisheries Conservation and Management Act created regional councils to develop finfish management plans in accordance with the "best scientific information available." Unfortunately, by all accounts, the best information available is scanty and inconclusive. Working within these limits, the regional councils have already established a conservative tradition of erring on the side of the stocks, and there is no reason to believe this tradition will change in the near future. Clearly, this policy serves long-range interests, but over the short run the fishing industry is handcuffed, perhaps unnecessarily so in some instances.

## The Neglected Sand Launce

We have suggested that, pending the restoration of fish stocks, the fishing industry will remain at the mercy of the vagaries of nature. But man's history is the story of his transcendence over the vagaries of nature. To encourage that historical process, one avenue Sea Grant is taking is research into the economic potential of underutilized species. With its advisory and education arms to carry research results out into society, Sea Grant is in a unique position to see this potential realized.

Common opinion currently holds that populations of all finfish and shellfish species along our coasts are massively depleted. This is a misconception. The northern New England fishing industry has been characterized by reliance on a handful of traditional species which insure the highest economic return. It is these few species whose populations have dwindled most markedly in response to fishing pressure and perhaps other, unknown factors. Consequently, interest is growing in the potential exploitation of non-traditional species.

Roderick Smith, Assistant Professor of zoology at the University of New Hampshire is studying a group of underutilized finfish which holds economic promise: the family *Ammondytidae* — sand launce or sand eels. In New England waters, sand launce are occasionally taken as bait fish; in northern Europe, however, they have surtained a major fishery for over two decades.

Smith's work has already indicated that sand launce have the potential for supporting a major fishery on this side of the Atlantic. However, a host of questions must be answered before a fishery can grow up around a non-traditional species. Markets must be identified and developed. The season and location for profitable harvest must be determined. The optimum gear, fishing techniques, and preservation methods must be investigated. Finally, biological data must be gathered for management — otherwise, a surge of pressure on the underutilized fish may reduce its population to the same depressed state as the traditional species. Until these problems are addressed, the investment capital and attendant risk place the new venture beyond the reach of the small, family-owned businesses which dominate the northern New England fishery.

Smith began his sand launce research in the summer of 1978 under a grant from the New England Fisheries Development Program. His work supported initial optimism as to the abundance and marketability of sand launce, and their susceptibility to capture by day trawlers with modest on-vessel gear and handling modifications.

In 1979, on the heels of this promising work, Smith launched a more ambitious three-year study under Sea Grant sponsorship: to compile the biological and population dynamics data to support a sound sand launce management scheme. It was an opportunity to work toward management of a species *before* serious exploitation took place — all too rare in a field where reaction and hindsight have been the norm.

Smith chose to site his research on Stellwagen Bank (an area roughly bisected by a line drawn between Gloucester and Provincetown, Massachusetts). Stellwagen appears to support a large population of sand eels and is accessible to many New England day-trawler ports. The bank is also representative of sand launce banks generally, so much of the knowledge gleaned there should be useful in understanding and managing populations located elsewhere. Finally, since sand launce are not presently fished on Stellwagen Bank, the project could gather baseline data unhampered by the problems associated with a fishery in decline or collapse.

By trawling for adults, sampling larvae with plankton nets, and laboratory analysis of the catch, Smith began to piece together a picture of the population structure of sand eels. The picture is constructed of such data as life span, time and duration of spawning, and larval survival. This kind of information will provide a baseline against which to measure the effects of an active fishery.

The picture beginning to emerge is one of a sustaining, perhaps growing, population which is localized into concentrated pockets or microhabitats. Spawning activity is greatest in the

How can dynamics information help? No simple arithmetic formula can describe what is happening in an exploited fishery. Where and when a stock is fished can be more important than how many fish are taken. For example, if fishing pressure can be timed or located so as to avoid taking pre-spawning individuals, regulators may actually be able to increase the harvest, and at the same time more effectively protect the species.

This, however, requires more knowledge than we now have. The most obvious way, then, in which Sea Grant research can serve to loosen constraints on the fishing industry is by filling the gaps in information on the basis of which regulations for commercially valuable fishes are set.

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winter. Spring, early summer, and autumn appear to be the best seasons to harvest sand launce on Stellwagen Bank. A large by-catch of dogfish sharks in the summer creates handling problems and can be very destructive to gear.

As the work progresses, Smith will develop a biomass estimate for sand launce on the bank. Regulators can translate such an estimate into the total fishing pressure (number of boats, length of season, etc.) which an *Ammodytidae* fishery on Stellwagen can be expected to support. The population dynamics information will, for its part, help regulators direct fishing pressure so as to allow the greatest yield without diminishing the resource.

## Herring Genealogy

Sardines (juvenile herring) are the one fish processed in volume in northern New England; in the state of Maine alone, the commercial fishery for Atlantic herring accounts for value added revenues in excess of $60 million per year. Although commercial exploitation has traditionally focused on juvenile herring, extension of the U.S. contiguous zone to 200 miles has opened access to large adult herring populations, and an extensive offshore fishery is anticipated. Such an established and growing fishery demands the protection of a comprehensive management plan.

The major obstacle to the design of such a plan is the present inability to distinguish between herring populations in the northwest Atlantic. Two spawning concentrations are currently recognized within U.S. territorial waters: one in the Gulf of Maine, the other on Georges Bank. Others have been identified off Nova Scotia and further north. Herring from different concentrations mix during migration, but the extent of inter-spawning, if any, is unknown.

Irving Kornfield and Bruce Sidell of the University of Maine Migratory Fish Research Institute are engaged in unraveling that unknown. The information the two zoologists are seeking is crucial to herring management plans which historically have treated geographically discrete aggregations as genetically discrete. It may be, indeed, that individual herring return unerringly to their home turf to spawn. If so, an abnormally low catch of young herring during migration could be identified as a problem peculiar to just one spawning aggregation — perhaps one outside U.S. waters. But without such knowledge, fisheries managers would be forced to cut back quotas throughout the management domain in response to an irregular catch. And the difficulty of pinpointing a cause would be multiplied by the number of spawning groups, as any or all of them could be involved.

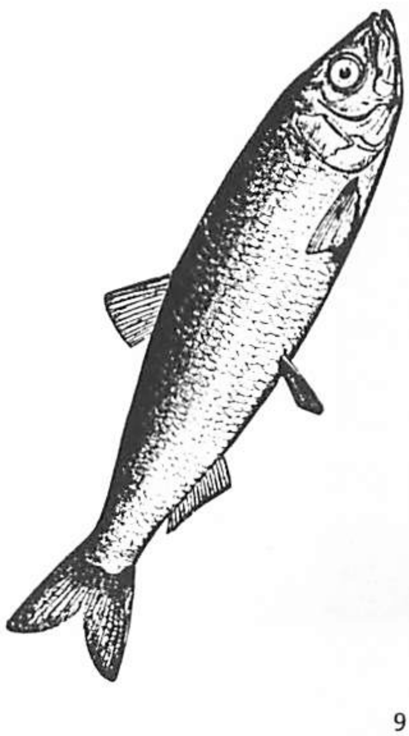
Until recently, fisheries scientists have attempted to define populations by means of structural differences between individual fish. Although useful, this approach has a significant weakness: such morphological traits are influenced by environment, so their genetic basis cannot be known with certainty.

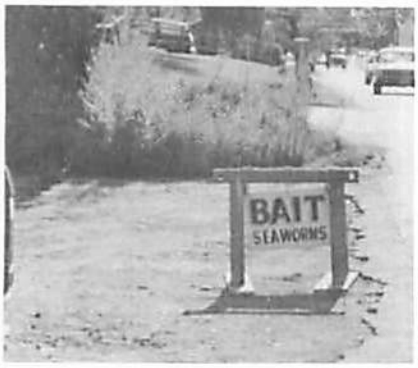
As an alternative, in 1979 Kornfield and Sidell proposed a biochemical approach. Unlike morphology, biochemical "fingerprints" are believed to be unaffected by environment, and thus reliable evidence of a fish's genealogy.

Kornfield and Sidell established a cooperative sampling network in 1979 which includes commercial and government groups in both the U.S. and Canada. Juvenile and spawning adult herring were collected from a number of Gulf of Maine locations. Tissue samples were stored in liquid nitrogen immediately upon collection to maintain a high level of enzyme activity for subsequent analysis.

Analysis of these samples revealed three previously unknown biochemical markers by which to trace the herring's genealogy. At the same time, the zoologists resolved several additional known enzyme systems.

During their remaining year of research, Kornfield and Sidell will collect adult herring from presumed breeding grounds. Based on gene frequency profiles for these specimens, they will evaluate the degree of reproductive isolation for the sampled spawning groups. The same clues can be used to determine the extent of population mixing during migration periods, when herring are heavily exploited.






# Interspecies Dynamics and Restoration

Fisheries management is sometimes regarded as a scheme forced on the industry from without. But there are clear instances of industry itself actively pursuing rational management when faced with the steady depletion of a valuable living resource. And, on occasion, when the lives and fates of several organisms are sufficiently intertwined, it is not an individual species, but a total environment, which must be managed as a whole.

The restoration of a depressed population, however, even under sound management, can be one of nature's more time-consuming processes. So, when within his power, man has never hesitated to give the population

## Down the Food Chain

What is the world's most valuable living resource? Lobster? Abalone? Swordfish? Ounce for ounce, none of these delicacies ranks in value with the lowly marine baitworm. Bloodworms and sandworms, while retailing at only pennies per worm, are weighed out in grams and tenths of grams, making them perhaps the world's most valuable marine species on a dollar per pound basis.

The baitworm industry is an important one in northern New England, among the top five fisheries in the state of Maine in total landed value. In fact, Maine harvests about 90% of this country's marine baitworms, and thousands of sport fishermen depend on Maine worms as a bait source.

In recent years (1975-1977), however, Maine landings of bloodworms (*Glycera dibranchiata*) have dropped by 50%, and although the sandworm (*Nereis virens*) held its own during this period, it too began to show signs of decline in 1978. A much longer-term trend has been the steady shrinking in size of the average baitworm landed, and an almost proportional increase in price.

In 1975, when baitworm landings were still up, David Dean, a University of Maine, Orono, zoologist, and Michael Mazurkiewicz, a biologist from the University of Maine, Portland, were experimenting with methods for culturing polychaetes, the group of segmented worms which includes sandworms and bloodworms. In 1979, the two University of Maine marine biologists turned their attention to baitworm management.

The knowledge needed for intelligent management has heretofore been lacking. What, for example, should be the length limit, if any, on baitworms? Presumably, a worm should have a chance to spawn before it is harvested, but spawning seems unrelated to size. Perhaps age is the determining factor for spawning readiness, but the intuitive method for estimating age — counting segments — has proved unreliable.

The only sure way to establish a size/age relationship, decided Dean and Mazurkiewicz, is to take the worms back to the lab and grow them yourself. This, the two zoologists were as well or better prepared to do than anyone else in the field.

A size/age relationship, however, would be insufficient for management purposes given a certain peculiarity of marine baitworms: individuals of both species are believed to spawn only once, but while some five-gram, 18-centimeter worms have been known to spawn, others reach three times that length and nearly ten times that weight without spawning. Why? Dean and Mazurkiewicz suspected the influence of parasites.

A variety of parasites had been recorded as infesting both sandworms and bloodworms, and other species have been known to suffer destruction of germ cells by parasites. Might not the same cause lie behind the reproductive peculiarities of baitworms? Although virtually no information was available on the effect of parasites on host baitworms, the two Sea Grant investigators added to their research plan a study of parasite types and incidence and their relationship to the host's sexual maturity and size.

Finally, the Sea Grant researchers proposed a restocking of "dead" flats. Some once-productive beds, having been over-harvested in the past, have failed to recover even after being closed to digging for years. Dean suggested that once a population drops below a certain critical level, it cannot recover. "Seeding" bloodworm larvae on such a tidal flat would test whether population density was the problem or whether some other factor made the flat uninhabitable. If successful, the restocking would open up new harvesting areas to a troubled industry.

In 1979, the first year of their three-year project, Dean and Mazurkiewicz gauged the growth of both sandworms and bloodworms in the lab as against their counterparts in the field. For example, in both environments sandworms weighing one-tenth of a gram in the spring increased their weight by a factor of ten in six months. Bloodworm growth was less successful, with lab and field replicates showing growth spurts during different seasons, and modified containers were designed for deployment in 1980.

A parasite survey was also begun, and two protozoan parasites were isolated from the gut of *Glycera*, one in maturing females and the other, interestingly, only in large, sexually immature bloodworms. An investigation of the effects of these parasites and a search for others was scheduled to continue into the second and third project years.

## Biography of a Bivalve

Given the tidal flat's importance as a marine habitat along the New England coast, the dearth of comprehensive studies on its ecology is somewhat remarkable.

a helping hand.

In the ocean, such assistance may involve a culturing phase during which eggs, larvae, or juveniles are brought to maturity, or at least to a more independent stage of life. Or it may be a simple matter of transfer from a hostile environment to one where the organism is expected to thrive. Both techniques have been used successfully with terrestrial species. In either case, a knowledge of the species dynamics is prerequisite to aiding restoration.

In 1979, two projects investigated the dynamics of commercially valuable inshore species with an eye toward using that knowledge to speed the recovery of their staggered populations.

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In fact, the first such study in the eastern United States was conducted in 1962 and remained the one and only for fifteen years, when a 1977 seasonal study was undertaken at the same field site. Thus, the soft-shelled clam *Mya arenaria*, economic kingpin of the tidal flat, while fairly well understood in isolation, is largely a mystery in terms of its relationships with its neighbors and its neighborhood.

But in research, as in life, the squeaky wheel gets the grease. In 1955, in the middle of a decade-long decline in Maine *Mya* landings, a significant amount of soft-shelled clam research was going on. In 1977, after twenty years of annually increasing landings, the level of *Mya* research activity was much lower. In short, when things were going well, *Mya* got little attention.

In recent years, however, there are indications that the average size of landed soft-shelled clams is diminishing, which may, in turn, indicate an imminent decline in the stocks. Associated with this decline is the desire of coastal towns to manage their own flats, for which the necessary background information is clearly lacking.

A team of University of Maine and University of New Hampshire scientists began to address that lack in 1979. Composed of a sedimentologist, a biologist, a geochemist and an aquaculturist, the team set as its long-range objective the development of a tidal flat management plan. Toward that end, each investigator contributed a subproject from the viewpoint of his particular specialty. The biologist and the geochemist proposed to look jointly at the tidal flat's nutrient chemistry and the processes affecting *Mya*'s food supply. The sedimentologist undertook to investigate the tidal flat surface sediment and suspended matter, and the role of the soft-shelled clam in cycling these materials. *Mya*'s chemical ecology — in particular, whether clams established in a bed chemically signal larvae to set — was pursued by the aquaculturist.

Taken together, their findings could be directed toward the most practical kinds of work: assessing which tidal flats (and which sections of them) are likely to be strong producers of clams; determining whether spat can be reliably induced to set on a flat; developing techniques to enhance the survival of laboratory-held larvae, and assessing the potential of field sites for soft-shelled clam mariculture.

A secondary objective for the team was to develop a comprehensive research project to submit to Sea Grant for consideration in 1980. The 1979 proposal had been worked up the previous year by the team members in conjunction with Maine's Marine Advisory Service which had instigated the project in direct response to coastal community needs. Because the research was called for by the marine community and held great promise, but was still being refined, the 1979 work was supported by Sea Grant Development Funds.

The development of a comprehensive project was aided by a related 1979 study conducted by John Commito of the University of Maine's Science Division. Commito was studying the community structure and population dynamics of *Mya* and two marine baitworms which coexist on tidal flats. The drastic differences he found between *Mya* populations on dug and undug flats argued strongly for the primacy of digging among all the factors which negatively affect clam bed productivity. Digging appears even more devastating to spat than to the older clams which diggers actually harvest.

In 1980, Commito's studies and those of the *Mya* team will dovetail into a single Sea Grant project. Their combined results to date have led the researchers to focus their 1980 investigations on "The Effects of Clam Digging on the Tidal Flats Environment and *Mya arenaria* Populations."

# Aquaculture

In evolving from hunter-gatherer to farmer, man brought under his control many of the variables which influence the quality and abundance of his food supply. And what he has done on land, can he not accomplish in the sea?

The marine equivalent of agriculture is aquaculture; aquatic organisms are grown under controlled conditions. Although an established industry for a handful of species, aquaculture is, for the most part, in the experimental stage. Providing the knowledge and tools to bring this fledgling

## Low Cholesterol Lobsters

Many of us have an interest in eating lobster, but what are lobsters interested in eating? A whimsical question? Not according to Robert Bayer and Margie Gallagher of the University of Maine who have spent the past four years investigating lobsters' dietary needs. Specifically, the two scientists from the Department of Animal and Veterinary Sciences have been working to devise a low-cost diet for lobsters which would yield the greatest possible weight gain in cultured lobsters and those held in pounds prior to sale.

The landings of the lobster *Homarus americanus* in northern New England are equal in dollar value to the landings of all other marine species combined. Each year in Maine and New Hampshire, millions of pounds of lobsters are held in high-density confinement for periods of up to six months. There they are traditionally fed a scrap herring diet to encourage growth, harden their shells and reduce cannibalism. The availability and quality of that herring is unpredictable, making the development of an artificial diet very desirable.

A number of unknowns, however, stand in the way. What, for example, are the nutritional needs of this prized crustacean? Although the question has been under study for several years, work has focused on juvenile lobsters in highly specialized controlled aquaculture systems, and has met with limited success.

As Sea Grant investigators, Bayer and Gallagher sought to improve on this work with an alternative approach: determining the nutrient content of the wild diet. The gut content of wild lobsters were analyzed for crude fat, protein, mineral content, and other nutrient components. This approach yielded some insights that could not have been gleaned from a laboratory population — for example, that the lobster appears to vary its diet in the wild in accordance with the hardness stages of its shell.

Computer analysis revealed the most economical sources of the necessary nutrients, and a recipe was formulated. Components of the substitute diet were chosen to supply the nutrients found in the wild diet: fish meal for marine protein and lipids; yeast for protein and B vitamins; alfalfa for carotenoids, and so on.

This experimental diet was fed to and successfully maintained adult lobsters. Furthermore, in an overwintering test, lobsters fed the artificial diet from October to February gained 40% more weight than those fed the traditional herring diet. Bayer and Gallagher attempted to improve this percentage with the addition of a cholesterol supplement but discovered, surprisingly, that lobsters grew best on a Bayer/Gallagher diet without added cholesterol.

A second obvious use for artificial lobster feed is as bait. Toward this end, Bayer and Gallagher monitored the responses of lobsters exposed to various potential attractants, and incorporated the most successful into a pelleted bait. Maine fishermen tested the bait by fishing it in pairs of traps with regular herring bait on one trap and synthesized bait on the other. The herring and the artificial bait fished equally well in many cases, and the University of Maine is producing a bait pellet that can be used in conventional bait bags.

After four years of refining, Bayer and Gallagher have developed a feed which is a potential boon to pound operators, aquaculturists, and lobster fishermen. The diet is presently being used commercially in one pound in Steuben, Maine.

## Gaffkemia Vaccination System

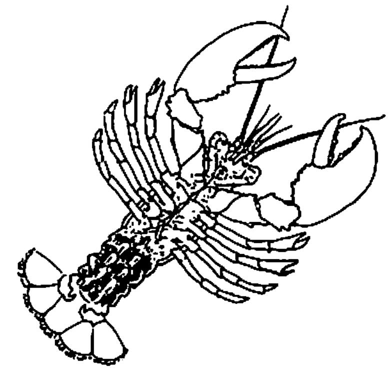
When he developed a vaccine which prevents gaffkemia in lobsters, University of Maine graduate student James Rittenburg had every right to feel excited. Lobster is Maine's biggest dollar fishery, and gaffkemia probably its biggest headache. The disease takes its toll in the field, but it is in lobster pounds where it merits its reputation as scourge of the industry. When an infected lobster is brought into a pound, the disease spreads quickly in the crowded conditions, and once an individual lobster contracts the disease, death inevitably occurs.

But control of a disease at large is not accomplished by the development of a vaccine alone. The Sea Grant project begun in 1979 by a Maine team led by Kenneth Mumme and Robert Bayer is a graphic illustration of the extensive work to be done between vaccine development and disease control.

Obviously, the kind of triumph which has been scored over human diseases such as smallpox is out of the question here; gaffkemia will continue to exist in the wild populations. The goal is rather to control gaffkemia in pound-held lobsters (and eventually, lobsters in culture), thereby preventing the catastrophic losses which now plague the industry.

Kenneth Mumme is a chemical engineer. Robert Bayer represents the Department of Animal and Veterinary Sciences. The rationale for this blend of disciplines is that industry to maturity is one way in which Sea Grant research is contributing to the availability of living marine resources while the wild stocks are under FCMA protection.

The opportunities for aquaculture in northern New England are enormous. The extensive ragged Maine coastline, much of it undeveloped, provides thousands of miles of access to precious seawater. As for New Hampshire, the potential aquaculture sites along its short coastline are multiplied many times by the intracacies of the Great Bay estuarine system.



the project essentially breaks down into two areas of study: the vaccine, and the vaccination method handled largely by biologists and engineers, respectively. The two will mesh into a total system and must, therefore, be pursued in a coordinated way. For example, one proposed delivery system would require vaccine which is temperature tolerant; another, a vaccine which is effective when highly concentrated.

Vaccine testing was emphasized during 1979. In a laboratory test in which lobsters were challenged with injections of *A. viridans* — the pathogen which causes gaffkemia — all unvaccinated lobsters died in less than three weeks, while vaccinated lobsters remained free of infection.

The results of a field test of the vaccine, however, were ambiguous. A total of 22,073 lobsters were vaccinated at a pound in Hancock, Maine, and deaths dropped to 2.5% as against 13.5% the previous year. Ironically, researchers were disappointed. The reason: there was no outbreak of gaffkemia. Though good news for the pound operator, this eliminated any opportunity for scientists to compare the reactions of vaccinated versus unvaccinated lobsters in a disease environment.

This may, however, be an indication of the vaccine's power. An outbreak usually originates with a lobster which is placed in the pound during the early fall when the water is at its warmest. Most of the early-placed lobsters were among those vaccinated, so the vaccine itself may have prevented any disease outbreak. Nevertheless, this does not constitute scientific evidence, and the test will have to be repeated.

Also begun in 1979 was engineering evaluation of candidate vaccine delivery systems. Four are under consideration: routine manual injection; incorporation of vaccine into lobster feed; dipping lobsters into a vaccine solution bath upon their arrival at the pound; incorporation of a vaccine delivery system into pegs which are used to jam lobsters' claws closed.

Upon selection and design of a delivery system, a second battery of biological studies will be required to ensure that the vaccine will be effective when processed into a form which is compatible with the delivery system. The details of these studies will depend on the system chosen, but among those likely to be included are: tests of the effects of adding preservatives or antibiotics to the vaccine; studies of the shelf-life of frozen, freeze-dried, refrigerated and room-temperature vaccine; and experiments to determine the limits of concentration and other physical properties of the vaccine.

## The Scourge of Salmonids

Salmonids — trout and salmon — hold an important place among conservation, sport and commercial fisheries. At present, the over 2,500 commercial facilities and government hatcheries in the U.S. produce more than $100 million of fish at wholesale prices. It is estimated that between 20-30 cents of every dollar spent raising these fish is attributable to disease loss or control.

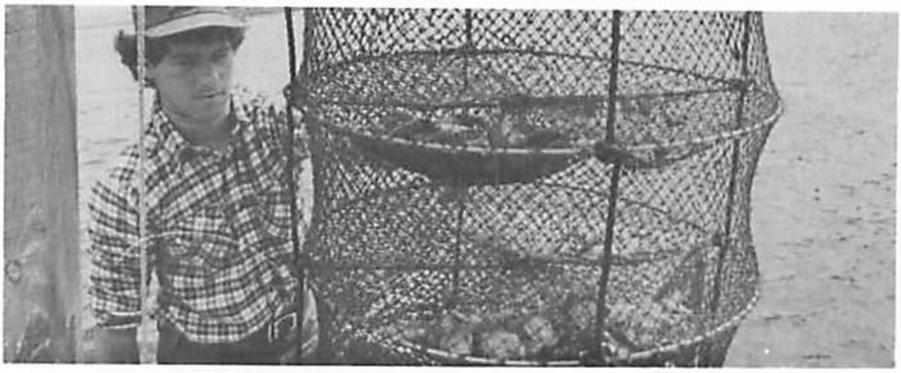
The diseases of migratory fishes, particularly Atlantic salmon, have been the subject of University of Maine research for a number of years, most recently under the coordination of the Migratory Fish Research Institute. In 1979, Bruce Nicholson and Anne Hanson of Maine's Department of Microbiology began a three-year research program to provide the missing genetic data on the disease agent which causes infectious pancreatic necrosis (IPN).

A viral disease of salmonids, IPN's toll in the natural environment is often multiplied in the crowded conditions of a hatchery or aquaculture facility. The common transport of large numbers of fish from one place to another compounds the problem by introducing the virus into previously uninfected populations.

Industry, government and universities are expending considerable effort in developing vaccines for IPN and other fish diseases. Most work is still in the preliminary stages, however, slowed by a lack of genetic information on the disease agents.

A body of evidence has accumulated to indicate that the many isolates of IPN virus differ significantly, but what these differences imply for the detection and control of the disease was unknown at the outset of Nicholson's Sea Grant project. So Nicholson collected IPN strains from New England, Nevada, Idaho, Canada, Denmark and France and analyzed each using an antiserum effective against a strain from Maine. Although all of the isolated strains were neutralized to some extent by the antiserum, the degree of effectiveness indicated that they fall into several groups — that is, classifications based on the nature of the antigen of each strain.

Casual inspection of the data suggests anywhere from two to five groups. Development of vaccine which is effective against all strains of IPN will require a fairly exhaustive grouping of types. A definitive grouping will follow testing of all (or most) antisera against all (or most) viruses. Such



confrontation, and statistical analysis of the data they provide, are underway, and will continue throughout the study.

The easiest — though by no means easy — vaccine to prepare is one based on killed virus. Most current IPN research is therefore directed toward this goal, and Nicholson's serological analysis promises to facilitate these efforts. However, vaccines based on live weakened viruses, though more difficult to prepare, are also more effective. They more closely approximate the disease and, consequently, provide greater protection. Live vaccines are also easier to administer to large populations.

With this in view, Maine microbiologists are attempting to chemically induce temperature-sensitive mutants of the IPN virus. Such mutants have been shown to have decreased disease-causing ability; they can furthermore be prevented from replicating by an adjustment in temperature. Work is proceeding to induce temperature-sensitive mutants, but even if mutants useful for vaccine are not achieved, this line of experimentation will provide necessary genetic information on the IPN virus.

## Mechanized Oystering

New activity in the troubled fishing industry is looked upon with hope, particularly in a state such as Maine where fishing is so important to the economy.

Commercial oystering is a fledgling industry in Maine. The industry's stability and growth face obstacles, not the least of which are the labor-intensive nature of portions of an oyster operation.

In 1979, University of Maine agricultural engineer John Riley completed a two-year effort to introduce some profitable mechanization to the industry. The goal of Riley's program of equipment design and development was to produce working prototype cleaning and grading machines, and to test them on a commercial operation.

Three guiding principles emerged during the course of Riley's early work: (1) Because Maine's oyster operations are small and independent, any equipment developed had to be as simple and as inexpensive as possible. (2) Because these are non-standardized operations, relatively portable, separate machines were called for. (3) Finally, any equipment designed or constructed could only be truly evaluated by a commercial oyster grower.

In 1978, prototype rotary brush cleaners and rotating drum sorters were designed and successfully tested. In early 1979, more advanced versions of the drum sorter were built and installed on the service rafts of two commercial oyster growers. After almost a year of continuous operation, with only minor design changes, they have been judged one hundred percent successful. Sorting efficiency has been high and damage has been insignificant.

Although the original machine was designed to grade mature oysters, a need was identified to sort seed oysters in the one-half-inch to one-inch size range. Juvenile oysters, raised in trays or nets, usually grow at significantly varying rates due to positioning, crowding and other environmental factors. To promote maximum and even growth, the juveniles are separated and grouped with oysters of a similar size. This has been accomplished with shaking sieves requiring much hand labor. Minor modifications to Riley's drum sorter resulted in a machine which successfully performed this task.

A fishing gear manufacturer has expressed interest in marketing a commercial version of the grader. Preliminary meetings have been held to discuss licensing, availability of blueprints, and other business details.

A rotary brush cleaner was also designed under this Sea Grant project. Oysters grown in trays or nets accumulate silt, algae, barnacles and other fouling organisms on their shells which must be removed prior to grading and packaging for market. It is also often desirable to clean small oysters before returning them to the water for further growth. A pre-commercial prototype of the rotary brush cleaner was constructed, and successfully tested by oyster growers. Like the grader, this machine is now at a stage suitable for manufacture, and drawings are available.

The oyster processing equipment was originally intended to be shore-based and was therefore powered by electric motors. It was subsequently decided, however, that the equipment was needed on the service rafts, and for this purpose, Riley developed a small, gasoline-driven, hydraulic power pack. These power sources allow any or all on-board equipment to be powered from a single source, the only connections being flexible hydraulic lines. This allows for flexibility in equipment layout, and available power for operating winches and hydraulic booms. Two such systems have been in successful commercial operation for a year.

# Seaweed Research

Man's raw materials have not changed over the years — only his ingenuity in using them. The earth's living and mineral resources have remained roughly constant throughout man's history. Some prehistoric forebear discovered that certain rocks, when heated, yielded a shiny, workable material which held an edge and made terrific weapons.

Less dramatic, but analogous advances are made each time a new application is found for a standard material. Over its short lifetime, Sea Grant has supported a number of research projects of this kind. Extracts from marine

## Hybrid Vigor

Many Americans have tasted seaweed, either dried and packaged as found in specialty shops, or wrapped around raw fish dishes in Japanese restaurants. But most people in this country would still rate edible seaweed as a curiosity.

The surprising fact is, however, that each American consumes a daily average of 30-100 milligrams of edible seaweed — in the form of a substance known as carrageenan. An extract derived principally from the marine red alga known as Irish moss, carrageenan is used extensively by the food, cosmetic, and pharmaceutical industries as a stabilizing and texturing agent. Presently, much of the world's supply comes from the Canadian Maritime Provinces and New England which produces 10,000 dry tons per year, all from the harvest of natural populations. In recent years, however, harvests have consistently fallen short of demand and appear to be in steady decline. The phycocolloid industry has consequently become interested in mariculture as an alternative source.

The choice makes sense. In addition to being a very important red algae species, *Chondrus* may be well suited for tank or pond cultivation. There is a good base of biological and biochemical information available on *Chondrus*, and considerable technical knowledge on its cultivation on a pilot scale.

If their success in agriculture is any indication, genetic techniques could make a great contribution to seaweed mariculture. Such is the belief of Donald Cheney and Arthur Mathieson of UNH's Jackson Estuarine Laboratory. The two phycologists have for the past two years been experimenting with seed stock selection for improved strains of Irish moss just as agricultural scientists have to produce high-yield, fast-growing, climate-tolerant varieties of wheat and other terrestrial crops.

This Sea Grant research actually consists of three mutually related studies. Selective breeding can only be accomplished when there is significant variation among individuals, so one task is the search for the material to form a diverse gene pool. *Chondrus* populations from subtidal, intertidal, open-coastal, and estuarine habitats, and from various geographical locations are being compared for genetic differentiation. Eight populations from New Hampshire and the Maritime Provinces have been analyzed, and results to date indicate that there may be substantial differences among individuals within a relatively small area. From such diverse breeding stock, offspring with hybrid vigor may be produced.

The feasibility of selective breeding can only be predicted, however, when it is known to what extent the desired traits are genetically controlled. A second area of study is therefore to examine the extent to which carrageenan yield and growth rate are inherited. A preliminary estimate for carrageenan yield was reached by comparing the yields of 160 individual plants from seven populations before and after being grown under uniform conditions. Although yield was at first highly variable leading investigators to suspect much genetic diversity, differences in yield decreased over time. It appears now that non-genetic factors account for most, but not all, of the differences in carrageenan yield observed.

These same plants also showed significant differences in growth rate, and in resistance to disease and to natural enemies. One particularly healthy strain was also among the highest producers of carrageenan, making it a prime candidate for cultivation if it has a fast growth rate.

The culmination of these selection studies will be, of course, genetic improvement of *Chondrus* strains for mariculture. In 1980, the third and final year of this Sea Grant project, research will emphasize crossing genetically diverse strains to produce hybrid vigor. Concurrent with this work, Cheney and Mathieson will be attempting to induce polyploid plants chemically. A polyploid — a plant with more than the normal number of chromosome sets — would be sterile, and thereby of great value in mariculture. Instead of maturing reproductively and then dying (as is usually the case), such a sterile plant with desirable traits could be vegetatively cloned indefinitely.

## Carrageenan and Cancer

While their colleagues apply strain selection techniques to seaweed mariculture, two botanists from UNH's Jackson Estuarine Laboratory — Arthur Mathieson and Eleanor Gallagher — have teamed up with a University of Washington pathologist to test the carrageenan itself.

Like all food ingredients, carrageenan is subject to testing for safety, but its colloidal nature presents particular problems to investigators. Customarily, a food additive is tested at 100 times the concentration normally ingested. Carrageenan, however, forms a solid at high concentrations making it impossible to conduct the standard feeding tests with a 100-fold safety factor. To complicate matters, the six distinct carrageenans in commercial use have both species have been found useful as antibiotics, antiviral agents, industrial enzymes and immunosuppressants.

Among the most productive sources of useful extracts are the seaweeds. Two 1979 UMe/UNH Sea Grant projects focused on the economically valuable Irish Moss (*Chondrus crispus*), one seeking to improve its suitability for aquaculture, the other studying the pharmacological effects of its principal extract, carrageenan.

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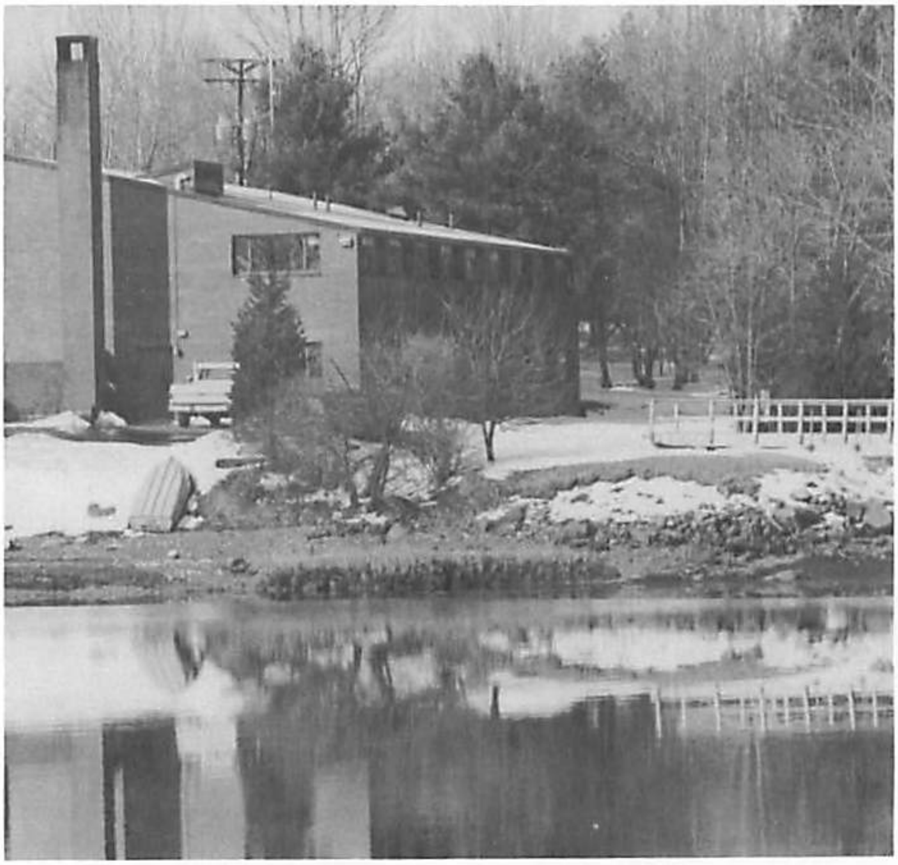
high and low molecular weight forms which appear to differ in their effects on living creatures.

In 1979, the UNH/University of Washington team embarked on an alternative testing regimen — to study the effects of carrageenan directly on living cells in culture. The Sea Grant team first grew fibroblasts — a type of connective tissue cell — from chicken embryos in media with varying concentrations of the carrageenans commonly used as food ingredients. They then extended their investigations to human cells.

The widespread use of carrageenan makes it imperative to determine the compound's pharmacological effects, and whether these effects are beneficial or detrimental. But a second motive also lay behind the research — the exciting possibility that carrageenan may have anticarcinogenic properties. Carrageenan is a sulfated polysaccharide — a complex sugar. Recently, a polysaccharide extracted from marine algae was shown to block the adsorption of viruses to the cell wall. Since viral adsorption is one way in which a normal cell is transformed into a malignant one, this was a clue that marine algal polysaccharides may be anticarcinogens.

Secondly, carageenan effects changes in animal cells which are believed to be related to changes in cell surface components. Malignant or cancerous cells characteristically show a reduction in or absence of high molecular weight molecules at the cell surface. By the addition of compounds — such as carrageenan — which are similar to those that are absent from the cell surface, normal growth may possibly be restored to malignant cells.

A final piece of evidence for the anticarcinogenic potential of carrageenan was provided by the team's first year of research. Cultured human fibroblasts showed decreased growth in the presence of carrageenan, decreased growth which was shown not to be the result of any toxicity. This result raises the possibility that cancerous growth may likewise be restrained. The Sea Grant investigators will study the effects of carrageenan directly on malignant human cells in the ensuing two years of their project.



# MARINE ENVIRONMENTAL RESEARCH

# Great Bay Estuary, New Hampshire

The Great Bay estuary system accounts for more than one-half of New Hampshire's modest salt water coastline. Still largely undeveloped, Great Bay has been the subject of extensive biological research conducted at the University of New Hampshire for over thirty years. However, much of the data has been collected as isolated studies of small habitats or individual species.

Following the inception of the Sea Grant program at UNH, and continuing as part of the UMe/UNH cooperative program, an integrated multi-disciplinary research effort studying the physical and biogeochemical

## Storm Runoff

Do mathematical models work? They are the mainstay of modern weather prediction, which is to say that, yes, they work, and at the same time they are far from perfect. Yet with the advent of the digital computer's ability to process vast amounts of data quickly, mathematical models have emerged which can make predictions which transcend time and space, predictions hitherto beyond human capability.

Land use decisions for the coastal zone surrounding New Hampshire's Great Bay estuary system will have a significant impact on the area's water quality. But what the specific impact will be from a given decision or event perhaps only a mathematical model can answer in adequate detail. This has been the approach of investigators in the Great Bay modeling project of which Paul Bishop and Yen-Hsi Chu's 1979 Sea Grant work was a part. The two UNH Civil Engineers combined field work with computer modeling to advance the understanding of dispersive transport processes in the Great Bay system.

A hydrodynamic model — one which describes the flow of tides and currents in the estuary — had been developed earlier in the Great Bay project. But in addition to moving through the estuary with tides and currents, a contaminant is subject to another process — dispersion. Even in still water, a contaminant will disperse on the molecular level, approaching uniform concentration throughout the water: Knowledge of the rate and extent of dispersion is necessary to predict the pathway of any pollutant entering the estuary. Bishop and Chu conducted three dye tracer studies to gather this information.

In the first, dye was released in the lower Piscataqua River — the largest in the system — and dye concentration was measured both in the river and in the Little Bay portion of the estuary over one complete tidal cycle. This data was used to estimate the magnitude of dispersion coefficients and for calibration of a two-dimensional model.

A high-runoff event (a storm) releases a sudden, heavy influx of contaminants into surface waters. Dispersion under such conditions was determined during two dye studies conducted in the tidal reach of the Oyster River, another of the five major rivers feeding the estuary. To simulate post-storm conditions, the first dye study was carried out during spring high-flow conditions. For comparison, a second dye study was conducted in September 1979 during low fresh water flow.

This work was done in conjunction with the New Hampshire Water Supply and Pollution Control Commission (NHWS&PCC) who were also interested in surface runoff to the Oyster River. The shared expertise, equipment and personnel enhanced the research of both parties. Data from these studies is currently being applied to ongoing model development work to be used for analysis of water quality impacts on tidal rivers.

In conjunction with Bishop and Chu's work with NHWS&PCC personnel, a comparison of several simplified tidal prism flushing models was undertaken for the Oyster River. The optimum model was then applied to other major rivers of the Great Bay estuary system. This information will be used for assessing the capability of the various rivers to remove contaminants introduced from upland sources.

## Trace Metals

While their colleagues on the Great Bay Project modeled the estuary's hydrodynamics on a computer, two UNH geochemists were studying the flux of trace metals in the bay. In 1979 Henri Gaudette and Berry Lyons of the Department of Earth Sciences completed two years of research into the pathways and fate of metals introduced into Great Bay. Their work focused on two questions: (1) Where do these chemical species end up, and how do they get there? (2) What role do the sediments play as a net source or ultimate depository for trace metals?

What is the specific interest of this trace metal research? Some metals are of concern for their toxic effects above certain concentrations. Others — iron, in particular — are good indicators of the behavior of other chemical species. An understanding of trace metal/sediment chemistry should precede decisions regarding dredging, pipeline or other offshore construction, or any human activity which threatens to disturb the sediments or infuse metals into the bay. The chemical inputs from the sediment will also form an important part of the overall environmental model of the system under development by the Great Bay Project.

Unlike so many organics which are strictly the products of man's ingenuity, the metals under study occur naturally in aquatic systems at background levels. Consequently, it is more difficult to determine for metals, on the basis of short-term measurements, whether man's impact is being felt. What levels of trace metal concentration are natural for a particular system? Data on a relatively undeveloped estuary such as Great Bay therefore becomes useful as a baseline against which to compare future fluctuations.

processes of Great Bay has been undertaken.

UNH mechanical engineer Barbaros Celikkol led a three-part 1979 study of nutrient processes in Great Bay. The theoretical portion of the study analyzed mixing processes and effective viscosities in order eventually to understand the distribution of nutrients in the estuary. Concurrent work concentrated on the development of computer programs to analyze two and one-half years of nutrient field data taken in the estuary. Finally, an investigation of nutrient fluxes within a small north temperate saltmarsh resulted in a publication of the same name.

Two other 1979 projects which advanced the Great Bay work are described below.

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The Great Bay estuary can be conceived as an open system with five inputs (five major rivers) and one output into the Gulf of Maine via the mouth of the Piscataqua River. The results of Lyons and Gaudette's research can thus be divided into three basic areas: (1) the riverine input of trace metals into Great Bay; (2) the pore water (fluid between the particles of bottom sediment) chemistry variation in the bay itself, and; (3) the estuarine budgets of trace metals in Great Bay. In this case, preliminary budgets were developed for two metals of prime concern: copper and chromium.

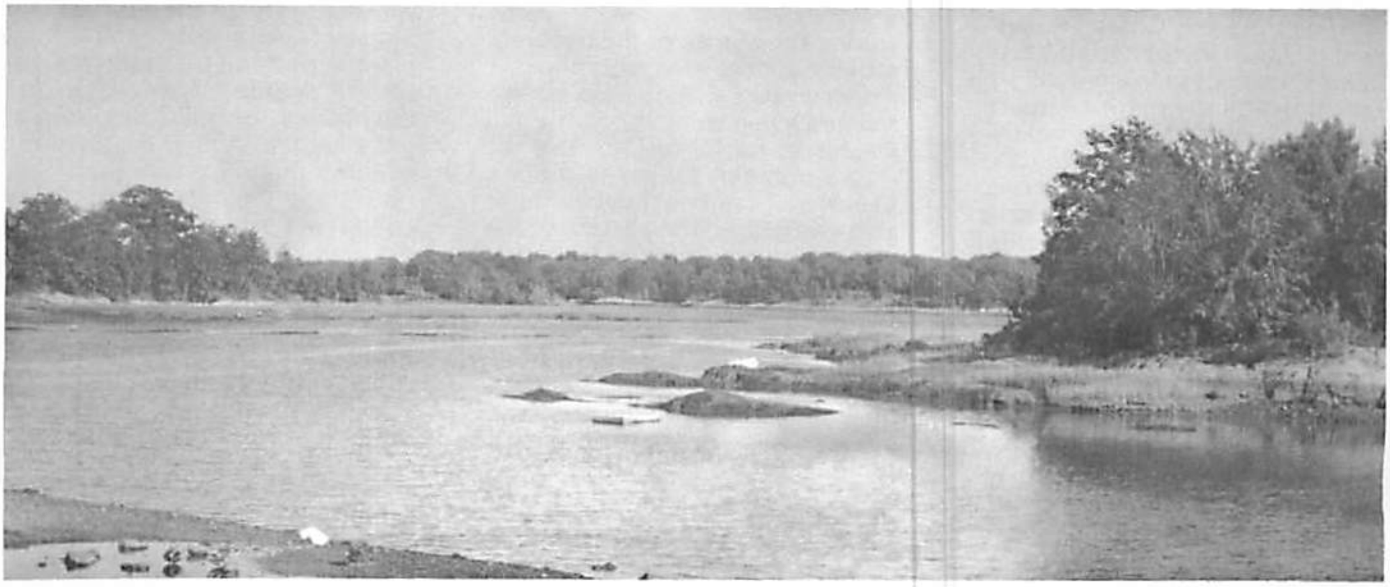
In Great Bay pore fluids, the UNH geochemists discovered variations in trace metal and nutrient concentrations, both seasonally and laterally (over time and space). Physical/chemical considerations are insufficient to explain these variations; biological activity must be taken into account. Estuarine life varies over space and time, and indeed, the interplay between the activity of microbes and macrofauna was found to be an important factor influencing chemical variation.

Such interplay illustrates why the Great Bay project is a multidisciplinary one. An adequate environmental model must incorporate the physical, chemical, geological, and biological forces in the estuary to be useful to real-world decision makers. The seasonal increase in pore water dissolved iron, for example, is related to increased organically-associated iron. In turn, pore water molybdenum concentrations are intricately related to sedimentary iron concentrations. These benthic fluxes are not, however, an important factor in the overall trace metal budget of the estuary.

Gaudette and Lyons also found seasonal variations in the concentrations of four trace metals in the rivers entering the Great Bay system. Simple dilution may be the major factor here: iron, manganese, copper, and chromium concentrations in the incoming rivers were highest during periods of low runoff; the lowest concentrations are associated with high runoff events. On the whole though, the mean concentrations of these metals (with the exception of nickel) in the river are close to world "average" values.

This is not to say that all observed concentrations were naturally occurring. To the contrary, Gaudette and Lyons found evidence that significant amounts of at least two trace metals were anthropogenic (originating from human activities): chromium in the Salmon Falls River and copper in the Bellamy. Preliminary budgets for these metals further support the conclusion that the major input of each has been anthropogenic.

The budgets also indicate that the estuarine sediments serve as the major reservoir for these metals. However, when metals migrate out of the estuary onto the continental shelf, they do so on fine-grained particles. This last finding is a particularly interesting one which may greatly aid the search for the pathways of a number of toxic and potentially toxic substances in aquatic systems.



# Estuarine Modeling in Maine

Like New Hampshire, Maine counts the estuary among its most valuable resources. A nursery for marine life, a livelihood for inshore fishermen, a recreational resource — the estuary is much more than a place of natural beauty.

Accurate predictive models of estuaries are needed to describe the dynamics of the movement and concentration of various materials introduced into these ecosystems, either accidentally or intentionally. These

## Radionuclides

The nuclear power industry, with all its attendant controversy, is a reality. Nuclear power plants are operating, and more are under construction, across the U.S., particularly at sites on the water's edge where a copious supply of water is available to cool excited reactors. Indeed, the release of thermal effluent in the form of heated cooling water has been one of the main concerns of anti-nuclear activists.

It is another form of pollution from nuclear plants, however, which has attracted the attention of two University of Maine physicists — the release of radionuclides.

In 1978, the Maine Department of Marine Resources was considering reopening the mudflats of Montsweag Bay in Wiscasset for clam harvesting. Some areas of the flats, however, are exposed to the effluents of the Maine Yankee Nuclear Power Reactor, and clams living in these areas ingest radioactive sediments. Sale of these clams, it was feared, might violate U.S. Food and Drug Administration regulations.

Charles Hess and Charles Smith of the University of Maine have been studying environmental radiation and the marine impacts of nuclear plants since the early 1970s. In 1978, the two investigators began a Sea Grant project to describe the distribution of trace elements in estuarine sediments using hydrodynamic models.

The Sea Grant researchers' first objective was to devise estuarine hydrodynamic models which account for the peculiarities of northern New England estuaries. There are currently two families of mathematical estuarine models — each with their respective advantages. Hess and Smith opted to employ *both* models, modifying them to include the features characteristic of Maine estuaries. These features include a vertically well-mixed water column, a large tidal excursion, and extensive exposed sediment flats at low tide. For application of the modified models, Montsweag Bay estuary and Salt Pond estuary in Blue Hill, Maine, were chosen based on the availability of reasonable data bases and interest in the marine resources of the areas.

The two models were modified, applied to Montsweag Bay (the site of the Maine Yankee Nuclear Power Reactor), and the results compared.

For verification of the models' computational results, a field program was conducted in Montsweag Bay. Sediment samples were collected along transects in mudflat areas of commercial interest to worm diggers and potential clam digging. Sediment was analyzed for radionuclides using high-resolution gamma-ray spectroscopy for both the exposed tidal flats and submerged areas which were sampled by boat and Eckman dredge.

During the course of the two-year project, a large area of productive clam flats was opened by the Maine Department of Marine Resources for harvesting. The Hess and Smith studies of the patterns of radionuclides in these areas were used to help define the area which was opened for digging, areas in which clams yield in the vicinity of $10,000 to $20,000 a year.

## Point Sources

In 1979, a University of Maine scientist began a three-year study of the flow regime in Maine estuaries. Bryan Pearce chose Penobscot Bay, an estuary under development pressure, as the study site because an extensive set of field data was taken there in 1970 by the National Ocean Survey. Since field work is very expensive, the Penobscot data is being used to generate knowledge of estuarine flow at a very reasonable cost, knowledge which can then be applied to other northern temperate estuaries. Development is underway on two computer models which will eventually be coupled to predict material transport in the bay.

The modeling work is at the core of a group of related projects studying Penobscot Bay, both proposed and underway. These include studies of how larval forms migrate into the estuary as well as a study for predicting the impact on shellfish beds of proposed treatment plants.

By linking a flow model to these related studies, information can be provided which is needed by commercial interests and regulating agencies for decision-making in coastal areas. For example, knowledge of how larvae move into the estuary influenced by flow will reveal whether they will pass through the effluent plume of an industrial or treatment plant at one site or another. Conversely, the models should predict the pathway of pollutants from a point source to their destination, whether that destination is a flourishing shellfish bed or the continental shelf.

To accomplish this, Pearce has chosen a model developed by the National Weather Service. Earlier investigators used a vertically-averaged model, one, that is, which predicts only a *net* flow at any single point. In an estuary, where salt and fresh water mix, net flow predictions may obscure important details. At one point models can be used to understand the impact that power plants, chemical industries, municipal waste treatment facilities, mines, oil spills, and natural and artificial toxic substances will have upon estuarine resources.

where the bay is well stratified, for instance, field data indicate a definite flow upriver along the bottom. A vertically-averaged model would predict flow downriver.

The applications for which the model is intended reveal why this difference is a critical one. For example, a related project is designed to investigate the mechanisms by which the weak-swimming larvae of the American eel migrate upstream in the spring, when the Penobscot has significant fresh water outflow. A vertically-averaged model could shed no light here. If, however, flow is in different directions at different levels in the water column, the larvae could control their migration by adjusting their depth. An overall goal of this study is to verify a simulation of the bay that predicts the variations in velocity from the top to the bottom of the water column.

The two models under development predict circulation and dispersion, respectively. Once the two are coupled, sites on the shore of Penobscot Bay will be selected, based on their potential for industrial or high-density residential development, as sources for the hypothetical discharge of a conservative (non-degradable) pollutant. The coupled model will then be operated to determine the fate of the pollutant under specified conditions of wind, tide and river flow.

# Hybrid Projects

Sea Grant research is mission-oriented, designed to enhance, in one way or another, the conservation and wise use of ocean resources. Sometimes this goal is best pursued through one or another of the traditional academic disciplines. But often a project's mission straddles disciplines, or even resists classification into the general categories of living marine resources, marine environmental research, and marine advisory services and educa-

## The Struggle for Living Space

Marine fouling communities are assemblages of sessile (fixed) organisms which feed largely upon suspended matter. They typically inhabit exposed hard surfaces, natural or manmade, in the coastal zone. Aside from pure scientific interest, fouling communities draw attention because of their conspicuous effects on man's activities in the marine environment: they clog off outflow pipes, create drag on boat hulls, and foul aquaculture rafts. In concert with the sea's powers of physical weathering and chemical corrosion, marine fouling organisms make the ocean a very inhospitable environment for any physical object. Countless remedies for biological fouling have been attempted, from fouling-resistant paint to peel-away sheathing. It is appropriate that, in this age of increased awareness of ecology, the problem is approached by seeking to understand the interactions of fouling organisms with one another and their environment.

In 1979, Sea Grant supported the first year of a study of long-term fouling community development in the Great Bay estuary. UNH zoologist Larry Harris began testing a series of hypothesis concerning how fouling communities are influenced by two factors: (1) predation, and (2) the angle of the substrate (the surface on which the community establishes).

Harris proposed that, given time, fouling communities will go through a succession of stages ending with domination of most of the space by one or a few of the superior competitors native to the system. Competitive confrontations will be the primary mechanism by which prevailing species reach dominance, and predation will influence which of several species wins.

He further proposed that the success of individual species will be affected by the angle of the substrate, and the development and eventual structure of the community will vary accordingly. On horizontal surfaces, the accumulation of sediment was predicted to inhibit colonial organisms with an encrusting form, with the eventual community structure reflecting this influence.

Harris sited his experiments in Portsmouth (NH) Harbor at the mouth of the Great Bay estuary. In mid-summer, beneath a cement pier in the harbor, his team of divers placed a set of rectangular plexiglass panels, some with their faces aligned horizontally, others vertically. Three substrate angles are being monitored for their effect on the fouling communities which develop: vertical, upper surface horizontal, and under surface horizontal. Predator effects are being studied by selectively restricting the access of the three conspicuous large predators (starfish, cunner, crab) associated with fouling communities at the mouth of the estuary. Every two to four weeks, depending upon the time of year, divers photographically monitor the progress of both surfaces of each panel. At the same time, the concentration of unconsolidated particulate matter on each experimental surface is measured.

Although the fouling communities have had only six months to develop, some interesting results have been noted. A thick layer of sediment on all upper horizontal surfaces precluded the settlement and growth of most organisms found on other surfaces. However, the activity of crabs on the predator access panels dispersed some of this sediment. The lower horizontal community is much richer and more complex than the upper surfaces. During the winter, hydroids give the community an upright structure. Vertical surfaces have few hydroids and are dominated by an encrusting tunicate.

In October 1979, divers began taking close-up photographs of the competitive interactions between the major competitors. The photos will be analyzed for insights into how the struggle for space is carried on.

In early 1980, a second complete set of panels was added as replicates. Unlike the first panels, the second group will be relatively clear when the barnacles set in April, which may give the barnacles a competitive edge.

Harris' studies will add to the understanding of the basic processes which govern the ecology of the Great Bay estuary and the southern Gulf of Maine. Only by understanding these processes and how systems are linked and influenced by changes in other components of the total ecosystem can predictions be made about the impact of proposed changes in the estuary — changes such as filling salt marshes, building oil refineries, or adding a new species to the system for mariculture.

## Remnants of Things Past

The cataloging and preservation of archeological remains in the coastal zone carries a certain urgency. Wave and storm erosion, combined with the relatively high development pressure along the shore, puts coastal remains in a particularly precarious position. Coastal sites are being destroyed at a fantastic rate. This is especially tragic in light of the richness of the tion, and such projects might be described as, " hybrid".

Such are two 1979 projects described here: an environmental study which concerns itself with marine life; and an archaeological investigation that provides information required by environmental impact statements for coastal development.

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archaeological record there. The historical data lost in this manner is gone forever.

Even if this loss were not a concern in itself, there are now strong economic and legal reasons for a concerted program of archaeological surveys in the coastal zone. By law, all federally funded or licensed projects must be examined for their potential impact on historic properties, including standing and subsurface remains. Failure to so review projects can result in construction delays and economic losses. Informed decisions require data on specific sites and the surrounding locality, and this data does not exist for much of the northern New England coastal zone.

While professional archaeological research in New England has lagged behind the rest of the nation, the members of amateur archaeological societies have contributed to the general data base. Sadly, the data from the amateur excavations resulted in the destruction of sites because of poor excavation and recording techniques.

In 1979, Sea Grant funded a coordinated University of New Hampshire/University of Maine project which holds promise for preserving some portion of the coastal archaeological record in northern New England. Charles Bolian of the UNH Department of Sociology and David Sanger of UMe's Department of Anthropology headed up the subprojects in their respective states.

The two approaches taken by Bolian and Sanger differed because of the longer history of related work in Maine. The area of Sanger's research (Boothbay Harbor and vicinity) had already been professionally surveyed so that most of the sites were known. Bolian's research area, on the other hand, was relatively unknown, and thus required more basic work of a survey nature.

At UNH, the early months of 1979 were devoted to background research. Both archival research and personal interviews with coastal residents were used to identify probable sites throughout the New Hampshire coastal zone. During the field season, Bolian's survey team visited as many reported sites as possible, performing test excavations to determine the status of the site (its relative state of preservation) and its approximate age, cultural affiliation and ecological setting.

Aside from the straightforward cataloguing of sites, the field data filled a second important function. Prehistoric peoples, like their modern counterparts, chose locations for habitation based on ecological variables which they considered favorable. In fact, a preliminary hypothesis had been developed which predicts the likely location of sites based on soil type and slope. Bolian's data was used to test and begin refinement of this hypothesis.

A refined model should permit planners and archaeologists to more accurately predict archaeological site locations and plan for their preservation. From the scientific viewpoint, this approach will permit interpretations about prehistoric man's adaptive strategies in the various microenvironments of the coastal zone. The seasonal rounds of early New Hampshire hunters and gatherers can also be analyzed.

During the summer of 1979, Sanger's crew conducted six weeks of field-work in the Boothbay Harbor area of coastal Maine. Nearly 100 archaeological sites were examined and assessed for the *National Register of Historic Places*. Those sites deemed "significant" can be declared eligible for the *National Register* and thus protected from destruction.

The 100 sites examined represent less than 50% of the shoreline to be examined. Of those sites, seven were either placed on the *National Register* or were judged to have definite *National Register* potential. The UMe archaeological team planned to complete the field survey and site evaluation during the summer of 1980, for *National Register* eligibility.

The results of the joint project have provided information valuable not only to New Hampshire and Maine archaeologists, but to their colleagues interested in general problems of cultural development in the Northeast. The coordinated approaches used in the two states have provided a uniform data base easily utilized by other researchers.

The applied benefits of the project include data useful to planners who are attempting to have orderly growth and development while conserving cultural resources. Federal and state agencies, and private entities using federal funds, can use the information in obtaining environmental clearance related to cultural resources. The development of predictive models will facilitate field assessment related to federally licensed or funded projects by permitting the prediction of archaeological site locations without costly field research.

# MARINE ADVISORY SERVICES AND EDUCATION

# Marine Education

The importance of the ocean to this nation is not felt merely along a narrow coastal strip. Energy-hungry inland communities look to offshore fossil fuel resources for relief. The interior states expect an uninterrupted flow of seafoods and marine commerce. Round trips of hundreds of miles to coastal recreation centers are not uncommon.

The implementation of the 200-mile limit on national fishing privileges, increasing numbers of marine oil spills, and interest in sea floor mining all highlight the necessity for marine education. At the same time, the burgeoning development of ocean resources, and the attendant concern for

## Northern New England Marine Education Project

The ocean is not a discipline, but an area to which disciplines are applied. Physics, biology, engineering, all the natural sciences can be, *must* be, applied to ocean problems. Likewise, the sea has its place in history, art, and geography. Therefore, the way to improve marine education in our schools is not to extend the school day an extra hour and add another class, but rather to infuse marine topics into the traditional subjects.

What is needed, according to John Butzow of the University of Maine's College of Education, is a kindergarten through twelfth grade (K-12), cross-disciplinary series of marine educational materials that fit the special conditions of the Gulf of Maine. Although outstanding instructional materials have been developed in such states as Delaware, Hawaii, New Jersey, and Texas, these materials demand substantial modification in order to ready them for use north of Cape Cod.

With a 1976 seed grant from University of Maine Sea Grant, Butzow and Harry Dresser, also of the University's College of Education, sought to adapt a marine instructional materials set to Northern New England needs. After an evaluation of existing materials, the Delaware Coastal/Oceanic Awareness Studies (COAST) were selected as the most appropriate prototype and were modified for area schools, initially for grades K-8.

But a challenge greater than developing teaching materials is how to get them used in the schools. The Sea Grant educators accepted this challenge with their 1978-79 full-scale Northern New England Marine Education Project.

In 1976 and 1977, Butzow and his graduate assistants conducted three marine education conferences in Maine and New Hampshire. This was the groundwork. Teacher support was obtained at the conferences, and several school districts were identified whose superintendents felt they could commit their schools to the field testing of the new curriculum materials.

Butzow and Les Picker, a graduate student, then conducted teacher workshops at each of the participating schools. Participants received materials and teacher's guides for units with such titles as "Clams and Other Critters," "Burt Dow — He's Retired Now," "Ships, Shipping and Waterways," and "Coastal Indians of Northern New England." These units combined subjects from social studies, home economics and literature, to art, science and math; the workshops showed teachers how the program materials should be used in their classrooms.

As the teachers infused the modified COAST units into their curricula, regular faculty meetings and consulting sessions were held to discuss problems teachers had experienced in using the material. At the same time, teacher feedback was used to revise the units.

During the second year of the project, the program was carried into the high schools. Here, a different set of expectations had to be met. Although tolerant of an interdisciplinary emphasis, high school teachers needed a disciplinary focus so that the marine education units could fit easily into a social studies or English or science course. To insure that this need was met, teachers were brought in at the writing stage to help prepare the instructional materials for grades 9-12.

As its final year of funding drew to a close, the impetus of the project showed no sign of abating. Long-range plans are on the drawing board to establish a permanent Marine Education Office in the newly organized Center for Marine Studies at the University of Maine at Orono. Maine state agencies as well as marine educators in the New York-New England region have offered cooperation and suggestions. The Sea Grant project is sure to have a sustained influence on the advancement of marine education in Northern New England.

## Seacoast Sciences and Our Maritime Heritage

It is difficult to imagine a better teaching tool for marine education than the northern New England coast. The stretch from Portland, Maine to Salem, Massachusetts is rich in physical monuments to the region's maritime heritage. The same area displays a remarkable diversity of coastal topography, from rocky shore to sandy beach. Yet, with this resource at hand, there have been few opportunities in the public schools of Maine and New Hampshire for students to investigate the relationships between the many facets of the marine sciences, maritime history, ocean resources, and economic development of the coastal zone.

In 1978 and 1979 two New Hampshire Sea Grant educators created such an opportunity. Their goal was to encourage students to investigate the natural and social history of the seacoast area, to become aware of the importance of local marine resources, to acquire an informed and open mind about coastal management practices, and to share their knowledge with others.

marine environmental quality, is demanding record numbers of specialists in marine disciplines.

Yet, the schools have not kept up. A whole generation is entering an era of marine affairs for which it is unprepared.

Graduate-level students have long collected educational dividends as participants in Sea Grant-funded research. But Sea Grant is committed to a much earlier start. In 1979, three Maine/New Hampshire projects focused on marine education from kindergarten through senior year in college.

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UNH education professor Michael Andrew and Eleanor Milliken of Oyster River High School in Durham, New Hampshire, called this opportunity "ASHORE," — A Science-Humanities Oceanographic Response to Education. They designed ASHORE as an interdisciplinary course and secured it a place in the curriculum of Oyster River High School, and York High School, York, Maine.

The ambitious project was approached in three steps. The early months of 1978 were used to examine field sites, interview specialists, and assemble resources. This activity was in preparation for an intensive summer mini-version of ASHORE which was offered to elementary school teachers, and taught by the three teachers who would instruct the high school course in the fall.

The summer program integrated maritime history, art, and literature with the marine sciences and technology. It served as a first run with the multiple benefits of crystalizing the course material, allowing the ASHORE instructors to test various materials and activities and receive feedback from the participants, and giving the elementary school teachers an intense but varied marine experience to carry back to their classrooms.

Activities included architectural tours, cruises, and field studies of shore life and features. A two-day workshop at the Isles of Shoals featured literature, art, history, marine biology, and archaeology. Concurrent with these studies, the teacher-participants shared teaching techniques and developed their own teaching tools including written units, photographs and slide/tape presentations.

In the fall, ASHORE opened in the high schools to a new set of enrollees. The philosophy paralleled that of the summer program. With marine topics as the subject matter, students developed skills in conducting interviews, constructing displays and models, writing guidebooks and other publications, taking and developing photographs, and teaching their peers.

Although Sea Grant funding has concluded for the project, the continued success of ASHORE has been assured by its popularity at the Oyster River High School. Due to the large number enrolled in the fall of 1980, two semester courses were necessary to accommodate the students.

## Ocean Projects Course

The transition from college to the real world is traditionally one of the more traumatic rites of passage in our society. It's essentially the passage from the ideal to the real; from theory to application.

Some students at the University of New Hampshire, however, make the transition successfully before graduation. Students enrolled in the Sea Grant-funded undergraduate Ocean Projects Course are signed up for an experience perhaps as far from the ivory tower as one can get — working as a member of an interdisciplinary team on a meaningful ocean-related problem under real-world constraints.

Projects are of three basic types: those that lead ultimately to a piece of working hardware to solve a technological ocean problem, such as the development of a hand-held sonar for divers; those that involve the gathering and analysis of scientific data, such as a study of prey preferences of selected benthic predators; and those that are comprehensive studies of an ocean-oriented societal problem with recommendations for action, such as an investigation into the effects of East Coast fisheries regulations.

Under the guidance of a faculty advisor, each student team is required to define its problem, prepare and submit a budget, consult with experts from the marine community, and make progress reports. In addition, students on hardware-oriented projects deal with vendors, and design, build, and test prototype models. Other student teams meet with local, state, and federal officials, do comprehensive library searches, gather and analyze data, and conduct appropriate surveys.

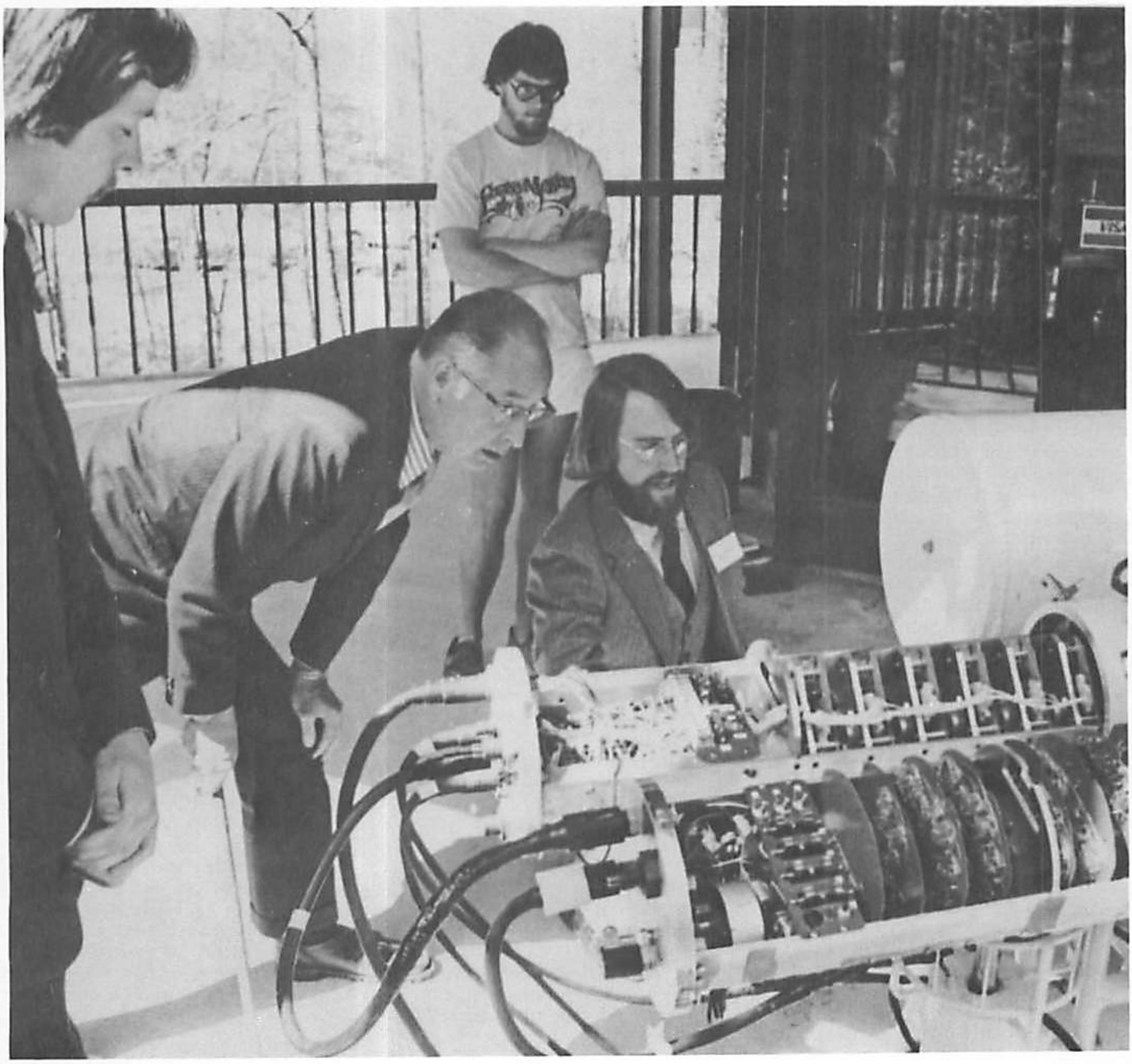
Obviously, a final exam would be out of the question in the Ocean Projects Course, not to mention anticlimactic. Instead, evaluation takes place in May when each project team makes an oral presentation. Students defend their work before a jury of experts invited from various sectors of the ocean community, both inside and outside the University. The jury selects a project (or projects) for special recognition.

Beyond the juries' consistent words of praise, there have been other indications of the quality of Ocean Projects work. Student reports have been used as resources by state agencies, and often the student project makes a valuable contribution to the research of its faculty advisor.

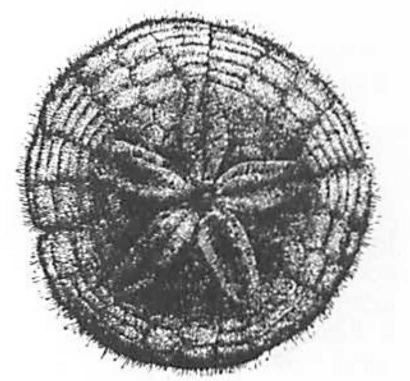
For example, one 1979-80 project which received special jury recognition was "A High-Speed Data Acquisition System for Use with an Autonomous Submersible," involved four electrical engineering students and a mechanical engineering student who developed a sonar system for an unmanned underwater vehicle. Some version of this system may be incorporated into a vehicle being developed under federal funding — a vehicle which *itself* started as a student Ocean Project.

Students from every four-year college within the university are eligible to enroll in the Ocean Projects Course, and although it is a two-semester course, and a time-consuming one, complaints are rare. The reaction of one 1979 student participant is typical.

"This course tied all my engineering courses together," he observed after the jury session. "It gave me a chance to apply my textbook knowledge to a real life application."



# Marine Advisory Services



Through Sea Grant, the nation's universities play a three-fold role in putting our ocean resources to work. Training students and conducting applied research are well-known functions of a university. But equally important is the advisory function: assuring timely and effective transfer of knowledge to those who need it, and providing a feedback mechanism for alerting researchers of current and upcoming problems and opportunities. Every Sea Grant program is mandated to carry out this function.

Within this common mandate, each advisory unit must shape itself to best

## Maine Marine Advisory Program

The Maine Sea Grant Marine Advisory Program (MAP) sponsors a number of activities designed to bring useful information to people in a variety of settings. Marine specialists located at strategic locations along Maine's 3,000 miles of coastline are dedicated to assisting individuals as well as groups in solving problems associated with coastal issues and the wise use of the sea's resources.

In Maine, one of the largest groups served is commercial fishermen. Marine Advisory personnel work closely with fishermen in developing and testing new gear and in introducing and practicing various methods of fishing. Development of the gillnet fishery in Eastport and Friendship, Maine was one area of focus in 1979, as was experimentation with a variety of fish traps.

Commercial fishermen also benefited from a series of seminars conducted (in cooperation with the Midcoast Community College) by MAP specialists on investments, taxes, and other topics pertinent to running a small business. In addition to the seminars, printed materials and video-tapes on these topics were made available to fishermen's cooperatives and fishing communities. As an outgrowth of these workshops, several managers of fishermen's cooperatives took an interest in discussing management training needs with an MAP specialist.

An emphasis which continues in the work of MAP staff for the fishing community is that of fisheries management. In 1979, a MAP fisheries specialist hosted a series of Sunday morning brunches with fishermen to discuss their needs in relation to management issues. In addition to these small informal meetings, the annual Maine Fishermen's Forum organized by this specialist provided valuable information on fishermen's concerns about formal/informal management. As a result, the specialist was able to work more effectively with biological and social scientists in defining critical problem areas in fisheries management. Also, a series of fisheries management articles written by the specialist appeared monthly to inform those interested in the complexities of the management process. In conjunction with the New England Marine Advisory Service and the National Marine Fisheries Service, MAP personnel helped to produce a radio series entitled "Fishing and Our Law," which detailed various topics in fisheries management issues.

Another topic established as priority in 1979 was cold water survival. Lecture/demonstrations on hypothermia, personal survival procedures, search patterns, rescue methods, and communications techniques reached over 1,700 people. The effort to reach more fishing families with the most up-to-date information on these subjects continues to be an important goal (of at least one MAP staff member).

Many people besides fishermen benefited from the cold water survival program, and it is the intention of all MAP personnel to reach as large an audience as possible.

The harbor masters of Maine were another target audience in 1979. Through the efforts of the MAP, harbor masters were brought together for the first time to share their experiences and ideas in solving problems common to all of them. Legal topics including ordinances, law enforcement, and the authority or liability of harbor masters were explained by personnel from the Marine Law Institute in these seminars.

Work by one MAP specialist with the Nature Conservancy was completed in 1979. The topic of concern was coastal land management, and the MAP specialist was instrumental in producing materials and providing support for the management committees of the Rachel Carson Salt Pond and Damariscove Island preserves. Results of this work included a history of Damariscove Island and a guidebook to the salt pond area.

The MAP develops a variety of educational programs every year. Each with its different goal is delivered in the most appropriate way including personal contacts, filmstrips, news articles, and meetings. A popular topic of educational interest in Maine is aquaculture, and the MAP has played a key role in disseminating information about Sea Grant-sponsored research on mussels and oysters as well as about how to begin in the aquaculture business. In fact, partly through the efforts of MAP personnel, the aquaculture industry in Maine has truly flourished and now includes 50 separate businesses.

The education of youth about various marine topics continues to be a major topic of interest to the entire MAP staff. In 1979, a filmstrip series was completed to teach elementary school students about six of Maine's most important marine fisheries: clamming, gillnetting, lobstering, scalloping, seining, and trawling. Though designed for a specific age level, the series has been successfully adapted by teachers at other grade levels, and by community groups for adult learners.

In response to a need expressed by 4-H youth education leaders, several MAP staff members became involved in developing a 4-H marine camp held in a wilderness setting on the coast. Through direct experience, students learned more about the resources of the sea and their responsiserve the needs of its own constituents. New Hampshire's compact coastline and small but diverse marine community calls for a small, versatile core staff of advisory personnel, complemented by temporary or part-time agents with special skills for specific projects. In contrast, Maine's fishing industry alone demands that an advisory program employ several very specialized full-time agents.

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bility when using those resources. This work stimulated the development of a 4-H publication on marine education which will be completed in late 1980.

A new educational endeavor was undertaken in 1979 when a MAP staff member began working with the Marine Trades Center in Eastport helping develop their commercial fishing course curriculum. The one-year program prepares individuals to enter the fishing industry.

Central to all of the work carried out by the Marine Advisory Program is the dissemination of information through Maine Sea Grant Publications. In 1979, over 4,000 pieces of information were sent to schools, libraries, individuals, research units, businesses, and government agencies within the United States and in 22 foreign countries. Questions on a variety of topics ranging from marine careers to alternative species were routinely researched and answered by the MAP publications staff. The mailing program to Maine's 17 fishermen's cooperatives continued in 1979, providing up-to-date information to the fishing industry.

## Fisheries Technology

The Maine Department of Marine Resources (DMR) established an Extension Service in the late 1960s to provide technical assistance and information to Maine's fishing industry, and to serve as a liaison between the industry, marine researchers, government agencies, and the general public. Extension Service headquarters is at the department's research facility in Boothbay Harbor.

Extension agents, working directly with the fishing industry, cover the entire Maine coast. DMR agents have undertaken projects to assist the industry by solving practical problems, identifying and encouraging the use of underutilized species, and improving information flow among all those involved with the harvesting, processing, and managing of Maine's marine resources.

Extension personnel have continued efforts to establish an ocean quahog fishery in Maine as an alternative for the state's fishermen. Previously, extension personnel had developed and refined a hydraulic skimmer dredge suitable for use by Maine boats to harvest ocean quahogs and surf clams. In 1979, three Maine processors expressed interest in producing minced and stuffed ocean quahog products, and extension personnel are now working with these processors and with a commercial quahog harvester on a proposal to fund a pilot quahog processing and marketing operation.

Technical assistance on two-boat trawling techniques for adult herring continued to be provided to the Maine fishing fleet operating out of Gloucester, Massachusetts. A report was prepared with maps showing locations of catches and observations off the Massachusetts coast. An extension agent from the Virginia Institute of Marine Science was also trained by a DMR counterpart to introduce two-boat trawls to Virginia waters.

The DMR vessel RV *Explorer* and its crew were used as support for a number of research projects in 1979. During the winter, shrimp larvae survey tows were made in the Sheepscot River, and three trips were taken to Monhegan to collect bottom samples for paralytic shellfish poison research being conducted at Bigelow Laboratory for Ocean Sciences. The *Explorer* conducted a groundfish survey from Saco Bay to Sheepscot Bay during April and May, and then spent six weeks tagging groundfish in the Sheepscot Bay area, in support of the groundfish assessment program.

Other support activities carried out by the *Explorer* included the setting and monitoring of a temperature buoy in Sheepscot Bay as part of the shrimp research project, and serving as a support vessel for the DMR dive team which tagged and monitored lobster and scallop populations.

Extension personnel on the RV *Explorer* also began an extensive survey of fishery resources in Penobscot Bay. Emphasis was placed on monitoring the abundance of flatfish and of the shrimp *Pandalus montagui*. The abundance and movements of oversize lobsters were monitored by the use of large fish pots. A survey of 18 large alewife runs in Hancock and Washington counties was carried out in the spring, and management problems were discussed with the alewife harvesters.

Face-to-face conversation with commercial fishermen provides the foundation for much extension work. In 1979, as part of their quality assurance planning, the DMR interviewed fishermen on methods of improving the quality of fish products. Both fishermen and processors contributed to a report describing the status and future of the whiting industry. Further interviews with fishermen provided information on problems associated with monofilament gillnets, and a proposal was written to study the effects of such nets on the industry.

The DMR Extension Service also carried out a number of small projects in 1979, including gillnetting for bait fish, assistance in the development of a proposal to evaluate the sea urchin industry, and participation in an advisory agent workshop in New Hampshire. Agents compiled catch observations aboard commercial

vessels, mussel harvesting and quality data for use in future management plans, and available information on long line fishing equipment in anticipation of increased future use.

## New Hampshire Marine Advisory Program

The purpose of the Marine Advisory Program (MAP) is to develop, implement and evaluate informal education and informational activities which will assist New Hampshire's coastal resource users, government officials and citizens in making informed decisions regarding the use and allocation of our state's marine resources. Marine Advisory staff serve as the link between the university and the community. Programs and activities are designed for specific audiences. The program staff are also responsible for identifying problems related to New Hampshire's marine resources, and communicating this information to university researchers for possible study or solution.

During the past year extension and public education programs have continued to grow and mature. The spring Odiorne Point Interpretive Marine Education Program served more than 100 schools; 4,000 school age students participated in the Odiorne experience, yet many requests had to go unfilled. To help alleviate this pressure, 18 marine docents (community volunteers trained by UNH faculty and staff in marine-related topics) worked with education specialists in the Odiorne program. Originally, the spring Odiorne program was designed for grades 1-6. Again, because of the tremendous response from area schools, it was redesigned and is now offered to all schools, K-12. The summer marine education programs at Odiorne have also experienced significant growth. Last year more than 2,000 persons representing the general public, non-school groups and community organizations participated in such programs as tidal pool tours and the natural/social history of New Hampshire's coastal areas.

The Marine Docent Program itself is contributing greatly to our marine education outreach efforts. In 1979 30 trained and qualified docents presented 200 programs to more than 7,000 people.

In a different dimension of the Advisory Program's activity, a Sea Grant-supported study, initiated through the MAP showed the benefits of shipping imported containerized cargo, destined for northeastern US markets, to the port of Portsmouth rather than trucking overland from Halifax. This has resulted in an annual benefit to the New Hampshire economy of $7.5 million, in addition to the saving realized by shippers and customers.

And the MAP worked to assist New Hampshire's commercial fishermen. For many years all fish landed in Portsmouth were sent to market in Boston via independent trucking companies. Fishermen depended upon these trucking companies for preserving the freshness of the catch and paying the fishermen soon after trucks returned from market. Spurred by lack of adequate trucking facilities and late payments, a group of New Hampshire and southern Maine commercial fishermen decided to explore the possibility of setting up their own fisheries cooperative. Responding to this need, the MAP supported a study and part-time agent to explore the financial, legal and business aspects of establishing such a venture. As a result of the study, 14 commercial fishermen contributed $1,000 each to establish the Portsmouth Fisheries Cooperative in the fall of 1979.

The marine communication and information program at UNH was an administrative part of the Marine Advisory Program at the beginning of 1979. During that year, however, it was determined that the information coordinator should report directly to the Director of the Marine and Sea Grant Programs. This change was made to reflect the breadth of support provided by the communication and information program. The change in no way diminished the connection between the MAP and communication programs, since communication of research and other information to user groups was still seen as a primary responsibility.

During 1979 the Marine Program bi-monthly newsletter *Windward* was established and published regularly. It was targeted toward four audiences: educators, researchers, commercial fishermen, and persons interested in coastal management, plus, of course, the general public.

A series of public service announcements, "Coastal Issues" was produced and distributed. The Information Coordinator served on a committee of New England Sea Grant Directors and representatives of the New England Marine Advisory Service (NEMAS) to analyze information needs of commercial fishermen in the region. The recommendations of that committee resulted establishment of a Fisheries Communicator, funded through NEMAS, administratively connected to the UNH Sea Grant Program. The Communication and Information Program also carried out a wide range of projects designed to carry information to the scientific community as *well* as the general public, often in cooperation with regional and National Sea Grant communication networks.

## 1979 BUDGET SUMMARY

| PROJECTS | SEA GRANT FUNDS | MATCHING FUNDS | STATUS* |
|---|---|---|---|
| The Neglected Sand Launce — an underutilized species<br>R.M. Smith | 55,543 | 22,165 | N |
| Herring Genealogy<br>I.L. Kornfield, D. Sidell | 33,934 | 30,841 | N |
| Down the Food Chain<br>D. Dean | 18,879 | 32,158 | N |
| Biography of a Bivalve<br>L. Watling et. al. | 50,000 | 3,590 | N |
| Low Cholesterol Lobsters<br>R.C. Bayer | 14,981 | 7,531 | F |
| Gaffkemia Vaccination System<br>K.I. Mumme, R.C. Bayer | 16,258 | 9,325 | N |
| The Scourge of Salmonids<br>B.L. Nicholson | 22,794 | 19,062 | N |
| Mechanized Oystering<br>J.G. Riley | 48,057 | 29,893 | F |
| Hybrid Vigor<br>A.C. Mathieson, D.P. Cheney | 45,831 | 14,714 | C |
| Carrageenan and Cancer<br>T.W. Wight, E.T. Gallagher | 41,091 | 9,872 | N |
| Storm Runoff<br>P.L. Bishop, Y. Chu | 13,604 | 6,983 | N/F |
| Trace Metals<br>H.E. Gaudette | 29,383 | 13,447 | F |
| Radionuclides<br>C.T. Hess, C.W. Smith | 40,668 | 29,108 | F |
| Point Sources<br>B.R. Pearce | 16,371 | 13,886 | F |
| The Struggle for Living Space<br>L.G. Harris | 10,260 | 8,886 | N |
| Remnants of Things Past<br>C.E. Bolian | 23,768 | 22,818 | N/F |
| Northern New England Marine Education Project<br>J.W. Butzow | 34,881 | 11,883 | F |
| Seacoast Science and Our Maritime Heritage<br>M.D. Andrew, E.T. Milliken | 29,200 | 26,046 | F |
| The Ocean Projects Course<br>J.B. Murdoch | 34,268 | 31,953 | C |
| Maine MAP<br>R.K. Dearborn | 166,688 | 39,157 | C |
| Fisheries Technology<br>K.A. Honey | 75,000 | 37,500 | C |
| New Hampshire MAP<br>B.A. Miller, L.F. Eklund, J.M. Steed | 125,964 | 37,472 | C |

*N=new project
C=continuing project
F =final year of project