SEA GRANT

University of New Hampshire/University of Maine
Sea Grant College Program

SEA GRANT

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Sea Grant is the biennial report of the UNH/UME Sea Grant College Program for the period 1981-1982 under Grant #NA-81AA-D-00035 as required by the Office of Sea Grant, National Oceanographic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C.

UNHMP-AR-SG-85-14

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The Cover: *"Oarweed, Sea Colander, Starfish and Moonsnails," a watercolor by Wendy Turner, Kittery Point, Maine. From a private collection.*

THE MARINE PERSPECTIVE

New approaches to the study of the oceans are forging links between traditional academic disciplines, and are encouraging a spirit of cooperation in marine research. This "new oceanography" provides such flexibility and breadth of expertise that it might serve as a valuable model as universities seek solutions to the great problems facing society today.

In marine research this cross-linking of disciplines has led to major scientific discoveries, with the promise of more to come. In New England, for instance, biologists, chemists, oceanographers, geologists, engineers and others hope to determine why the area off our coast is one of the world's richest fishing grounds. UNH and UME researchers are involved, contributing information about water circulation and temperature patterns, water chemistry, and other factors influencing the productivity of the region.

The plentiful existence of marine resources in our region leads to disparate aspirations for their use, and differing viewpoints often result in conflict. The U.S.-Canadian boundary dispute off the coast of Maine, controversy over construction of the Seabrook Nuclear Power Plant in the Hampton estuary, lawsuits pitting fishing interests against those promoting offshore oil exploration, and the complex management schemes for the New England fishery, all illustrate this clash of conflicting interests.

To use Gulf of Maine waters wisely requires a full understanding of the ocean, its processes and resources. Our increasing reliance on the ocean and its resources will ultimately require broad public knowledge and understanding of this environment. As a Sea Grant College Program, the Universities of New Hampshire and Maine have an obligation to achieve the highest level of excellence in marine research, and also in marine education and public service.

The challenge is an exciting one, and the prospects for development of various marine resources are equally exciting.

- Three quarters of the sun's energy reaching the earth, rains on the oceans. Can it be harnessed from conversion waves, currents, thermal difference, salinity differences, or from the biomasses?
- What is the meaning of chemosynthesis? Does it give new clues to the origins of life?
- Over 99% percent of the globe's water is in the oceans and the ice caps. Can it be made economically available to reduce the world's critical water supply problems?
- Are the ocean basins or the deep ocean geological structures stable enough to accept the 13,000 cubic meters of nuclear waste the world will generate in the year 2000?
- Can we truly farm the sea as we now hunt it? Can we domesticate its species as we have terrestrial species?
- What of pharmaceuticals? Some now come from the sea, more will probably follow.

Possibilities go on and on. The educational milieu provided by this environment and the opportunities for collaboration that exist between disciplines is unique. Cooperative research, the inter-connecting of fundamental science to enhance understanding of complex problems in the ocean, and the embracing of the totality of the "new oceanography" augurs well for the future of the marine science programs at UNH and UME.

A statement prepared by the National Association of State Universities and Land Grant Colleges on the role of marine programs in higher education sums it up well:

"Using the oceans . . . intelligently, is one of the great challenges of this age. Marine food, energy, minerals, transportation and recreation as well as the preservation of the marine environment are increasingly accepted as a necessary part of our future, but we need to educate ourselves if we are to derive maximum benefits of the sea."

Pedro De Alba wants to help oil companies maintain a sure footing. That's why his recent Sea Grant research investigated the result of overload on sand when it is subjected to earthquakes and violent wave action.

What can happen is liquefaction, a process that is over in seconds, but which can leave incredible disaster in its wake. It starts when vibration forces the sand grains closer together. As the sand tries to compress, water pressure in the voids between the grains increases. The water tries to flow, but — at first — it can't. The pressure increases. Eventually, the grains are forced apart, leaving nothing but water. Whatever has been resting on that sand, whether oil rig or pier foundation, no longer has anything to support it. The next step is collapse.

The problem has been how to get accurate underwater sand samples to run lab tests for liquefaction potential. The minute a core sample is taken, the natural deposit's unique characteristics — its stress history and its grain structure or fabric — are destroyed, and there is no way to reconstitute them correctly in the laboratory.

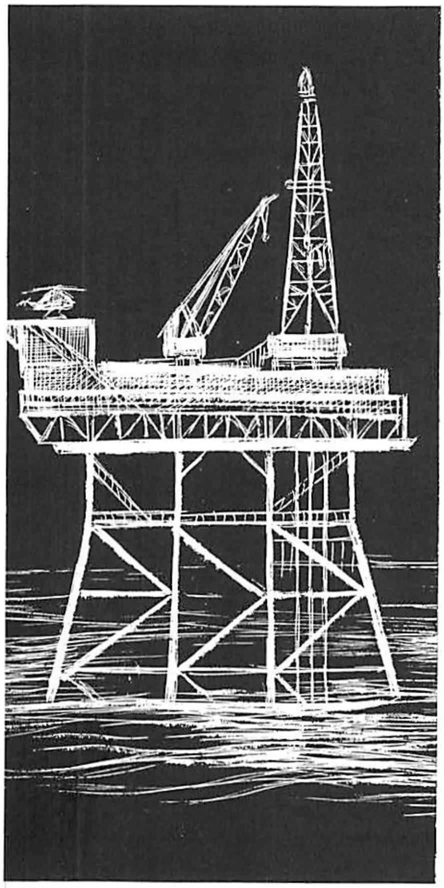
"With granular soils, soils that don't have cohesion, that don't stay together, you can't just scoop them out and then try to rebuild them in the lab. There are some built-in effects that are proper to the material, the way sand is in the field. You lose all of that by any of the standard techniques used in foundation engineering."

De Alba theorized, however, that the speeds at which acoustic waves travel through sand and the varying oscillation patterns they form would correspond to fabric differences within the sands. "Our premise was that we could measure these acoustical patterns, take sand samples back, and reconstitute them in such a way that we could get back the same elastic wave transmission properties that were there originally. Then, we hypothesized, we would also get back the mechanical properties we were actually trying to measure."

De Alba's premise is a premise no longer. His three-year Sea Grant project did indeed prove that sand fabrics can be identified by acoustical signatures, each as individual as a fingerprint.

Using a small triaxial testing chamber, De Alba has sent compression and shear waves through sand samples and recorded the resulting "finger prints." Each specimen was then subjected to cyclic load from a piston, a process which simulates earthquake action and which continues until liquefaction failure results. The data achieved correlates the degree of resistance with the type of sand fabric.

The project has implications beyond the laboratory success. As De Alba explains, "We were concerned with the design of foundations for oil production platforms in the Gulf of Maine. The Georges Bank area is essentially a huge sandbank and potentially subject to earthquake damage from liquefaction. The long-range goal is to develop a field tool that will go down a standard drillpipe to take acoustic measurements and sand samples for further lab testing." Development of such a tool would enable oil companies to predict ocean-bottom areas susceptible to liquefaction. They would then have the option of moving the platform away from trouble spots to areas with more liquefaction resistance.



"Drillpipes traditionally have to be extremely stout because they get all kinds of banging around . . . They really can NOT be delicate."

The transducers were designed by Kenneth Baldwin while a PhD candidate at the University of Rhode Island. Now an assistant professor in the mechanical engineering department at UNH, Baldwin devised transducers that De Alba describes as "if not unique, at least highly unusual."

"We're producing two kinds of acoustical waves — shear waves and compression waves — in the same transducer. Ken has now taken the same design and made it even smaller to fit in a field tool about 3½ inches in diameter. He's also made it more rugged to take the abuse it's likely to get.

"Drillpipes traditionally have to be extremely stout because they get all kinds of banging around. They're thrown down onto the drill floor and they're beaten on with wrenches. The whole process of putting the thing into the ground is one which involves a lot of vibration. They really can NOT be delicate. So this is one of the things we're working on, trying to make this thing damage-proof to the extent we can.

"When we're finished, we're going to test this at a site on land. We'll no doubt break it up the first time, but we'll just keep bringing it back until it doesn't break anymore. Then we'll be ready to try it offshore where things are even worse.

"The standard drillpipe has a bit on the end of it which just churns away. It's hollow, and we plan to drop our field tool down inside. Our tool will come out the bit end, take measurements, and be retrieved up the pipe. Then the drill will continue to advance downward, perhaps at ten foot intervals, so that we can conduct tests at different levels of the first 100 feet of the seabed. The whole operation is rather tricky. Sometimes tools

Liquefaction can also be caused by the rocking of a heavy offshore structure during a storm or by the effect of violent wave action on the seabed.

jam down the string and practically the only way to get them back is essentially to destroy them. So there's a good chance that we'll lose one or two at sea."

How acute is the liquefaction danger in the Gulf of Maine? Unlike the Pacific Coast, New England has no sustained pattern of earthquakes. The most significant occurrence was in 1752 in Cape Ann, Massachusetts. Even then, says De Alba, there were indications of liquefaction. Reports from the period speak of "sand boils," mini-volcanos that erupt on the earth's surface when granular materials try to flow after quake overloading.

The UNH professor notes that the very lack of minor quakes in New England may make Georges Bank even more a prime candidate for liquefaction. His research showed that although liquefaction failure could eventually be induced in all the sands tested, those which resisted the longest were those with a fabric history of repeated minor stresses. He adds that liquefaction can also be caused by the rocking of a heavy offshore structure during a storm or by the effect of violent wave action on the seabed.

Although his Sea Grant funding for this project has ended, De Alba's liquefaction research has not. He and Baldwin think they have overcome the problems of drillpipe interference by siting the transducer source out from the side of the pipe. They plan to construct their miniaturized prototype shortly and are looking for possible funding from oil companies., Ironically, research into stabilization of oil platforms may be hindered by the current stabilization of oil prices. "With the price of oil the way it is," says De Alba, "people are being very timid about investing." ■

MARINE HISTORY

Thanks to modern technology, marine archaeologists now have the ability to electronically scan the seabed and record the anomalies appearing there. But, they've found, a bump on the bottom of the ocean isn't always a shipwreck. Instead, such a blip may prove to be something as mundane as a Glenwood kitchen range.

David Switzer is a professor of history at New Hampshire's Plymouth State College. In a Sea Grant-funded, remote sensing survey of the Piscataqua River Basin, he and his team chalked up "discoveries" in both categories.

The researchers had hoped to find remnants of New England's cultural history. The Piscataqua River where the survey took place has a rich maritime history that goes back to the seventeenth century. Fishing fleets sailed out in search of silvery harvests of cod. European vessels docked in the busy ports to unload goods for the colonists. Unwieldly river gundalows pushed their way up the Great Bay estuary with loads of brick and other cargo. Along the shores of Portsmouth and Kittery, the hammers resounded, building America's first ships for trade and revolution.

During the remote sensing phase of the survey carried out in 1980, numerous "hits" were recorded. Based on Jane Hunt-Brackett's research into old customs records, newspapers, and early maps, it was determined that eighteen of these warranted further investigation. As designed by the Kittery Historical and Naval Museum, the project was to investigate not only

"The visibility is low there, the currents are extremely high."

wrecks but other submerged historical/cultural areas as well. These included shipyards, anchorages, bridges, as well as submerged historic and prehistoric terrestrial sites.

To do so, Switzer's team relied on three types of remote-sensing gear: side scan sonar, a magnetometer, and a sub-bottom profiler. One of the team members, Charles Mazel, then a graduate student in the University of New Hampshire's ocean engineer-

ing program, also devised a navigational control system that allowed them to correlate the boat position with site discoveries.

In an article for the *INA Newsletter* published by the Institute of Nautical Archaeology, Switzer described the system:

> Position plots were recorded at one-minute intervals during survey runs. Constant triangulation information was provided by two Cubic Auto Tape 'interrogators,' each of which received signals transmitted from a shore-based responder. These signals were converted into digitally displayed metric distances. At the sound of a buzzer set to indicate one-minute intervals, the plotter marked the boat position (on an x-y grid); and the 'event record' was noted on the sonar, magnetometer, and sub-bottom profiler displays at the same time.

"The navigational system was fantastically accurate," notes Switzer, "it enabled us to place dive buoys close to the anomalies. But when it came time to investigate targets, they turned out to be disappointing."

An early disappointment was off the Isles of Shoals. A hurricane was reputed to have destroyed an entire fishing fleet in Gosport Harbor in the mid-1700s. No evidence of it remained when the Sea Grant researchers (who were also funded by the State Historic Preservation Offices of Maine and New Hampshire) visually inspected areas where hits had been recorded in 1980. "The bottom was completely barren," says Switzer. He surmises that the area had probably been dredged in the nineteenth century when a breakwater was built between Starr and Cedar Islands. Further offshore, between Starr and Lunging Island, was more disappointment. There, strong magnetometer hits proved to be a load of iron pipe, a truck chassis, oil drums, and a 1930s Glenwood range.

The electronic gear, while accurate in detecting bumps in the sediment or the presence of ferrous material, proved to lack the discernment necessary to distinguish between cookstoves and cannons. Time and again, sites that hinted of cultural resources yielded only non-significant debris or large boulders. In one instance, a tangle of underwater grasses reflected a misleading blip on the sonar readout.

Balancing these frustrating finds was the discovery of what could be an important eighteenth century American shipwreck and the ruins of the longest wooden arch bridge ever built in the United States.

Up in the northern part of Great Bay, sonar confirmed the existence of what historical records indicated was a 2600 foot long bridge with an unsupported arch of over 200 feet. Built by Timothy Palmer in 1794, the Piscataqua Bridge, the longest wooden bridge in America, was an engineering marvel that was eventually carried away by ice floes in 1855. And there on the screen was evidence of its timbers, "strewn in jackstraw fashion, but in a relatively straight line."

There are only five known examples of 18th century American ship construction. Hart's Cove may make six.

"The visibility is low there, the currents are extremely high. There's only a short time at high and low tide when we have a 'window' to be able to check out the remains." Nevertheless, Switzer and team members Warren Reiss and Quentin Blaine did make one dive, accompanied by members of the Underwater Research class at the University of New Hampshire. The dive confirmed the remains of pilings and the presence of "huge, square-sawn timbers exceeding twenty-five feet in length."

Detailed documentation will have to wait, however. Although Sea Grant funding ended in 1981, the N. H. Historic Preservation Office was sufficiently impressed with project results to continue funding into 1982. Swimming circle searches, team divers continued their check of previously recorded anomalies. In Hart's Cove, New Castle, the searches began to pay off. "We found eighteenth century bottles as well as ceramic material of the same period." Lots of pipes turned up "with definite seventeenth century characteristics." The top of an Iberian storage jar dating from the early 1700s was found along with two North Devon stoneware plates. Dating from the late seventeenth century, the plates bore sgraffito designs — on one a stylized bird, on the other a tulip.

As important as the small finds was the discovery of a small shipwreck. Pieces of coral near the partially imbedded structure, possibly ballast, suggest that the vessel may have been employed in the lucrative West Indies Trade.

In 1983 the team was granted a permit from the New Hampshire State Historic Preservation Office to carry out a more detailed survey of the Hart's Cove wreck site with particular emphasis on documenting the structural remains. The area surrounding the wreck was found to be heavily dug over by "pot hunters" and the exposed structure badly deteriorated. Switzer believes, at this stage, that the small vessel (35-40 feet long) was American, indeed locally constructed. Structural details suggest at least eighteenth century origin. Following the survey, the site was reburied to preserve the integrity of the intact structure.

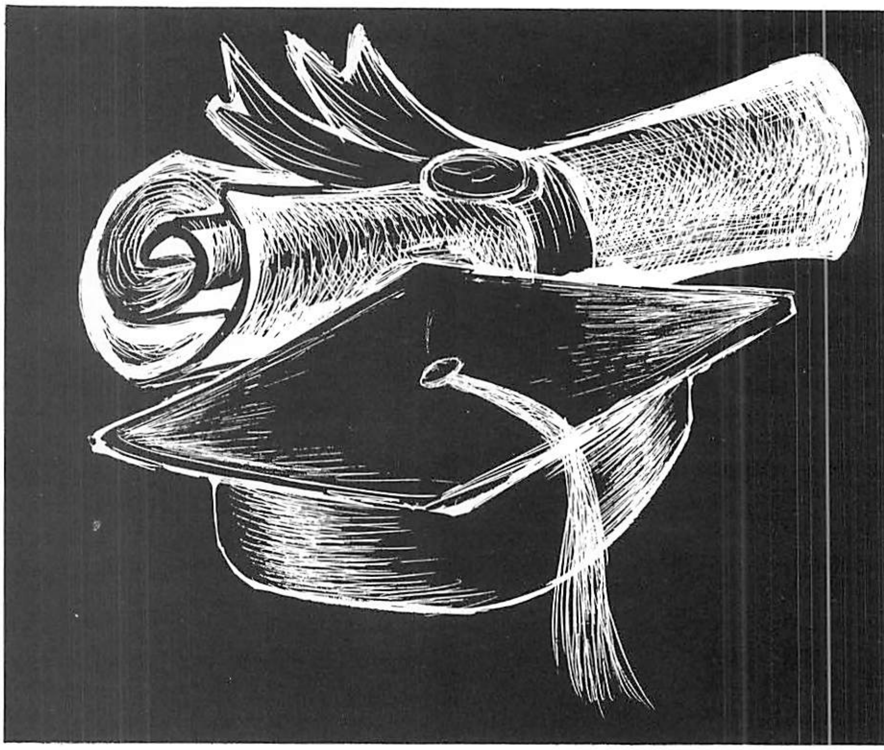
The team has made tentative plans to return, clear the site further, and take swim-over shots with a wide-angle lens to develop a photo montage of the wreck. They particularly want to look at and further document the vessel's peculiar construction where the frames (or ribs) meet the keel.

The find is significant and overshadows even the excitement of Palmer's Piscataqua Bridge. "There are only five known existing examples of American ship construction dating from the eighteenth century," Switzer explains. "Each represents a different type of ship construction."

Although the Hart's Cove vessel might be considered the Volkswagen of its day, its mere existence could add considerably to American nautical history. "They built by eye a great deal, so there aren't many plans left from that period," says Switzer. "Our knowledge of shipbuilding in eighteenth century America is the tip of an iceberg." As he and his team excavate their little Piscataqua River Basin vessel, they will be uncovering that iceberg yet another inch or two. ■

• Does *Aeolidia*, a creature that one student describes as "a snail without a shell," feed mainly at night to avoid predation?
• Will salmon, migrating upstream to spawn, be diverted by acid rain?
• What do lobsters prefer to eat, and will they feed in offshore areas which have been denuded of kelp by sea urchins?

These questions seem to share no common thread, no interconnection. Yet thanks to the 1981-82 winners of the Sea Grant-sponsored Ocean Projects course — an undergraduate course designed to give students practical experience solving research problems — researchers may begin to answer these questions and more.



The '81-'82 Ocean Projects team's advisor, Winsor Watson of the University of New Hampshire's department of zoology, is a neurobiologist interested in the cellular basis of behavior. He has found that nudibranchs such as *Aeolidia* have simple nervous systems particularly well-suited to comparison with the activity of single, identifiable neurons. In an attempt to determine whether the nudibranch was phototaxic, or light sensitive, a student of Watson's had been making hourly drawings of numerous *Aeolidia* and their changing positions in relation to a light source. The work was time-consuming; the data was intriguing but of insufficient quantity to be conclusive; the research intrusion may have been affecting the animals' behavior.

BAMA, "Behavioral Analysis of Marine Animals," solved all these problems. The project centered on an experimental tank with four light sources, programmed to activate individually at specific intervals. A time-lapse camera placed over the test chamber recorded the animal's position every minute, for sixty hours at a time. The resulting film was then projected onto an Apple graphics tablet. By touching the projected images with an "electric pen," the researcher could enter the position of the animal in terms of its exact x-y coordinates directly into the computer.

Watson sees the Ocean Projects course as a critically needed supplement to more traditional academic approaches. "Students are craving hands-on experience at this point in their careers. They need a taste of the real world."

The premise is one with which student-participant John Langley wholeheartedly agrees. When it comes to computers he says, "You don't learn just by reading in a book — you learn by making mistakes."

Ocean Projects coordinator D. Allan Waterfield says that Langley's enthusiasm is typical of those who take part in the practical Sea Grant course. "Each student team defines its problem; prepares and submits a budget; engages in dialogue with experts in the ocean community; designs, builds and tests prototye models or gathers scientific, historical or attitudinal data; makes interim oral reports; prepares a comprehensive final written report; and defends its results before a jury of experts drawn from the ocean community. Many past participants have gone on to become employed by such marine-related organizations as Seaward International, Exxon, the Portsmouth Naval Shipyard, Ocean Research Equipment, the U.S. Navy, Woods Hole Oceanographic Institution, and Normandeau Associates."

Ocean Projects is not the only UNH/UME Sea Grant effort aimed at undergraduates. An investigation into undergraduate marine opportunities at the Orono campus resulted in the development of two new marine courses and the establishment of a minor in marine resources within the College of Life Sciences and Agriculture.

Similarly, a Marine Studies Program coordinated through the New Hampshire College and University Council helped increase marine literacy among the some 31,000 students enrolled in NHCUC member institutions, most of them located at inland sites away from the coast.

Headed by Richard Fralick of Plymouth State College, the program developed a resource information manual for NHCUC marine faculty, implemented a model marine studies minor at Plymouth, and sponsored annual marine symposiums for faculty and students. Topics at the initial symposium ranged from a look at the Law of the Sea Treaty to a discussion by Dr. Ruth Turner of Harvard on the role ship-boring molluscs play in the breakdown of the hundreds of tons of wood washed into the world's oceans daily. ■

Fish piers and processing plants. Salmon ranches and coastal gravel mining. Marinas and tourist beaches. Oil refineries and power plants. Naval installations and boatbuilding facilities. Lighthouses and historic forts. Marine research laboratories and upriver pulp mills. Year-round residents and summer visitors. Commercial lobstermen and sport fishermen.

The uses and users — both present and potential — of coastal New England are overwhelming. That's why a team from the Northern New England Marine Education Project, under the direction of the University of Maine's John Butzow, decided to develop a special education unit to help adults better understand the conflicting demands on the Gulf of Maine.

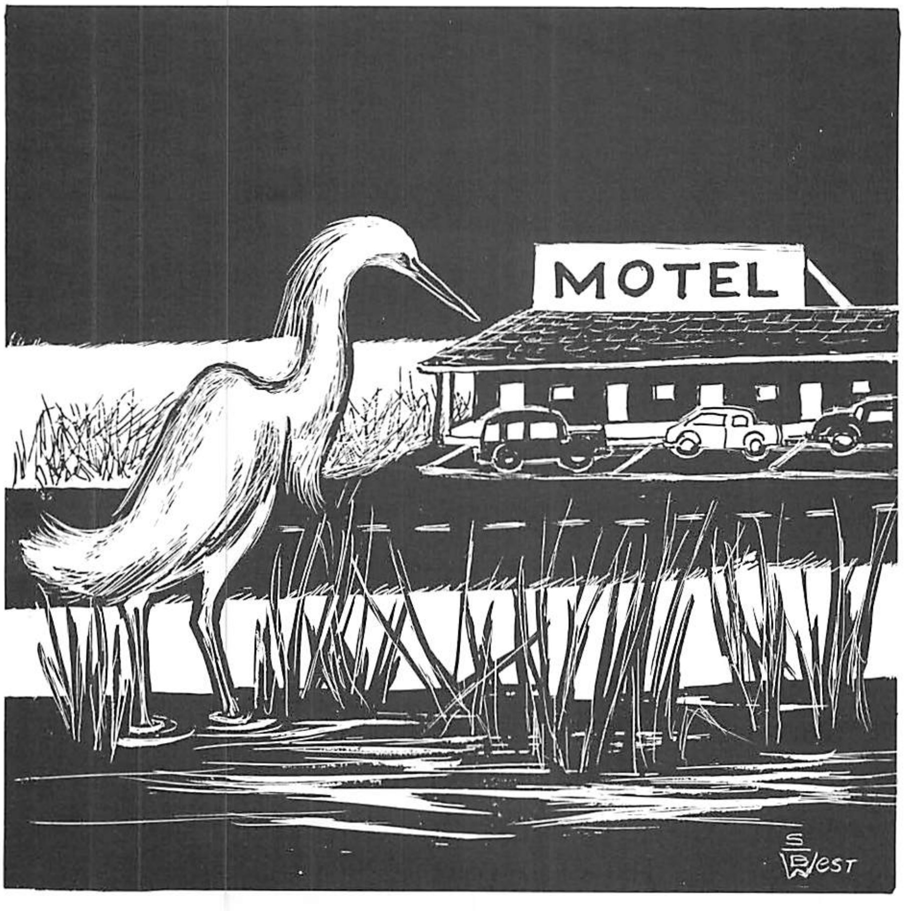
The guide, "What is our Coastal Future?" is designed primarily for use by informal adult education groups and is projected to encompass a flexible number of two-hour meetings. It is set up so that an instructor need not have an extensive background in oceanography or coastal issues and so that simple, everyday objects — from basketballs to milk cartons of sand — can be used to improvise laboratory experiments.

In the guide's foreword, Butzow notes: "The general focus within this project has been the Gulf of Maine. As the Gulf extends from Cape Cod to Nova Scotia, it washes an extremely long and varied coast. We have dredged and seined themes from the activities, concerns, organisms, vessels, and the past of this vast watery region of North America. We aim to be inclusive rather than exclusive . . . stimulating rather than expert. Our hope is that your students will become more questioning, interested, and critical of watery concerns. We hope your use of these materials will add water back into our culture."

In Maine and New Hampshire, strong home-rule procedures coupled with highly participatory local government make public understanding of the issues and opportunities facing communities particularly important. Thus, another facet of the Sea Grant "Preparation for Decision-Making" project has been the development of instructional television programs for a general adult audience.

"So far, a 30-minute video has been designed, produced, and field-tested on samples of adults from both coastal and inland locations in Maine. Approximately 300 research subjects completed pre- and post-viewing questionnaires and semantic differential attitude scales focused on the Gulf of Maine. The program, entitled 'The Gulf of Maine — A Sea Beside a Sea' describes many areas of concern and issues about the Gulf of Maine from the point of view of the ordinary citizen.

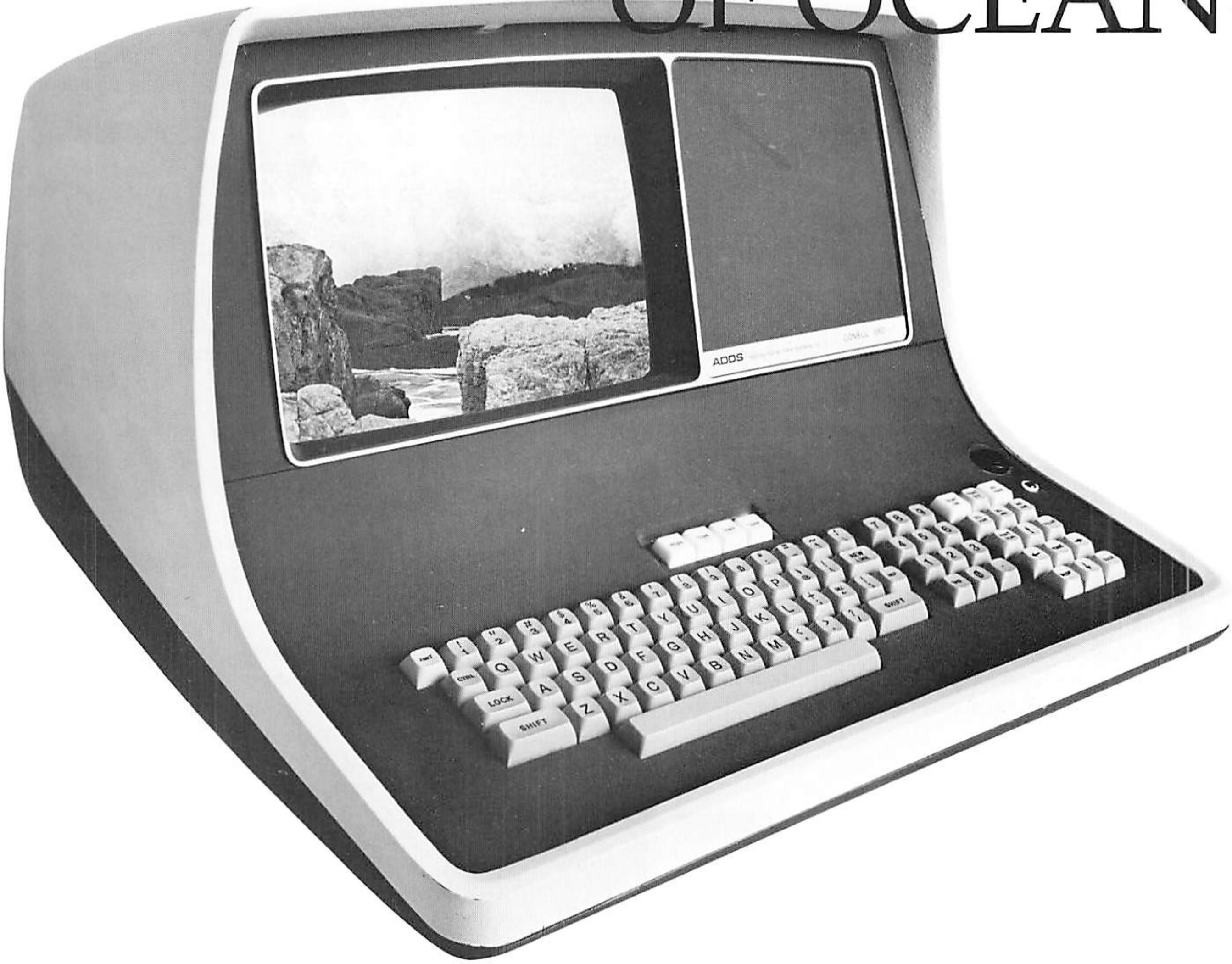
"A graduate student is concluding his dissertation on this first video, and the results of the sample viewers' attitudes are being used as design input for a second video, 'Fish and Fisheries of the Gulf of Maine.' At present, the working ideas indicate that the program will deal with the fishing industry from a broad context and will especially emphasize the economics of the industry as it relates to the state and the consumer."



And as if this weren't enough, Butzow and his team worked with UME's College of Education and the Maine Department of Marine Resources to offer a three-week workshop for 22 teachers during the summer of 1982. Emphasizing both the scientific and social side of marine studies, the course built on the middle school (fifth through ninth grade) infusion units that the Northern New England Marine Education Project developed. Lectures, laboratory work, and field trips ranged from a study of the history and ecology of the Penobscot estuary to such topics as maritime shipping, fisheries biology, beach geology, and marine literature.

Such projects can't help but raise the marine literacy level and allow coastal citizens to develop not only an appreciation of the Gulf of Maine's "beauty and bounty" but also a better understanding of human impact on its resources. ■

OF OCEANS



It was the kind of encounter from which cartoons are made.

There was Bryan Pearce from the University of Maine's civil engineering department. Confronting him was a weathered local resident, laconically asking, "Whatcha doin'?"

Pearce explained that he was setting up tide gauges which he hoped would give him data useful in eventually determining the currents in that part of Penobscot Bay. The native's response was predictably terse.

"Whatcha wanta do that for? Ya can't change 'em none, can ya?"

& ESTUARIES

Pearce ruefully admits that, no, he can't change the ocean processes he's been studying under Sea Grant. But by changing mounds of computer data he has collected into accessible form, he is providing valuable predictive information for everyone from commercial fishermen caught in a Gulf of Maine storm to environmental clean-up crews trying to track the path of pollutants in an estuary.

One of Pearce's projects, an assessment of estuarine flow regimes, was actually triggered by a fellow Sea Grant researcher's work on how eel larvae worked their way up rivers into the estuaries against tremendous spring tides. He realized that his own interest in "numerical simulation of currents and tides" would mesh with the needs of biologists. With computer modeling, Pearce hoped to use raw data developed by the National Ocean Survey on currents in Penobscot Bay to develop a circulation model that could predict transport in other estuarine systems.

"We were interested in residual currents that move at rates of kilometers per *day* rather than kilometers per hour. It's much easier to predict the larger tidal current rates ... but we put most of our effort into the net drift because that was related to the transport of eel larvae, fish eggs and pollutants. The idea was to come up with a mechanism where we could go in and answer the question, 'If you put something here, where would it go?'"

Pearce and a graduate student, Adrian Humphreys, created a grid system to simulate Penobscot Bay's convoluted geography, then fed in numbers representing available data on currents, winds, tides, and river discharge, all within given time frames. As Pearce notes, "Murphy's Law" was at work in this early phase of the project. The one year — 1970 — that the existing NOS data seemed most complete turned out to be the year that the Coast Guard station at Rockland didn't have wind data for correlation. Fortunately, the gaps were filled with information kept by lighthouse personnel at Matinicus.

A must for the researchers was to create a model with a vertical variation of currents. "Treating a system the same at the top and bottom just won't work," Pearce says. "In the real world, the top goes one way, the bottom goes somewhere else." The concept is particularly important for tracking pollutant spills. Indicating Sears Island on a map, Pearce notes that with Penobscot's residual currents, "The flow is out at the surface and it comes back underneath. If you dumped something down below, in fact, it would come back upstream."

The winds are an important factor in the circulation of the bay, but ultimately, density gradients caused by the fresh water input from the Penobscot River proved to be crucial to designing an appropriate computer model.

"One of the things we were trying to do was to see if we could get the winds to generate the kind of circulations we saw ... and we couldn't. That was a fairly big part of this study. Then, the next step was to add densities. We put a scheme together where we showed that the numerical vertical model *could*, in effect, predict this behavior."

The Penobscot estuary is hydrodynamically complex enough, Pearce says, to warrant further modeling and data analysis. Already his work with Humphreys has been cited by the *Review of Geophysics* after presentation at Oceans '81. But ironically, one impetus of the project — the hope to provide collaborative data in the study of eel larvae transport — proved fruitless.

"We had intended to work on down into the bay," biologist James McCleave explains. "But when we went down there and fished our gear, we found that the eels were so rare, we couldn't get any numbers that would allow us to do anything. And up in the area of the river where we ended up working, there was none of that geodetic survey data available. So our projects that were originally going to overlap for part of our study areas were forced to part."

Though the estuarine flow regime study was not able to help the eel larvae project, the information that was obtained *will* prove useful to Maine's Department of Environmental Protection and to state planners. And while the data is being refined and disseminated, Pearce has turned his attention to deeper matters.

Moving out from Maine's rugged coast, Pearce and a graduate student, Vijay Panchang, have been working with UMO mathematician Kewal Puri on wave climates in the Gulf of Maine. "What we did the first year," Pearce explains, "was to calculate storm-generated waves, design waves, what the jargon calls 'The 100-year wave.' In other words you get a wave that high or higher about once in a hundred years."

The researchers used a parametric model, incorporating data on major storms that had taken place in the area over the past thirty-two years. "We took the twenty-two strongest Nor'easters and ran all twenty-two through our wave model. Then we took the highest wave at each big point and used *that* to come up with probability distribution for the waves. We extrapolated from there to find the fifty and 100 year wave heights."

An important factor in the work was the significant wave height, the average of the highest one-third of the waves. "Say you have a train of 1,000 or 10,000 waves, which is the number of waves you might expect in a storm. There's a wave coming by every ten seconds for a day or two, roughly. If you have that, then statistically it turns out that the highest wave in that group is about twice as high as the significant wave height. That means that the significant wave height, which is thirty-five feet, more or less, all of a sudden turns into a seventy-foot wave. And if you're out there in one of those bad storms. . ."

The importance of this research was acknowledged twice in 1983. Not only did Panchang, a doctoral civil engineering student from India, win a national Sea Grant Association award, but he was also chosen as the 1983 recipient of a scholarship from the American Oceanic Organization.

Now in its second phase, Pearce's Sea Grant research has moved coastward again to study wave climates in Penobscot Bay.

"Maine's got 4000 miles of coastline with islands, bays, and inlets. There are a lot of little nooks and crannies where nobody knows what the waves are. Typically, the method (used to find out) is to look at the waves offshore and follow them inshore with what they call wave tracers. But when the waves cross — and they're bound to with thousands of islands — then what do you do? The conventional processes break down. What we've been working on is a model using combined refraction, which is bending, and defraction, which is scattering, along with local generation."

There is a sticking point, however. Unlike the dramatic offshore storm-wave measurements which were available from NOAA, localized wave measurements against which to check the model don't presently exist. So Pearce is seeking funding for a remote sensing device that would allow him to set up the equipment, say on Islesboro, and estimate the wave heights "within a fairly small length scale, say somewhere in the order of ten miles."

Meanwhile, an important aspect of the project is to incorporate the effects of finite depth in the forecasting model. As Pearce explains it, the focus is both physical and mathematical: physically, one must define the nature of the bottom boundary as, for example, permeable or impermeable; mathematically, there is a need for developing procedures to cope with these newly introduced complexities.

"The hard part is this next step," Pearce says. Originally, he'd intended merely to modify an existing wave model to include such shallow water effects as refraction and bottom friction. "But what we've chosen to do now rather than 'modify' is to use a completely different technique ... this combined refraction/defraction with local generation. There are only a few other people in the United States working on it, and some people in Holland. And nobody's working on it the way we are. That's exciting." ■

OF TIDES &

To most of us, a beach represents recreation. To L. Kenneth Fink, it represents work.

Fink is a geologist whose special interest is coastal geomorphology, how sand transport changes the coastline, and since the 1970s, he and co-researcher Duncan FitzGerald of Boston University have been studying Maine's beach processes. Now, with Sea Grant funding, they have concentrated their attention on the tidal inlets within the system.

The system itself is one that is little understood. "There is little information here in the United States on the 'indented shoreline system,'" says Fink. "Most information is derived from the barrier island system. Here in Maine, we have a glaciated coastline with 'pocket' beaches or barrier-spit type beaches. 'Bay mouth barrier spits' is what we call them. You find them in Oregon and some parts of Washington and California, but there they're different, they're nourished on an annual basis by river runoff."

"But these are very restricted sand systems we're dealing with. They're sediment starved, with very little resupply. There's no source of sand that we've identified so far that can supply the system." Fortunately, he adds, while the system's sand has "been obviously affected by human activities," the transport has been mainly within the system, without any permanent loss.

In addition to the purely scientific interest of exploring a relatively untouched research area, there was a very pragmatic basis to the project.

"Here, we have the Maine Wetlands Law and the so-called Sand Dunes Law which restrict activities which, in any way, are going to affect natural sand transport processes. Before any activity can take place, it has to be reviewed by the Department of Environmental Protection staff as well as the Board of Environmental Protection and a coastal geologist. And before one can make any knowledgeable decision, one has to have basic information on how the processes work."

The researchers knew they were dealing with a shoreline slowly being drowned by rising seas. They also knew that beach orientation is determined largely by interactions of the seafloor and ocean swell. In the Gulf of Maine, this has resulted in a swash-aligned system in which the beaches are parallel with the dominant wave refraction pattern. (In the rest of the United States, beaches are largely drift-aligned.)

Observation had also shown that the spit ends of the beach, areas closely affiliated with tidal inlets, suffered the most dramatic changes over the course of a year. And, Fink says, "I had identified several accumulation forms in beaches that I was convinced had to be associated with sediment transport into the back barrier environment by the tidal inlets. This told me that sand was being transported on a net basis into the tidal inlet and then it was being redistributed by wind dynamics into the back-dune portion of the beach."

The Fink/FitzGerald research verified that this was indeed happening. To determine seasonal and tidal cycle changes, they mapped delta forms, periodically profiled the areas at Popham, Ogunquit, Seawall, and Goose Rocks that were being studied, and even made aerial photos to document some of these drastic annual changes. Throughout the year, they also deployed current meters to determine water velocity in the tidal inlets at different tidal phases.

The latter technique provided some surprises to traditional coastal theory: namely the discovery that Maine's mesotidal class of tidal inlets were flood, not ebb-dominated, as

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they are in other parts of the world. "In a mesotidal environment, generally speaking, the inlets are ebb-dominated," Fink admits. "That is, the ebb currents are moving faster and can transport more sand than the flood currents. Therefore, usually you have very well developed ebb tidal deltas."

But Maine has few such deltas. Also, Fink says, "I've worked on the beaches for years and I know we always have two or three hours more time on the ebb cycle, in the inlets, than we do on the flood. When the floods come, they come in with a vengeance."

The current meters corroborated Fink's observations and underscored the need to study coastal morphology on a regional basis. Flood currents dominated at the throats of the inlets and at the spits and delta platforms. Only the seaward-most portion of the channel was ebb-dominated. As a result, there was a net landward transport of sediments into the back barrier areas and along the inlet shorelines just as Fink had suspected.

Research showed that in addition to being dependent on marsh size and tidal range, the back-barrier morphology in the Gulf of Maine is also affected in a major way by wind direction. The northwest winds blowing seaward modify the sand in the back-dune area to form parabolic dunes and rear-dune ridges one to five meters above the mean high water level. The pattern is for the flood-dominated spring tides to build up sand along inlet shores. (The process is accelerated when storm surges augment the flood-dominated tides.) These accumulations dry out during the neap tides and are then shifted inward by the northwest winds.

One of the next phases of Fink and FitzGerald's Sea Grant research is to use coring devices to look at the stratigraphic history of the beaches. Another is to find the "why" of these atypical inlet transport patterns.

"Now that we've found the flood dominance (of the tidal inlets), we're trying to explain it. There are two possibilities, one of which is the asymmetry of the tidal wave in the Gulf of Maine. Any wave that moves onshore, that is, into ever decreasing water depth, becomes more and more asymmetrical . . . you get breakers. Well, the tidal wave is doing the same thing as it moves through the Gulf of Maine. It's coming into increasingly more shallow water. Therefore, the tidal wave itself deforms so that the flood portion of it is steeper than the ebb portion.

"That's one possible explanation. The other one is that it's a relationship between the tidal inlet mouth and what we call the sill depth. That's the absolute elevation of the seaward most portion of the tidal inlet, a sort of threshold. It's the depth above which high tide has to rise before it can flood the inlet.

"In the meantime, you have this inertia of the ebbing current that has to be overcome. Think of it as a downhill flume with water running down that flume like a drainpipe. And you have to raise the water so high before you can reverse that uphill flow. It has to be high enough so that it develops enough of a head so it can flow *in* to the marsh and inlet system."

Although Fink is sympathetic to coastal property owners and problems caused by shifted sand, like many coastal geologists he feels that most conventional management tools — seawalls, dikes, dredging — offer only short-term solutions or merely shift a problem from one part of the coast to another.

"We must recognize that these areas are very dynamic, and any attempt or effort to stabilize them is going to alter the entire character of the whole feature. Any static item introduced is bound to have a rather serious impact on the future." If he had his way, management would equal benign neglect rather than manipulation of the beach processes. "People don't know enough about the system to predict exactly what the manipulation is going to produce . . . often there's very little return from it. If anything, we should try to imitate these natural processes, not thwart them."

The key phrase with Ken Fink is "natural processes." Just what is going on out there in the ocean, along the shore? If "a" happens, is "b" or "c" more likely to result? The waves build and break along the beaches in an endless rhythm that is not random. Can we determine the pattern? And if so, how can human activities be woven in harmoniously? With Sea Grant funding, researchers like FitzGerald and Fink will continue to study and unravel the threads of that everchanging tapestry that represents the Gulf of Maine. ■

How Much Carrageenan Did *You* Eat Today?

A staple of the standard detective story is "bugging." Someone (hero or villain) hides a tiny radio transmitter in someone else's (villain or hero's) car and is able to follow the vehicle through a maze of back streets to the secret destination.

The plot is analogous to what researchers at the University of New Hampshire have been able to do with *Chondrus crispus*, a ubiquitous New England seaweed commonly known as Irish moss. By radioactively tagging or bugging it with sulphur, the scientists have been able to follow a compound within *Chondrus* in a way that has widespread implications for mariculture and medicine.

Chondrus produces carrageenan, a natural thickening agent known to the Puritans and used today in everything from chocolate milk shakes to paint. While the average American doesn't eat paint, carrageenan is used in enough food products so that each of us ingests an estimated 250 milligrams/day. It is, according to UNH research associate Eleanor Tveter-Gallagher, "the Cadillac of the gels."

Gallagher and fellow UNH botanists Arthur Mathieson and Donald Cheney (now at Northeastern University) knew, however, that even within this commercially-important species of red algae there were varying degrees of gelling properties. And although different geographic areas have traditionally been seen as high-gel areas, field collections — whether raked, dragged, or picked — actually yielded a mixture of gelling abilities.

"The primary impetus of this work," Mathieson explains, "was to try to cultivate specific plant types with specific colloid properties and that came down to knowing about the reproductive state, how fast they grow, and all the rest. We found that there are different chemicals coming out of the various life phases of the plant. High-gelling fractions, called Kappa carrageenans, come primarily from sexual generation while Lambda or non-gelling fractions come from asexual generation."

Gallagher expands on Mathieson's "all the rest" by noting, "We wanted to know where the compound was synthesized in the plant and how the plant does it. Carrageenan is sulphated so we decided to add a sulphated isotope and follow its path."

The Sea Grant researchers put a measured amount of radioactive sulphur in solution and let the plant grow in it. The amount of sulphur remaining when the plants were removed from the water provided a quick test of their uptake of the chemical, as well as a measure of how fast the plants create the glucose (i.e. sugar) molecules that make up carrageenan.

With the process, the team was able to determine where the carrageenan was located in the plant. By using ultrastructural autoradiography, a painstaking technique that Gallagher says will allow taking what is akin to a snapshot of the interior of a plant cell, the researchers found that the material built up in the plant's cell wall.

The approach also enabled them to compare degrees of carrageenan build-up in different strains of *Chondrus*. As Mathieson points out, "It's like buying strawberries. You can buy a big, pithy berry that has no taste, can't you? Well, it's the same with seaweed. You can get a big plant without much structural meat or carrageenan."

The technique is proving a boon to mariculturists such as FMC/Marine Colloids of Rockland, Maine. Although high labor costs have squelched the development of a New England-based seaweed cultivation facility, the company is using the selection process in its Phillipines operation and in the Canadian Maritimes. It has, for instance, allowed them to isolate Iota carrageenans which keep stannous fluoride from precipitating to the bottom in tubes of toothpaste.

"Traditionally, the strain selection process has been on a grow-out situation. You put different strains in a small aquarium, try to optimize growing conditions, and see over a long time whether Plant A grows faster than Plant B. This old procedure requires huge mariculture facilities and a major investment of peoples' time."

"In contrast," Mathieson continues, "our process can be done in a laboratory and takes only a couple of days versus three to four months for the conventional and expensive growth studies. This allows them to screen a whole group of plants, pick a specific strain, and vegetatively clone the best for the purpose at hand. Since our sulphate experiments were done in tandem with growth experiments, there is a cross reference for the fast growing ones."

The radiolabeled sulphur also proved invaluable in another biomedically-oriented Sea Grant project in which Mathieson and Gallagher collaborated with Thomas Wight of the pathology department at the University of Washington School of Medicine.

Carrageenans are on the GRAS list of the U.S. Food and Drug Administration, i.e., "Generally Recognized as Safe." In the late 1970s, however, there were some reports indicating carrageenan caused colon cancer in rats. Since carrageenan is processed into over 150 different extracts for specific industrial purposes (mainly foodstuffs) the seaweed industry was understandably concerned.

Since then, Mathieson points out, flaws in these initial studies have been found. "They used artificially high dosages, not reflective of real consumption patterns, and an altered form of carrageenan, one in which the molecular configurations were degraded."

At the time, however, little specific data was available, and research to confirm or deny the disturbing reports was a high priority. Gallagher had seen a photo of human connective tissue (fibroblasts) that bore a startling resemblance to carrageenan. She decided to study what happened when labeled carrageenan came in contact with such tissue.

The project was aided by Marine Colloids Inc., which supplied carrageenans of specific chemistry for testing. "To do this type of work," Gallagher notes, "you have to know exactly what you're manipulating, and Marine Colloids has been very helpful in providing specific test substances."

Labeled carrageenan was added first to chick embryo fibroblasts, then eventually to human skin fibroblasts. With normal and malignant cells of chicks and human skin fibroblasts the results were the same. That is carrageenan significantly altered the cell's morphology, making them more polygonal, flatter, and less overlapping than untreated cells. It also retarded cell division, an indicator that rather than being carcinogenic, (i.e. cancer inducing) carrageenan may actually be an anti-carcinogenic agent.

The radiolabeling allowed the researchers to monitor the paths and behavior of the carrageenan. Of particular interest was the finding that carrageenan-treated cells stuck to the culture dish more tenaciously than the untreated control cells. That would suggest that carrageenan may interact at the cell surface, a premise supported by a report that carrageenan-like polysaccharide isolated from marine algae blocked the absorption of viruses through the surface of cultured cells. One of the ways a healthy cell is transformed into a malignant one is through viral absorption. Again, there is hope that further research will prove whether carrageenan has anti-carcinogenic properties.

At the moment, however, no one at UNH is ready to equate carrageenan as a panacea for the ravages of cancer. "There need to be some very, very sophisticated experiments done," says Mathieson. "They need to be done on different types of cells, different ages of cells, different combinations of extracts, different molecular weights, different sulphur chemistries . . . potentially, there's ten years of work here. This isn't something you can do overnight."

Still to be explored is whether carrageenan can replace heparin as an anticoagulant. Preliminary studies indicate that carrageenan will stop bleeding without the development of scleroic lesions, which can be a side effect when using heparin. Since heparin is vital for heart surgery and for treatment of certain blood clots, carrageenan's structural and functional similarities look promising.

Gallagher and Mathieson have not abandoned other New England seaweeds for *Chondrus crispus*. For two years now, they have also focused attention on *Gracilaria tikvahiae*, a red marine algae ranging from Prince Edward Island to Florida, but primarily found in warm estuarine areas north of Cape Cod.

Unlike *Chondrus*, which produces carrageenan, *Gracilaria* is a source of agar, a gelling agent used primarily in the microbiological and medical fields. A culture medium, for instance, is generally agar. Agar is also frequently used to coat antibiotics so that they break down slowly and don't initiate allergic reactions.

Gracilaria grows easily in warm-water Atlantic embayments, but these are high in sulphur, and the result is *Gracilaria* that produces a relatively poor quality agar. There is a commercially exploited agar species in Southern California, but the bulk of high quality agar comes from South American sources. Since this resource is as subject to shifting political winds as oil, there is a natural impetus to develop additional domestic sources.

The goal of the Sea Grant researchers is to reduce or eliminate sulphate from the plant's environment at various developmental stages. In some cases, Gallagher and Mathieson have tried to grow *Gracilaria* in a sulphate-free environment. In others, they have tried to fool the plant with chemical agents that inhibit the uptake of sulphate from the water. The radiolabeling technique developed on *Chondrus* allows them to monitor just how much of a reduction has been achieved.

In addition to their own research, the UNH team has been following with interest the investigations of their Maine counterparts into the complexities of *Ascophyllum nodosum*. Known as knotted wrack, this algae is brown rather than red and is the dominant seaweed along Maine's convoluted coast.

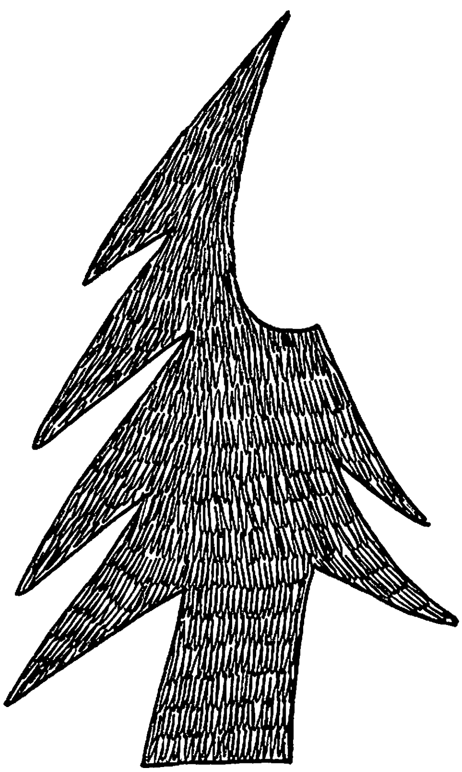
Ascophyllum has long been used in northern Europe, Atlantic Canada, and the northeastern United States as a fertilizer and for cattle fodder. It offers potential as an alternative energy source — methane — and, according to preliminary work in Maine (see box) may also prove to be a valuable deterrent to a voracious forest pest.

Robert Vadas of the department of botany and plant pathology at Orono has been studying *Ascophyllum* at a variety of test sites along the coast of Washington County, in the Damariscotta/Sheepscot River area, and around Mount Desert Island. His goal is to assess and eventually map the yearly growth rates and plant biomass at each of the sites. He wants to determine not only their present abundance but also how rapidly they grow back when harvested.

Since Vadas' studies show the "absence or paucity of natural seeding" by *Ascophyllum*, another objective of the project is to attempt artificial seeding of zygotes, both at the field sites and in the laboratory. Parallel studies to determine the influence of shading, temperature, wave motion, salinity, and other factors on the plant's early growth are also being carried out.

When the sampling data is analyzed, Vadas hopes to provide a body of information on which to base decisions regarding the wisest way to exploit this native resource.

Chondrus. Gracilaria. Ascophyllum. Given their current contributions to industry and their future potential shown by Sea Grant research, it may be time to categorize them as something other than mere weeds of the sea. ■



Something's Eating Our Forests

Picture a ghost forest. The trees are blighted, gray and rotting. If you're in Maine, chances are the culprit is the spruce budworm.

Nibbling its way through Maine's spruce and fir forests in epidemic proportions since 1974, the spruce budworm has decimated many of the valuable woods that form the basis of the state's paper and sawmill industries. In fact, it is estimated that by 1984, 15 million cords of softwood trees, equal to five years harvest, will be killed by the pest. Nor is the problem confined to Maine. A forest fact sheet prepared by the Cooperative Extension Service at the University of New Hampshire notes: "The spruce budworm . . . is one of nature's most destructive forest insects. In the outbreak years from 1910 to 1920 this pest destroyed an estimated 225 million cords of pulpwood in North America."

A Sea Grant project at the University of Maine may eventually provide an alternative to the current practice of widespread chemical spraying of infested areas. Chemist Michael Bentley and entomologist David Leonard (now at the University of Massachusetts) studied the reaction of spruce budworm larvae when confronted with naturally occuring plant compounds. What they found, says Bentley, was that "the abundant brown alga, *Ascophyllum nodosum*, significantly reduced larval feeding in bioassays."

The next step was to isolate and characterize the active substance responsible for this phenomenon. This was done by a purification process involving solvent partitioning and several types of chromatography.

"Chromatographic behavior, chemical tests, and spectroscopy showed the *Ascophyllum* substance in question to be a mixture of polyphenols. Related substances have recently been shown by Geiselman at Woods Hole and McConnell at Skidaway Institute of Oceanography to be important in inhibiting feeding of the marine snail *Littorina littorea.*

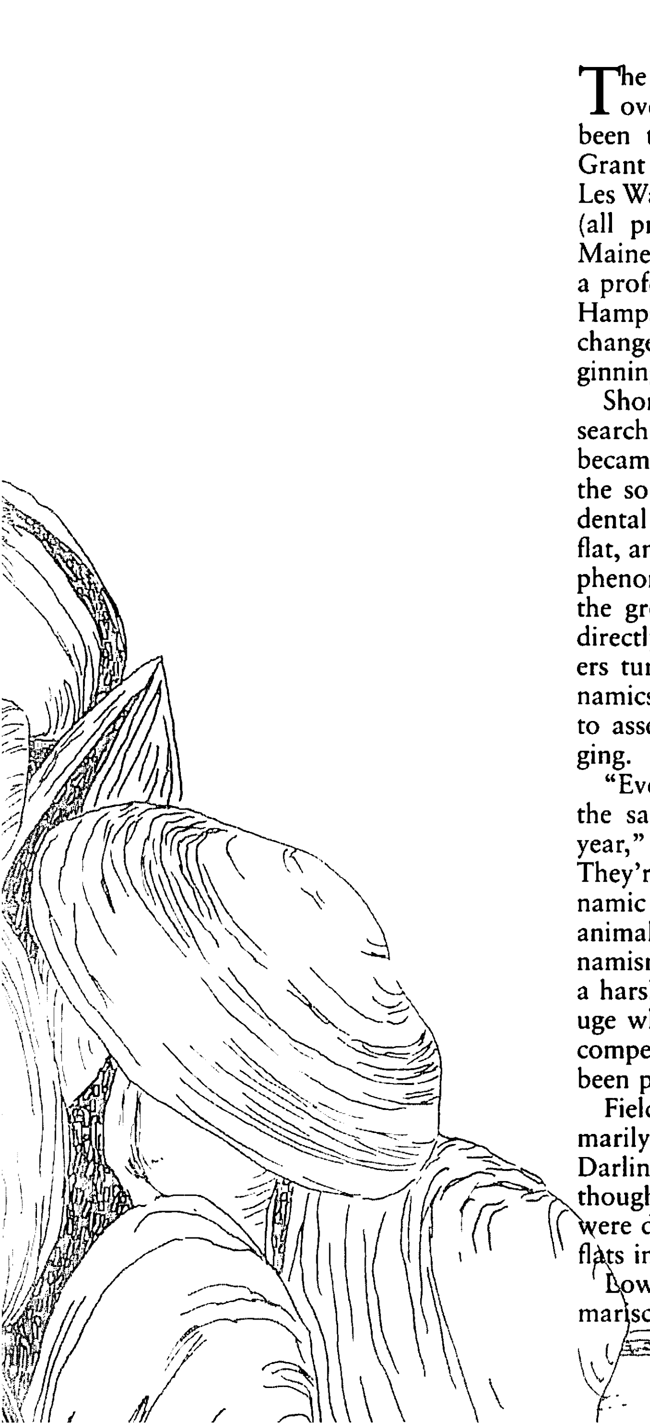
"In our own work," continues Bentley, "these marine polyphenols exhibited higher feeding deterrent activity than typical phenols produced by terrestrial plants. This is probably due to the different molecular substitution pattern produced in marine phenols compared to those of terrestrial origin."

Bentley noted the team had also discovered that *Ascophyllum* produces a substance which inhibits cuticle development in spruce budworm pupae. "We've had problems, however, in reproducing this activity in extracts, and we feel its production may be seasonal."

Papers on the Sea Grant findings have been presented in seminars at the Georgia Institute of Technology; Tsukuba University and the Forestry and Forest Products Research Institute, both in Japan; and at the International Centre of Insect Physiology and Ecology in Nairobi, Kenya.

It's all still in the preliminary stages, but someday a little bit of the sea may curb the appetite of a devastating woodland pest.

A Clam Called *Mya*



The effects of clam digging and the overall dynamics of mudflats have been the focus of a three-year Sea Grant study recently completed by Les Watling, Herb Hidu, Larry Mayer (all professors at the University of Maine, Orono) and Franz Anderson, a professor at the University of New Hampshire. It is a study which changed direction almost at the beginning.

Shortly after their Sea Grant research began, notes Les Watling, it became apparent that *Mya arenaria*, the soft-shelled clam, is almost incidental to the functioning of the mudflat, and that digging is the important phenomenon. As a result, only one of the group, Hidu, continued to look directly at *Mya* in the study. The others turned their attention to the dynamics of the flat so they could begin to assess some of the effects of digging.

"Everyone assumed that flats were the same, day after day, year after year," says Watling. "They're not. They're incredibly complex, very dynamic environments, and that means animals have to respond to that dynamism." And, while the mud flat is a harsh environment, it is also a refuge where many species which can't compete in the subtidal zone have been pushed.

Field research was conducted primarily at Lowe's Cove at the Ira C. Darling Center in Walpole, Maine, though some studies and experiments were done on several dug and undug flats in Washington County, Maine.

Lowe's Cove is a spot off the Damariscotta River — totally unpolluted and unspoiled other than some commercial, year-round digging. A small flat, only a quarter of a mile long and a few hundred yards wide, it drains completely and stretches to the edge of the river at low tide. Unlike many other Maine flats, this fine-textured flat has an abundance of attached macroalgae whose presence may be responsible for many of the chemical effects noticed here, effects which may not exist in flats without algae.

Temporal and spatial studies of this flat revealed that spatial changes in animal abundance were controlled primarily by a decreasing energy gradient on the flat due to tidal currents, wind, waves, and distance from the river's edge. With the advent of fall storms the flat began to erode, continuing to do so through early spring as a result of wind, waves, ice, and currents. In late spring it began to build up again, and continued to build through late summer.

"We looked at the flat on a very, very fine scale, taking the sediment out and bringing it into the lab," Watling says. Sediment features, both physical and chemical, were examined to determine (among other things) grain size characteristics and nutritional quality — both of which influence the type and numbers of animals living in the flat. Studies were also carried out to determine the influence sediment and chemical changes have on one another.

Data indicates that mud flats may strongly influence the adjacent estuary by acting as sediment banks that can periodically lend sediments to the particulate pool in the river. For instance, winter is a period of biological rest, metabolisms are lowered, and ice covers portions of the flat. This keeps suspended particulate matter (SPM) concentrations at their lowest. Maximum concentrations of benthic microflora are found. Benthic diatom blooms serve to trap finer grained sediment, raising organic matter concentrations.

Come early spring, as the ice melts or slides out into the estuary with the tide, a lot of inedible organic material which was tied up in things like cellulose, is taken offshore where bacteria can work on it, returning later as phytoplankton. Late spring and summer are dominated by biological processes. Bacteria levels peak. Suspended particulate measures increase, peaking during rain storms and in late summer.

Two main sources of suspended particulate matter were found. The type from offshore areas of the estuary was characterized by its coarse texture and high levels of protein — phytoplankton-rich seston and chlorophyl "a." That from resuspended in-situ bottom sediments was well sorted and had relatively low organic content which contributed virtually no protein.

This information helped answer a question the group had asked from the beginning, "Was *Mya* feeding on resuspended organic matter from the surface of the flat or from waterborne material coming in from the river?" Knowing the sources of SPM, and using isotope tracers, they proved *Mya* was feeding on phytoplankton and seston, material being brought in with the tide.

Related clam feeding and growth experiments carried out by graduate student Jonathan Eaton has added to the picture.

Eaton's research indicated clams are discriminatory feeders and respond to different particulate types in various ways. Clams are able to partially sort mineral particles from organic particles prior to ingestion. They are also able to sense the nutritional content of particles, with nutritious particles causing increased pumping activity in the clams.

Clams grow fastest in soft, fine-textured sediments and good current conditions. Slow-growing clams from coarse sediments in upper shore environments have higher percent shell weights and larger shell lengths than those growing under optimum conditions. The most rapid growth occurs in the spring and early summer.

On the Washington County flats, research assistant Jane Arbuckle tested the effects of topographic disturbance on clam recruitment. Snowfences were erected, furrows dug, and pools of standing water which were created in June were sampled until late October. Increased recruitment could not be demonstrated because young *Mya* were found to be highly mobile on the flats. Experiments with hatchery-produced animals confirmed the mobility of first-year clams. They also demonstrated a gregarious setting response which means that the presence of adult molluscs in an area stimulates metamorphosis of larvae in that area.

Though the data on *Mya* and the flats themselves are still not well integrated, *Mya* was found to be well linked into the community. "It's a participant in it, but it's fairly independent of most of the other animals' activities," Watling says.

The exception is human activity. Digging influences the flat in a myriad of ways. Certainly not all are recognized; some have been documented, and a few are well understood.

Any digger notices the two distinct layers in a flat overturned in the search for clams. The top layer is a dark brown, aerobic zone. The second is a black, anaerobic area which smells strongly of rotten eggs — hydrogen sulfide. Digging overturns the anaerobic layer, increasing the levels of dissolved and metal sulfide quantities at the sediment water interface. These last, at the most, a few days, and, while they are unlikely to cause a long-term toxicity problem to settling juveniles, they probably do not serve as a long-term attractant for new *Mya* populations either.

Dug zones are also characterized by higher concentrations of suspended sediment of a coarser texture than undug areas. The dug area itself becomes coarse, and contains lower amounts of organic material due to increased winnowing over the rougher bottom.

Overturning the sediment onto algae and other animals creates another problem. As the algae decomposes, hydrogen sulfide is produced and oxygen is depleted. Animals unable to move away will probably be killed.

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KIDS AND CLAMS

Like many other small towns in Maine, Jonesboro is a one-industry town. Nearly everyone in this community of 560 is connected to the business of clams in one way or another — either as clamdiggers or shuckers or shellfish dealers or retailers or shippers. In short, the life blood of Jonesboro depends on harvesting the soft-shelled clam.

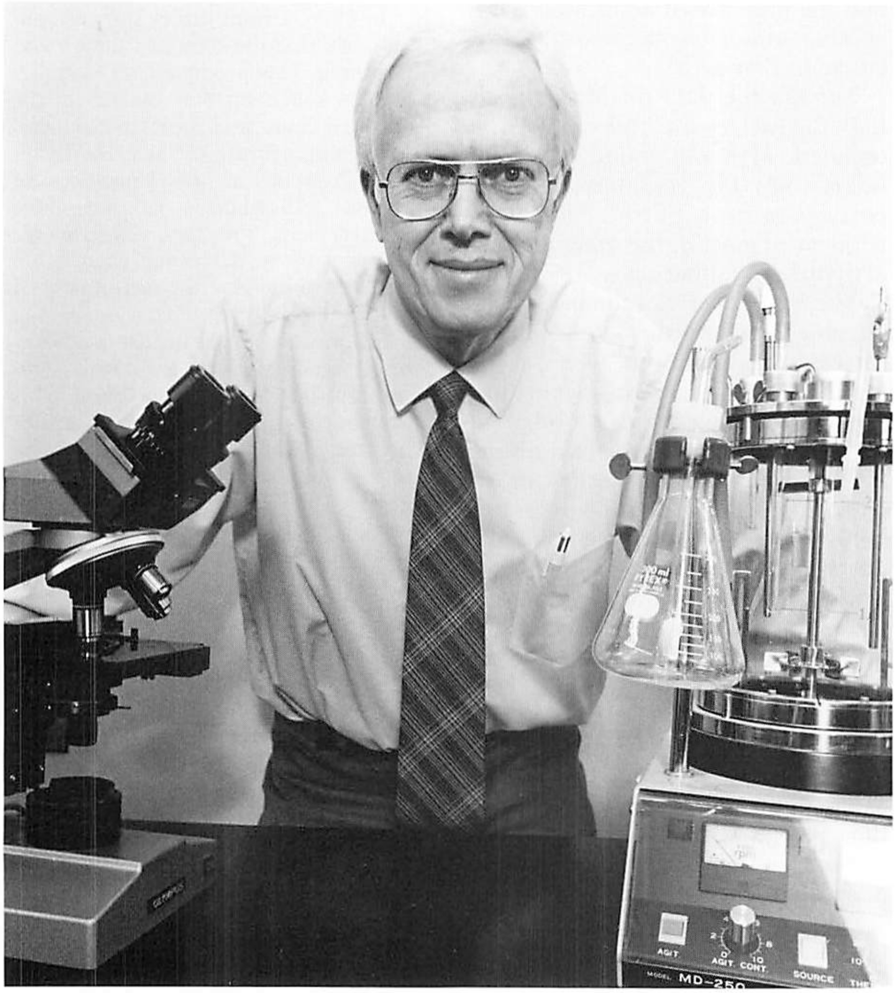
In 1976, a clam survey showed conclusively that the clam population was declining. This prompted the clamdiggers to solicit further research in the study of clams and their environment. With support from the Sea Grant College Program at the University of Maine and Maine's Coastal Zone Management Program, experiments were set up to determine what could be done to increase the recruitment of young clams on the flats.

From these experiments, a greater understanding about the area's clam resource has resulted and sound management of the clam fishery has also become more feasible. To continue raising clam seed for the flats without outside funding was not economically feasible for Jonesboro, however, so another alternative was sought.

Local resident, John Cox, suggested using youth volunteers from the local 4-H Club to set up and develop their own clam hatchery during the summer. With assistance from aquaculture specialist Sam Chapman from the Sea Grant Marine Advisory Program at the University of Maine, the Jonesboro Clam Hatchery has already spawned nearly a half-million clams, and the thirty 4-H members from ages nine to seventeen have learned all about the life cycle of the soft-shelled clam as well as aquaculture and hatchery techniques. At summer's end, they will take those half-million baby clams and transport them onto the flats of Jonesboro's Chandler River. This activity could lead to significant recovery of Jonesboro's clam population.

After Jonesboro, what? Sam Chapman is already envisioning the day when the university's Darling Center and its neighboring aquaculture businesses will cosponsor an aquaculture apprenticeship program, enabling teenagers to apprentice with professionals in the aquaculture industry.

Sugar Cane and Seawater = $C_2 H_5 OH$



It's harvest time in the Caribbean, and workers are busily loading an offshore barge with molasses, the sweet residue of the island's sugar cane crop. Fresh water is at a premium here, but that's no problem for the technicians running the fermentation plant aboard the barge. Seawater abounds. Quickly, they combine the molasses and salt water in a microbiological process developed by a Sea Grant researcher in New Hampshire. The result is an inexpensive alcohol that could end up as the base of a Japanese whiskey or, given another oil crisis, an alternative fuel for American automobiles.

The scene described is not yet a reality, but someday it may be. The technology, refined by University of New Hampshire microbiologist William Chesbro, exists. The next step is to transfer that knowledge to the private sector or find a government agency to fund a pilot plant.

Chesbro's Sea Grant project might be attributed to scientific serendipity. Originally, graduate student Bill Kolanko was doing some unfunded environmental research on marine pollution near sewage outfalls. To do so, he was tracing the fate of land-based microorganisms as they entered the ocean via municipal or shipboard wastes. "He happened to pick as his first test organism one that it was thought the marine environment would kill within a short time. If you find these, we thought, it would show they had just arrived and so were signs of recent pollution. Well, we found that assumption is true, but it's only true because they're starving to death. If you add nutrients, they grow just fine."

This particular bacterium, of the genus *Propionibacterium*, in some forms causes human diseases. But it has its good side, too, and certain species are used for the production of Swiss cheese, vitamin B-12, and propionic acid. In studying *Propionibacterium*, it occurred to the researchers that other terrestrial, high nutrient organisms might also blossom in the marine environment with sufficient feeding. And they, too, might have commercial uses.

In a parallel but independent project, Chesbro and his students had developed and patented technology for microbial fermentation that lent itself to a compact unit with a high throughput rate. It had nothing to do with seawater specifically since it could use any kind of water, but it allowed the fermentation volumes to be shrunk down to a size that allowed plant mobility. Since water transportation costs the least, the technology seemed ideal for a shipboard unit traveling from port to port.

Chesbro could see the potential for all these factors to be gathered together in a complementary project. He applied for and received Sea Grant funding to investigate the potential of seawater-based fermentation to provide industrial alcohols and feedstocks from sugar-rich plants. His goal was to explore not only the techniques of doing so, but the economic feasibility as well.

The technology seems ideal for a shipboard unit traveling from port to port. "The do-ability is there."

Common commercial yeast was chosen as the demonstration organism, in part because Chesbro knew enormous amounts of water had to be used with yeast in the fermentation process. "A significant portion of the start-up costs of an alcohol distillation plant comes from the need to drill wells or to buy water or dispose of water." If yeast could grow well in seawater, the potential for cost savings was immense. This would apply even to the huge conventional plants that used a stirred batch process. Using seawater, they need only be located coastally where they would have access to the ocean's billions of gallons of water.

The project was also designed to study closely the practicality of applying the patented continuous fermentation technology to seawater. The trick, according to graduate student Leslie Linkkilla, was to provide a healthy enough environment so that the yeast cells would produce lots of a desired product without growing too well themselves. Too good an environment would result in the microorganisms "overeating" and clogging the filters through which the product (in this case, alcohol) was supposed to pass.

Working with collaborators in Amsterdam who had mutual interests, Chesbro and Linkkilla investigated twelve yeast strains out of the thousands known. "We found some strains grow a little better than others but they'll all grow." In fact, the yeasts proved amazingly tolerant of a wide range of water quality. Samples were taken in areas ranging from Great Bay to the mouth of Portsmouth Harbor, and in several seasons, without the results being substantially different.

According to Chesbro, what's been achieved so far is the easy part. The best strains of yeast and the best nutrient mixes to use with seawater have been established. What is essentially a lab prototype in vials has been scaled up to a moderate 100-gallon a week recycling fermentation system. The next step is to find private or industrial support to build and operate a pilot plant.

From the start, Chesbro has been fascinated by the process which transfers promising laboratory research into commercially viable ventures. His Sea Grant funding was designed to help him lay the groundwork for this transfer. In particular, a portion was used to investigate the economic underpinnings that would justify building a shipboard unit that could travel from port to port. He and his students have proved that you *can* ferment alcohol in seawater — both in a continuous system and in the conventional batch system — but "part of the intent right from the beginning was to go to private capital next."

To this end, Chesbro has put aside his microbiologist hat and donned one labeled "economics." "I keep running into cost accounting," he says ruefully of his search to demonstrate the profitability of seawater fermentation technology.

For instance, while there are a multitude of federal and state tax breaks that favor the production of gasohol, the alcohol must be of "American origin." Is a barge off the coast of Puerto Rico producing eligible alcohol? How does the 200-mile Exclusive Economic Zone affect this issue? If establishing a Caribbean Initiative is still a goal of the Reagan administration, could the rules be bent if not broken? "The experts are going to have to tell me," Chesbro says of the varied political threads that need untangling.

He does feel, however, that the biggest potential for his fermentation technology is in markets outside the United States.

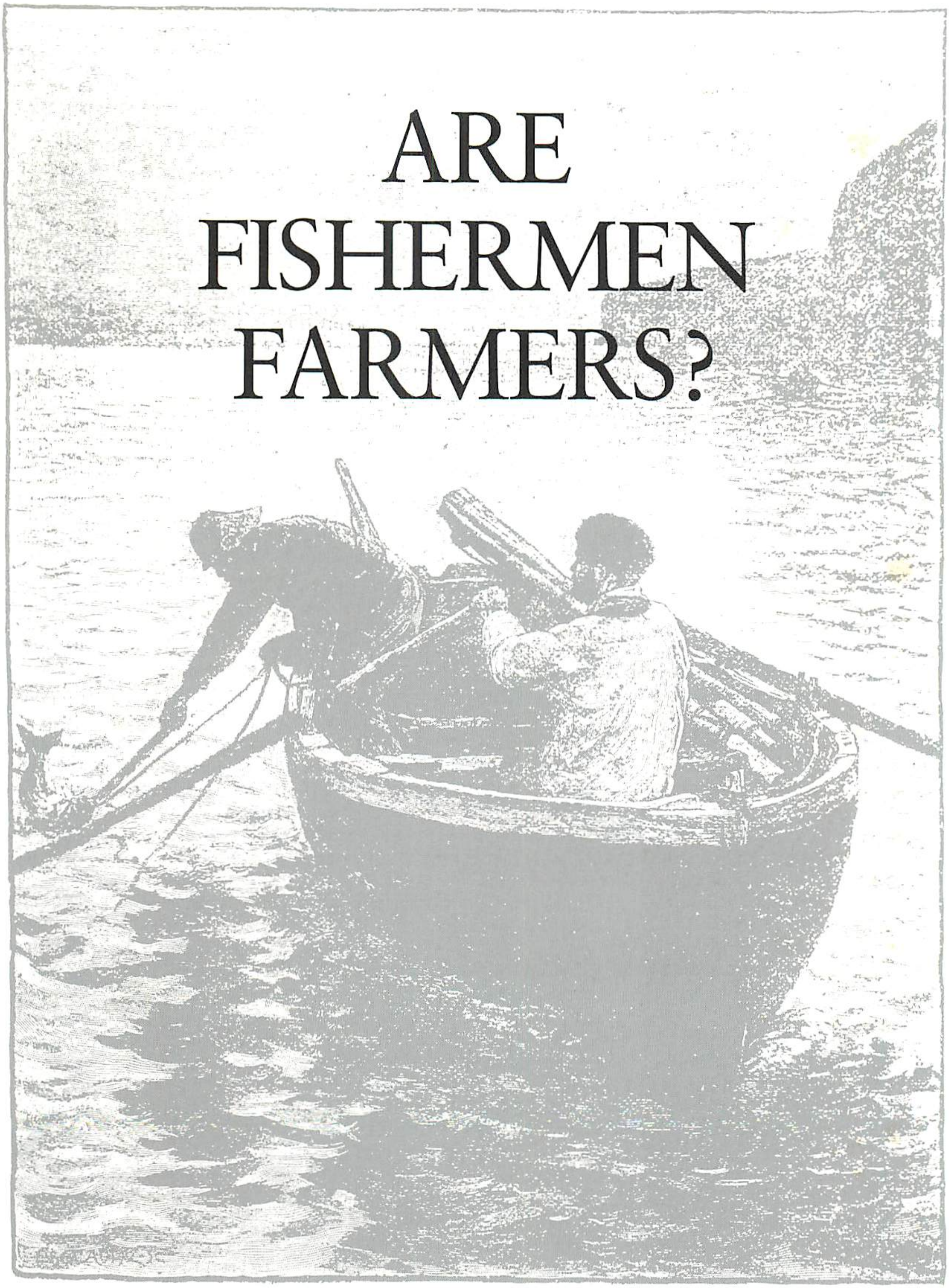
"Alcohol in the USA is used in a variety of non-drinking, non-burning ways. You can use it in paints, solvents, use it in cosmetics, pharmaceuticals, on and on and on. That market is essentially impenetrably dominated by synthetic alcohol made from petroleum technology. They can produce a purer alcohol and these people insist on exquisitely pure alcohol. Conventional fermentation, distillation, can not produce this. It's already at a cost disadvantage compared to petroleum-based alcohol and to get this spectophotometrically pure alcohol, you'd have to run the cost up so high it just wouldn't be competitive.

"This leaves the other two markets: beverages and gasohol. We've talked about some of the problems of tax breaks and origin as related to gasohol. California would be a logical place to site a pilot plant such as this but they've already got gasohol plants built there; there's no need for them to take risks with something new. Beverages? The beverage industry is tightly defined by the U.S. government. Some of your tightest laws in the U.S. define whiskey, beer, wine. All stipulate exactly what you start with and how it's done. So although conceivably you could make a rum from molasses and seawater, I really don't see it as something *I'm* going to develop."

But Chesbro has found in other parts of the world the cost of fermentation alcohol is competitive with or lower than that of the synthetic alcohols. The regulations governing purity and process are also considerably less stringent. "In Japan and all the Pacific Basin, liquor is what it says it is on the label . . . alcohol is flavored appropriately and colored appropriately to be whiskey, gin, rum, whatever you want."

So while the U.S. market for his fermentation technology is economically marginal (or at least until the next petroleum shortage comes around), attractive markets elsewhere do exist and merit further exploration. That's why it all comes back to that pilot plant, built full-size and operating, to demonstrate to the industry that this is a commercially viable approach. Chesbro sums it up in two sentences as compact as his fermentation unit. "The problems at this point are ones of technical scale-up. The do-ability is there." ■

ARE FISHERMEN FARMERS?



Jim Wilson argues the case against limited entry.

James Wilson would be the first to admit he's a maverick. While his fellow economists are touting limited entry as a tool for managing fisheries, Wilson has had the independence to suggest there may be alternatives. With Sea Grant and National Science Foundation funding, he set out to take a critical look at the economic underpinnings of the theory which supports limited entry and to collect and evaluate some of the arguments against it.

"The fisherman is not just a grind out there . . . he's very, very intelligent."

"The standard economic line is there are no property rights out there — that's why you have an overfishing problem. And if you put property rights in, you solve the problem. The analogy is always with farms, that if farms did not have property rights attached to them, no one would bother planting, no one would conserve the soil, because other people could just come in and take the harvest as they wanted."

The University of Maine economist feels the analogy contains huge jumps in logic. As he points out, a farmer always knows where his crop is and approximately when to harvest it. But the ocean's "crop" is mobile and unevenly distributed over a huge area so the fisherman doesn't have that guarantee.

Still, "Five years ago, I firmly believed limited entry was the best way to go." (In fact, Wilson's earlier work on the so-called lobster "fiefdoms" is often cited as the best example of why limited entry would work.) But the more he came in contact with New England fishermen, the more he worked with fisheries councils and cooperatives, the more his belief began to crumble. "The fisherman is not just a grind out there . . . he's very, very intelligent." If these people had doubts, it was time to check exactly why.

Wilson interviewed fishermen throughout New England, the Canadian Maritimes and some of the Mid-Atlantic states. Gradually a common thread emerged. "Their perception of the efficacy of this approach to managing the fishery was not that it was unfair or that they didn't like property rights or that it would restrict their freedom. It was mostly that they didn't think it would work. They're quite willing to have restrictions placed on the fishery, if the result would be a sustained fishery."

In simplest terms, a limited entry approach curtails the number of fishermen going after a particular species. Licenses would be limited, perhaps drawn by lot or given by grandfathering rights to those already in the fishery. Biologists would set quotas for a particular species and each license holder would be allowed to harvest a portion of this quota. License rights could be transferable; fishermen could hold onto an entire license or sell a percentage of it to another.

One of the problems is that fishermen (and they are backed by some biologists at Woods Hole) disagree with a basic premise of limited entry — the assumption that if you control the number of fish caught, you will have a direct effect on the number of fish available to be caught in subsequent generations.

The fishermen — and Wilson — doubt that we really do have this ability to fine-tune Nature. While they concede a certain spawning aggregate is probably necessary, they also feel the premise ignores a number of other biological processes that may be affecting the number of "recruits." Predators. Waning food supply. Water temperature fluctuations. Currents. Wave action. These are just a few of the variables that may have large impacts on successful spawning and on future fish stocks.

Another problem is how to ensure evenhanded enforcement of such a policy. Wilson notes in the November 1982 issue of *Land Economics*, that it has been difficult enough to enforce *fleetwide* quotas in the New England groundfishery.

A third problem with limited entry is that a fisherman would be limited to a single species license, stifling the flexibility that now exists in the New England fishery. As Wilson notes, "They're not a codfish fisherman, they're a groundfish fisherman and sometimes a scalloper and sometimes a lobsterman." Rather than conserving the fishery, such an approach may actually add to the problem. In Canada, for instance, a scalloper with a limited entry license has no choice but to keep going after scallops, even though he may see evidence that the supply is getting dangerously diminished.

This ability to move from stock to stock in New England is not just a vestigial tail of Yankee independence; the UMO economist feels it can actually be a tool for species conservation.

"The standard theory of overfishing states that as demand rises, fishermen fish harder and harder, driving the population stocks down. The supply is less but the high demand is the same. As prices go up and up, fishermen are encouraged to keep going until the population is at very low levels."

Drawing a graph, he shows how biologists have plotted biological population curves over the years. But, he points out, although there are peaks and valleys of abundance for individual species, if all the components of the system were added, one would see a fairly constant level of fish available.

Then, Wilson poses an intriguing question. What if all species got approximately the same price per pound? Then, fishermen would fish by relative abundance at any given time. They would cream off those "blooms" on the chart and switch to another species when populations fell low.

Wilson has increasingly come to feel that the best place to initiate fisheries management techniques is on the shore, not on the fishing boats. As it presently exists, our market structure is geared to frozen food, to large food-distribution chains. It's difficult enough for popular fresh fish to enter this rigid structure; there is almost no provision for "odd" fish. As Wilson puts it, "Retailers are convinced consumers only want haddock so they don't want to take a chance. They know that haddock works." As a result, their contracts with buyers are very species specific.

Wilson has more confidence in the consumer. "Tastes change very rapidly," he says, citing the growing popularity of monkfish and the increased market for squid and blue mussels. In his mind, consumers are ready and willing to veer from the traditional

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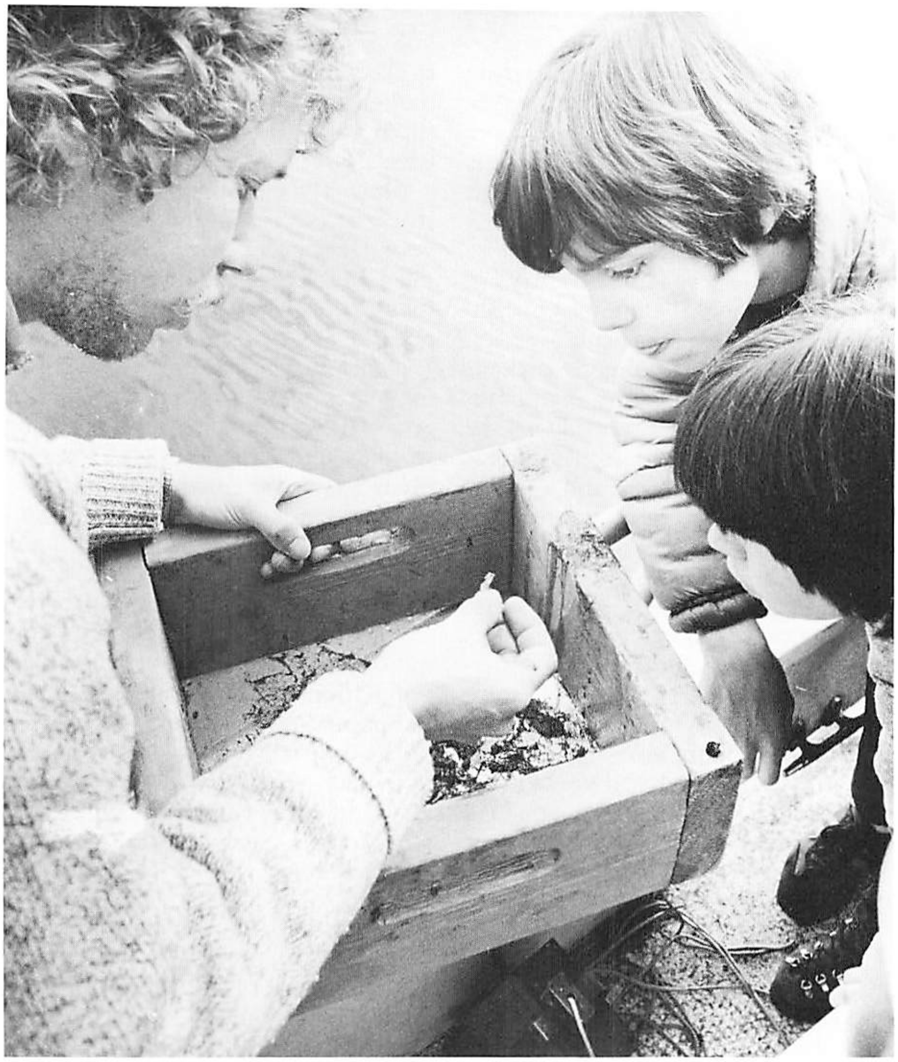

Teaching the ABSeas

The last time Sharon Meeker taught a class, she had to strap a canoe to the top of her car, wedge a card table and four chairs in back, find room for all the usual stuff (petri dishes, nets, microscopes, hot coffee, and field guides), and, later that morning, fish an adventuresome student out of the soft mud in the Mill Pond.

For Meeker, who is coordinator of volunteer activities for the Sea Grant Marine Advisory Program at the University of New Hampshire, and Julia Steed Mawson, the Program's marine education specialist, that particular Thursday was not atypical. When you depend on the great outdoors as your classroom, traveling light is not always an option and your educational parade is frequently rained on.

Meeker and Mawson, who is also director of the Odiorne Point Nature Center in Rye, exemplify UNH/UME Sea Grant efforts to serve the larger community beyond the campus. They both also subscribe to what might be called the geometric-progression theory of education. While they are committed to transmitting hard information about tidepools and humpback whales and the importance of salt marshes, they realize that time and budget constraints will not allow them to personally reach all who might be interested in northern New England's shells, shores, and seaweed. Their answer is to concentrate on training those who can share their marine knowledge with still other groups.

"If I can reach ninety teachers who can then reach three thousand kids, that's ideal," says Mawson. At the Odiorne Point Nature Center (where programs are co-sponsored by the N. H. Division of Parks and the Audubon Society of N. H.), she and her small staff of naturalists do cater to individual and family visitors. However, she is particularly gratified when she can instruct group leaders who can be "on their own" after a visit or two. In the spring of 1982, she and some of Meeker's volunteer docents worked intensively with several Girl Scout troops in coordinating three Discovery weekends at the state park. That fall, the Scout leaders were able to return for a fourth weekend, provide their own program, and simply use the staff as a resource backup.

Mawson takes a similar approach with classroom teachers who want to use Odiorne for ecological field trips in the spring. She runs pre-visit workshops that involve parents as well as teachers so that on the day of the trip, a school's participating adults will be able to answer any of the basic questions. A show and tell combination, the workshops combine lectures with hands-on activities, so that those taking part will be better able to transmit project techniques to students. During 1981/1982, approximately 250 schools and 5000 students participated in the 120 "Through the Looking Glass" programs.

The eventual goal is to convince annually-returning teachers, "You can do it on your own," so that Mawson and her staff can get on to familiarizing new schools. In addition to preparatory workshops, the staff also offers "Alone on the Shore," a resource and activity guide that has been distributed to 200 educators so far.

Work with college students is also important to Mawson. "We're trying to hit the undergraduates before they become teachers." To accomplish this, she supervises Odiorne interns from UNH's education and recreation/parks departments, works with environmental conservation majors who are required to put in eighty hours of appropriate volunteer work, and addresses a variety of on-campus classes. She has been particularly involved with Notre Dame College and feels her in-service workshops at the Manchester, N.H. campus have paid off. Now when the students journey to Odiorne, her only involvement is to offer some minor technical assistance in setting up transect studies or "critter counts" of different shore zones.

A major asset to Mawson's programs has been access to Sharon Meeker's docents, community volunteers who have made at least a two-year commitment to the University's Marine and Sea Grant Programs. "We've used them right from the very beginning at Odiorne, and in the springtime, they're the *only* staff members I have."

When it comes to backgrounds, there is no such thing as a typical docent. Recent recruits have ranged from a graduate student in entomology to an accomplished nature photographer, from a sports fisherman who formerly lived in the Chesapeake Bay area to a behavioral ecologist who was building her own house. But in a fundamental sense, this eclectic crew shares common traits. Beyond an intense interest in the interlocking relationships of the marine environment, they must be willing to become students again and be articulate enough for public appearances.

While some docents concentrate on Odiorne, others are responsible for taking groups through the Jackson Estuarine Lab on Great Bay or out to the Shoals Marine Lab on Maine's Appledore Island. A docent may present a slide show/lecture on mussel farming or help run an oyster bar at Portsmouth's Market Square Day. Some work with junior high school students who take part in the Floating Lab program, an oceanographic sampling expedition held each spring onboard a local fishing boat.

In 1981, ten Floating Lab programs attracted ten different Maine/New Hampshire schools and approximately 250 students. The number of cruises was doubled in 1982 and all were booked, despite the fact that the charge was considerably higher than in past years.

In the first six months of 1982, docents — who number over sixty — presented Sea Trek programs on topics ranging from tidal currents to ma-

WHODUNIT? A Marine Mystery

The plot may never make it to *Magnum PI*, but the mystery of "who put the hole in the clam shell" has been enthralling New England audiences for several years now.

Was it the reclusive snail? The jittery starfish? The crafty green crab? Maybe the shifty-eyed seagull? Only time and Mr. and Mrs. Fish will tell.

In real life, Mr. and Mrs. Fish are Jeff Sandler and Deb Hall who, with Sea Grant support, work out of the Southern Maine Vocational Technical Institute/Gulf of Maine Aquarium in Portland. They teamed up in 1978 to combine theater and marine education in a northern New England program called, "The Sea Comes Alive." Now self-supporting, they estimate that in an average year they provide approximately:

- 150 "creative drama" class presentations to Portland area school children,
- 80 school Ocean Day assemblies,
- 10 special needs programs for the elderly, hospitalized, gifted, retarded, emotionally handicapped and disturbed,
- 25 evening and weekend programs for civic organizations, scout groups, community service programs, church and social organizations.
- 20 in-service training workshops for teachers,
- 10 creative education workshops for college students and future educators,
- 20 other special presentations, and
- 50 opportunities for participation by volunteers.

Like "The Twelve Days of Christmas" listing, Mr. and Mrs. Fish's accomplishments could probably go on. And on. But one indicator of the esteem in which their program is held is their receipt of the 1981 Jefferson Award for Outstanding Public Service in Environment for the State of Maine. Let's see Tom Selleck match that!

rine archaeology, to some 20,000 people. The dollar value they represent is also considerable. "If you think of paying docents $5 an hour to attend training sessions and for the presentations they make," Meeker says, "it comes to about $50,000 a year."

Their training is as intensive as their eventual schedules. A typical week's itinerary for new docents included a field trip to Jackson's Landing Marsh on the Oyster River, an all-day study of barrier island habitat at Plum Island's Parker River Wildlife Refuge in Massachusetts, an introduction to the State Fish Pier, and a maritime history tour of Strawbery Banke, an historic preservation project. Experienced docents are also encouraged to attend since Meeker updates habitat lessons with new study techniques such as field microscope use.

By November, the newcomers will be expected to choose an area of concentration, to start developing resource materials on their own, and to work on their speciality with a trained docent having similar interests. However, Meeker stresses, "They're not simply memorizing someone else's program. The presentations evolve each year; each year they're a little bit different."

To assure technical validity, all presentations are subjected to a re-

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Sea Grant at Your Service

Helping people to help themselves. According to Sea Grant Marine Advisory Program (SGMAP) leaders Brian Doyle and David Dow, the true essence of advisory service work in New Hampshire and Maine is to "provide those individuals dependent upon marine resources with reliable university-based information so they can make decisions affecting future use or development." And during the past two years Doyle, Dow, and their staffs/cooperators have been plenty busy doing just that.

At its January, 1981 meeting the Northern Shrimp Management Committee voted to remove all tolerances previously allowed by law for shrimp mesh-size regulations. It soon became apparent to Maine fishermen and state regulatory agencies alike, that under the new regulations few, if any, existing shrimp nets could meet the new measurement requirements. Dow says that, "great concern was raised about the cost of replacing so many nets, what size twine to buy, availability of twine, enforcement problems and the ability of net manufacturers to produce sufficient numbers of nets in time for the start of the 1982 season." A number of fishermen and net manufacturers requested the Fisheries Technology Service (a cooperator in the Sea Grant Marine Advisory Program Network) to assist them in reviewing data used in the committee's decision.

It quickly became evident that the new twine sizes would prove to be of too large mesh for economic fishing and that presently allowed tolerances were releasing satisfactory numbers of juvenile shrimp. As a result of this new information generated by FTS, the Northern Shrimp Management Committee voted at its November 1981 meeting to reinstate shrimp mesh-size tolerances for the 1982 season. This action is believed to have saved the industry at least $1,000,000 ($750,000 in net replacement costs and $250,000 in lost harvest).

As energy prices continue to increase, the traditional methods of fishing in northern New England become ever more expensive, according to Frank Spencer of the Fisheries Technology Service. An alternative technique, used extensively in Europe, is longlining. It is an energy-efficient form of fishing, compared to trawling, and yields fish of more uniform size and extremely high quality. "But before investing sizeable amounts of income into longlining gear, fishermen must be convinced that the technique can be adapted to northern New England waters and is profitable," asserts Spencer.

So he and other FTS staffers arranged for Norwegian representatives to demonstrate their longlining gear aboard a Maine fishing vessel. Six commercial fishermen took part in the two-day gear demonstration which resulted in one spending $4,000 to purchase the demonstration gear and another placing an order of comparable magnitude. Further demonstrations of affordable semi-automated longline systems are being planned for the coming year. "Longlining will never totally replace trawling," says Spencer, "but in certain situations it can be a very viable, profitable alternative for the fishermen."

"Commercial fishing is a highly competitive industry," contends David Dow, "where specialized talents and knowledge, particularly in fisheries management, gear technology, and vessel safety, are required to be successful." In 1976 Sea Grant marine advisory staff organized and sponsored the first Maine Fishermen's Forum to provide the opportunity for academics, government officials, and the fishing industry to exchange ideas and learn from one another.

It has become an institution now. In 1981 more than 800 participants attended the three-day program which covered such topics as fiscal management and investment, groundfish development, trawl net construction, color video recorders, and safety.

In 1982, industry recognition of the success and importance of this annual event led the Maine Fishermen's Cooperative (MFC) and the *Commercial Fisheries News (CFN)* to assume the leadership role for the forum's organization and sponsorship. During this transition year Sea Grant still provided significant financial and staff support. However, in 1983 sponsorship by MFC and *CFN*, as well as the Maine Lobstermen's Association, will assure that the forum will become a totally self-supporting industry function — "the culmination of seven years of advisory service stimulated growth," Dow states proudly.

The Portsmouth Commercial Fishing Pier has served the New Hampshire commercial fishing community well since it was built in 1978. However, as the fleet expanded, the fishermen and pier regulators recognized the need for further improvements and asked SGMAP to assist in a study of operations and facilities. "We wanted to produce a list of alternatives and options which pier regulators could use in determining future pier expenditures," according to Brian Doyle. "In addition, the report ended up as a useful guide for other New England communities considering the establishment of publicly supported commercial fishing facilities."

Lest one get the impression that fishing is the only marine sector in northern New England, there were a number of other important areas where advisory service staff and cooperators were active, as well. In particular, the proper use and management of coastal resources, and K-12, as well as general adult marine education were priority concerns. "New Hampshire, unlike its surrounding New England states, does not have a federally-approved coastal zone management program," notes Doyle. "But a bill was before the Legislature and was to be acted upon during the 1981 session." Doyle organized a day-long conference for state legislators and local officials to examine the potential implications of coastal zone management for New Hampshire. He had representatives of government and private businesses from other New England states with approved CZM plans share their experiences with the 125 decision-makers in attendance from New Hampshire. Although that particular CZM bill ultimately failed in the Senate after passing the House, Doyle points out that "participants were nearly unanimous in their opinions that the conference provided them with the necessary information to make an informed decision about CZM issues."

As New Hampshire's most important and productive estuarine system, Great Bay is an active candidate for designation as a National Estuarine Sanctuary. Such designation would set aside portions of Great Bay for long-term research, education and interpretation, and provide necessary resources to wisely manage this important resource.

Sensing an opportunity, Doyle, working in conjunction with the N.H. Office of State Planning, organized a meeting of 40 federal, state and local officials to explore the possibilities of designating Great Bay an estuarine sanctuary. "The meeting provided the State Planning Office with enough information and support to generate a pre-acquisition grant application to NOAA. This is the first step in gaining sanctuary status." As the process moves forward Doyle and his staff plan to assist the State in gathering pertinent information required for the full application.

The responsibilities of northern New England's harbor masters have become increasingly complex over the past decade, according to Conrad Griffin, Cooperative Extension marine specialist and Sea Grant cooperator. To assist them in effectively managing their harbors, Griffin developed a comprehensive *Guide for Harbor Management*. This publication, distributed to harbor masters and municipal officers, examines the legal authorities of harbor management, details the function of a harbor committee, and looks at case examples of various methods of mooring layouts and channel markings. Griffin says, "There's usually quite a turnover in harbor master positions since they are non-paying jobs requiring ever increasing time commitments. With this program we hope to provide training sessions for both new and experienced harbor masters so they can more effectively manage crowded ports and harbors."

Helping people help themselves. That's the essence of the UNH/UME Sea Grant Marine Advisory Program. It's working in northern New England. ■

Some Other "Fish" in the Sea

Marine life in many forms, from fishing to fouling.

Launcelots of Stellwagen

In the old nursery tale, Rumplestilskin knew how to turn straw into gold. But unless there's a strong marketing effort, there's little likelihood that sand launce will be turned into sardines.

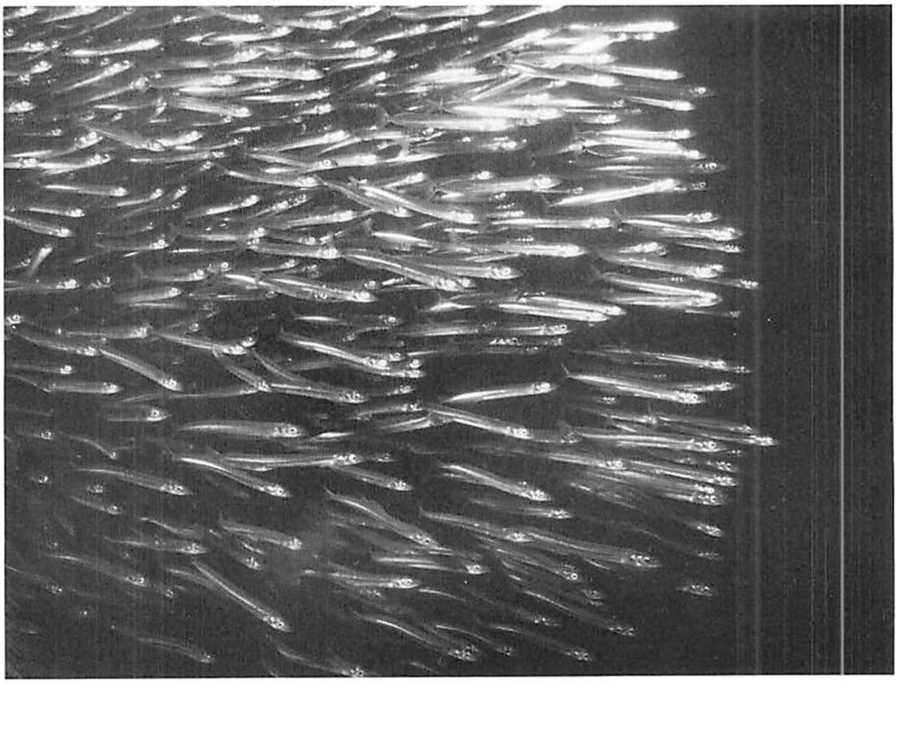
That's the conclusion reached by Roderick Smith, formerly with the zoology department at the University of New Hampshire. Now owner of two draggers fishing the Boothbay-Monhegan area in the Gulf of Maine, Smith directed a three-year, Sea Grant study of the population dynamics of sand launce on Stellwagen Bank.

It's not that there are insufficient sand launce to support a new fishery. "When we got there, there were plenty of them," Smith says, "and when we left, there were plenty of them. In fact, one of the oddball things we found was that many were apparently dying of old age. In the winter months we were getting substantial quantities of six to seven year old, dead fish mixed in the nets with young, live fish . . . an indication these fish are underutilized even in terms of Mother Nature."

Smith says the project also defined the best capture methodology. "Fishermen should use a bottom trawl. A mid-water trawl won't be as effective because when they're being chased, sand launce tend to go down into the sand."

The problem is that there is a limited market for the prolific fish. "There's a call for about 20,000 pounds a week in New York City, but you can get that in four hours in the summer." Similarly, although launces are used as bait for striped bass, "it doesn't take much time to meet the bait market needs." Nor is export to Europe a commercially viable possibility. "It's been a profitable fishery for some smaller boats in the North Sea, but isn't worth U.S. export involvement under any current circumstances."

What fueled Smith's interest in the sand launce initially was the premise that herring stock might vanish as a commercial entity and that sand launce might be able to take up the slack in this area and for menhaden,



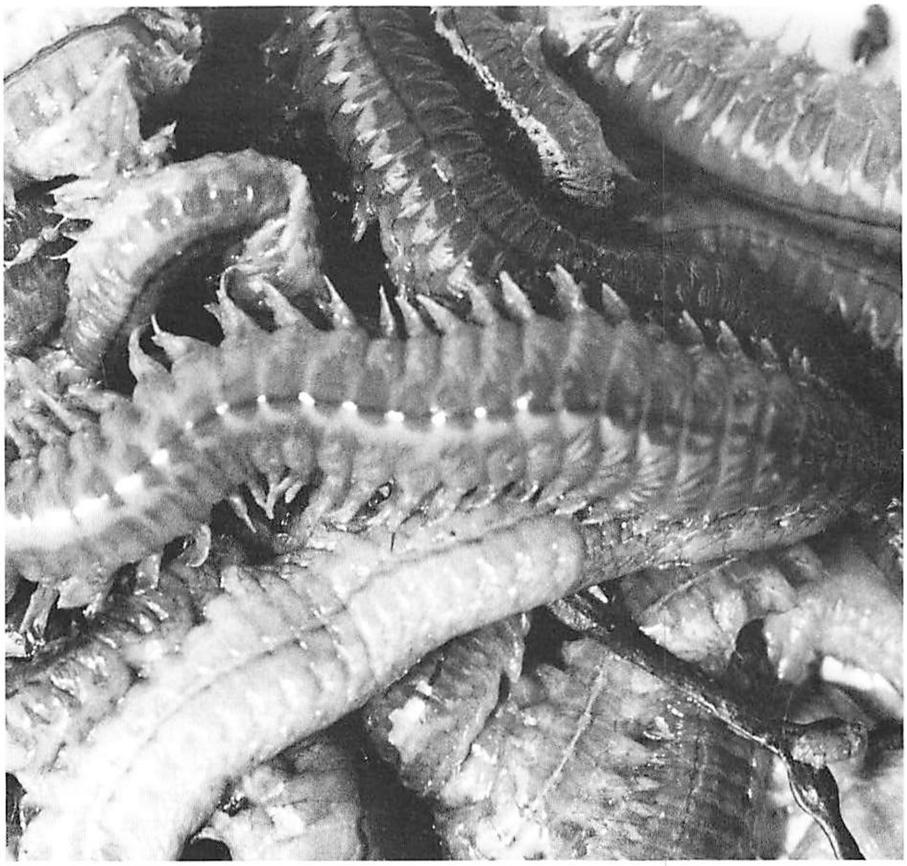
which are commonly reduced for fish meal and oil. "Unfortunately, (for potential sand launce fishermen, at least) the herring never did come down that far so it was totally unprofitable to try fishing sand launce on any large scale."

Smith had canned some sand launce prior to the project and found them to be not just edible but palatable, having a slightly milder flavor than herring. He feels now, however, that unless there's a major effort to establish prior consumer acceptance, it's unlikely that sand launce would offer a profitable fishery even if herring and menhaden were to disappear completely. And, he feels, "Given the financial situation today, no fisherman can afford the time or money to experiment."

Smith and his team did, however, get three years of valuable biological information on this previously unstudied species. Usually fishing stocks are not studied until they have been overfished. As a result, there is no background data from good years to use as a comparison for determining what may have caused the decline.

In contrast, thanks to Smith's Sea Grant project, three years of sand launce data now exists — including age structure, year class strength, individual growth rate, annual fecundity, time and place of reproduction, natural mortality, and migratory and distribution patterns — if the abundant "straw" on Stellwagen Bank ever finds a Rumplestilskin to turn it to gold. ■

Worth Every Wiggle



Few would debate the economic importance to northern New England fishermen of lobster or clams or such groundfish as haddock or flounder. But equally important as a valuable marine resource are baitworms, which in Maine rank between fourth and fifth in terms of annual landed value.

No wonder then that the industry began to be concerned when Maine bloodworm harvests declined 51% between 1975 and 1977, and sandworm harvests began declining in 1978. Recognizing that knowledge about the worms' biology, particularly growth rates and age structure of natural stocks, was insufficient to provide good management recommendations, David Dean of the University of Maine oceanography department proposed a Sea Grant project to fill some of these basic gaps.

"Rates of growth studies were the major thrust of the project for both sandworms and bloodworms. Secondarily, bloodworms were spawned in the laboratory to determine whether larvae could be reared for purposes of restocking tidal flats.

"It was found that bloodworm larvae can be obtained in the laboratory by artificial fertilizations. Preliminary studies suggest that a worm's coelomic contents may enhance larval development in cultures. Early benthic juvenile bloodworms *can* be obtained from these fertilizations but only with great difficulty. We know that the swimming stages can utilize standard algal diets used to culture bivalve mollusc larvae, but the food of early benthic juveniles remains unknown."

An intriguing direction for new research was indicated in the ancillary feeding experiments when it was discovered that sandworms (but not bloodworms) were voracious predators on juvenile bivalve molluscs, at least under laboratory conditions. Although a similar study of sandworm predation on bivalves under field conditions has yet to be tested, the initial findings were presented at the 8th annual Clam Conference, held May 1981 in Boothbay Harbor, Maine.

Perhaps the most exciting outcome of the project was a complementary discovery by a staffer at the Maine Department of Marine Resources (DMR). David Dean explains, "Sandworms and bloodworms were found to be cannibalistic in both laboratory and field confinements. It was then concluded that further use of confinements for growth studies wasn't warranted for these species. What was really needed was the development of a means to identify individual worms while they were growing unrestrained in their natural habitat."

This "means" came in early 1982 when the DMR researcher discovered a method of tagging individual worms. That summer, a joint pilot project between DMR and the Sea Grant program at UME was initiated to test the feasibility of this tagging method under field conditions.

"Preliminary results indicate that this method may permit reliable growth data to be obtained on baitworms for the first time," says Dean.

"Should this tagging test prove as useful as expected, a much larger research program on baitworm problems will be warranted." (Editor's Note: Dean's Sea Grant work in successfully spawning baitworms eventually led to a $49,000 federal grant from the National Institutes of Health. The award will enable him to study ways to grow myxicola, a rare marine worm used in research into Alzheimer's disease and cancer.) ■

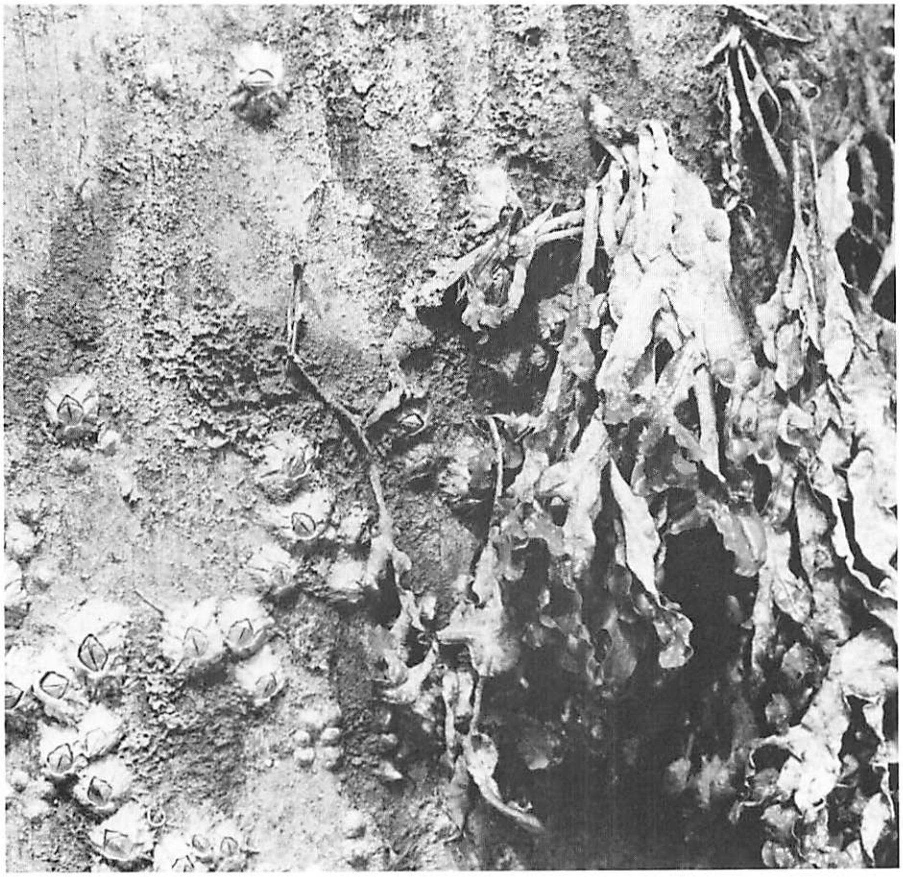
Fouling Causes Pier Pressure

Setting out panels to study the environmental impact of fouling communities is not a new technique. But for years, those doing the work have been primarily concerned with the type of panel material used. As a result, says a University of New Hampshire researcher, they are not taking into account an equally important factor — the way those panels are hung underwater.

Larry Harris is a UNH zoologist who has studied fouling communities as close as New England's Gulf of Maine and as far away as Australia's Great Barrier Reef. In a three-year project for Sea Grant, Harris set up varying configurations of 48 panels under a cement pier in New Castle. "In natural communities, there are great differences on the upper surface of rocks, the sides, and the under surface," says Harris. "I wanted to test this directly and see how the substrate angle affected the growth of fouling communities." Harris notes that he was also interested in the role of marine predators, and set the panels so that some allowed predators access while others excluded them.

By observing and photographing the underwater panels monthly, Harris was able to document that test results can be influenced significantly by the way panels are hung. Since such tests are often used to determine potential fouling that would restrict flow of power plant intake pipes, it is essential that the data be as accurate as possible.

Harris published an extensive article in *Artificial Substrates*, a technical review compiled by Ann Arbor Science. Among his findings on predators was the observation that fish tend to feed straight on or head down, rather than head up, indicating that they would have a greater effect on vertical panels or upper horizontal panels. Similarly, he found crabs are effective on upper horizontal panels but less so on lower horizontals since they can't walk upside-down.



To insure even greater accuracy, Harris altered the typical size of the test panels. "In the past, people have tended to use small surfaces for their tests. I used one-tenth of a square meter. Small squares could be easily dominated by a single species, perhaps a very large sea anemone or fast-growing sponge colony. But that doesn't happen quickly on big panels or in real world situations such as on a piling."

Certain species did, however, ultimately come to dominate the communities. "One set of panels has been up for over five years and another for five and a half. Over time, the communities have come together, they have converged, whether predators had access to them or not." The winners in this competition for space? Sea anemones and sponges.

This supports Harris' thesis that creatures such as ectoprocts, one of the few marine fouling organisms that had been studied when he began his own research, "almost never win in the big picture. They're too flat, with hard skeletons. With the exception of mussels, thick, soft-bodied creatures do better because they can extend over their competitors."

In the case of sea anemones and sponges, a lack of predators also helps their cause. "Sponges are superorganisms and in this part of the world, have few enemies. As for sea anemones, there's only one 'specialist', the nudibranch, which is not too effective. It tends to be seasonal because it's eaten by other predators such as fish and lobsters in the summer months. And it's not big enough to totally wipe out a group of anemones. The nudibranch grows too slowly, too many things can happen to it, and the anemones — once they get big enough — can fight back. They have special stinging filaments that, if tangled in the back of a nudibranch, can kill it."

Conversely, the research indicates that certain predators can be used selectively to keep certain fouling communities from building up in aquaculture situations. "For instance," Harris says, "it may not be such a bad idea to have a few little starfish on a string after oysters reach a certain size. They'll eat the smaller animals that might settle there, such as barnacles, baby mussels and other tiny bivalves, and keep them from overwhelming the oysters. And it's been found that if a crab is thrown in a box after oysters reach a certain size, the crab will keep the box clean without eating the oysters."

Marine competition for space and fouling community succession is a relatively new research field, with documentation only becoming available in this decade. Although his Sea Grant funding has now ended, Harris will continue his long range studies under the Coast Guard pier in New Castle. "I haven't stopped this fouling community study," he says. "The panels are still in place and we'll be photographing again in January." ■

A New Kind of Shell Game

They may not know the Latin names, but most New Englanders would probably be able to tell the difference between *Mya arenaria*, the soft-shelled clam, and *Mytilus edulis*, the blue mussel. But the identification problem gets complicated when these bivalves and others of their Atlantic cousins are in the larval stage — tiny pinpoints of life intertwined with coastal plankton.

According to Herbert Hidu, a zoologist at the University of Maine, this inability to accurately identify bivalve larvae has long hampered both applied and basic research efforts in estuarine and open coastal environments. One problem area has been that detailed studies concerning spatfall predictions for aquaculturists and fisheries management purposes have been extremely limited. Similarly, it has been virtually impossible to assess the potential impact of oil spills, dredge-spoils dumping, and other marine disasters on the larvae of individual species of bivalves.

Hidu and co-investigator Richard Lutz of Rutgers University are spearheading a Sea Grant project to close the identification gap. Their approach is multi-institutional and involves spawning and rearing larvae of as many bivalve species as possible which are native to the east coast of North America. Each of the researchers at the twelve institutions involved collaborate by providing systematic larvae samples and microphotographs of bivalve larvae at various developmental stages.

The key is that it is possible to identify shellfish larvae by using scanning electron microscopy to analyze larval hinge-tooth structure. "Most of the common species of bivalve have now been reared," Hidu says, "however, several of the more rare species remain to be reared and identified."

When the final gap is closed, the team will publish a comprehensive manual that field workers can use to identify wild bivalve larvae through routine optical microscope examination. ■

A Capital Trip for an Ocean Ship

On the one side, there are the lenders: commercial banks, credit unions, business firms, insurance companies, investment banks and venture capital companies. On the other side, there are the investors: fishermen, boat builders, dockside facility operators, manufacturers, processors, and marketing companies.

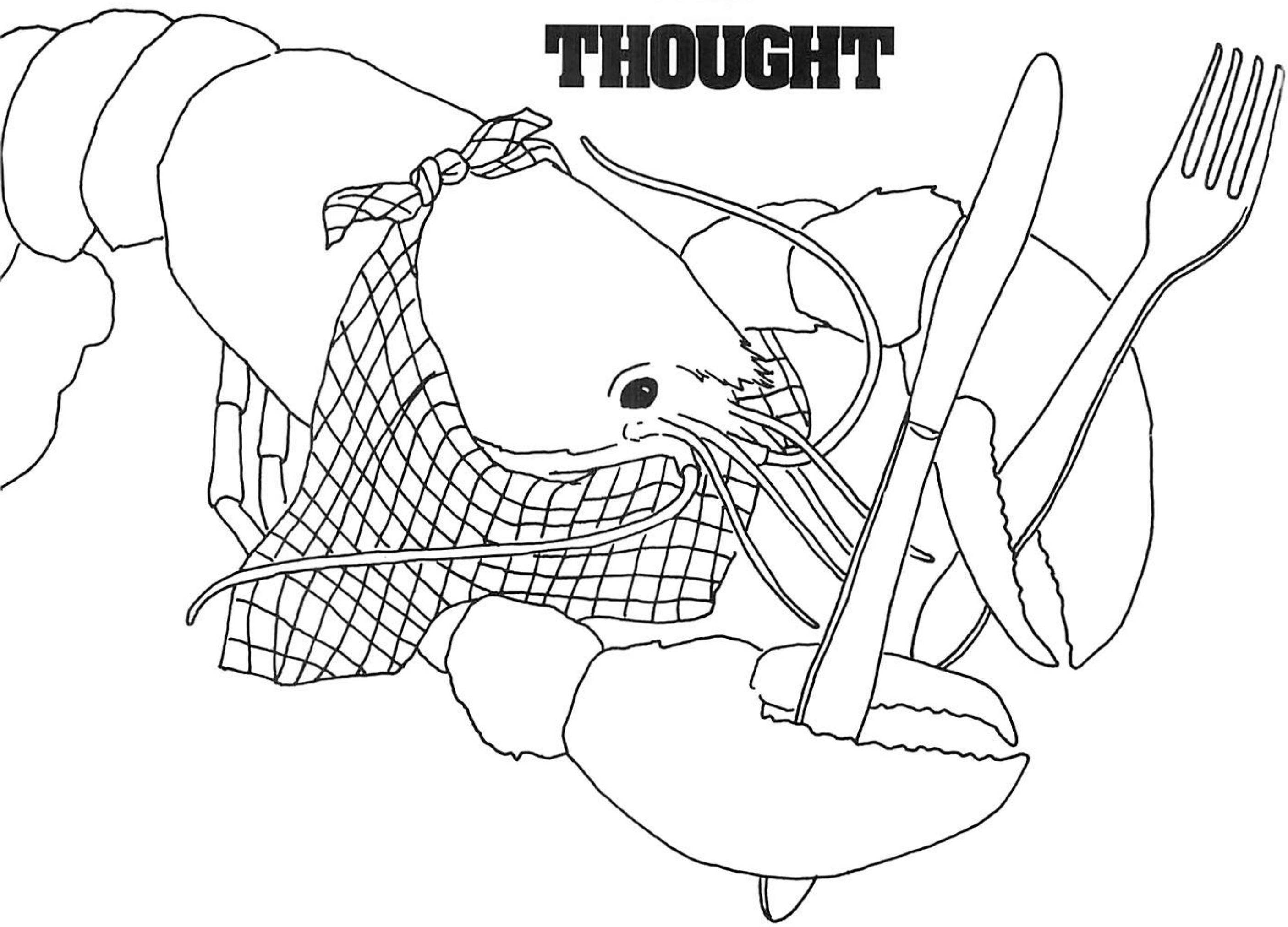
Under the direction of Berrien Moore of the University of New Hampshire's Complex Systems Research Center, the goal of this Sea Grant project was to determine the decision-making process which linked the two groups as partners in the New England fishery. A particular concern was the degree to which the structure of the fishery, including industry growth and ownership patterns, reflects changes in the availability of capital.

John Kelly, one of the researchers involved in the effort, notes that a data base on the New England fishing fleet was constructed using information retrieved from the U.S. Coast Guard offices. "The data base includes all vessels over five gross-registered-tons that are registered in New England, and contains data on the physical and financial characteristics of the vessels, including mortgage information. The data base employs INFO, a moderately powerful data base management system designed for Prime Computers."

Kelly says that the data base is important for several reasons: "First it is the first reliable census of vessels registered in New England. Secondly, it provides the information necessary for assessing the financial characteristics of the fleet, such as the number of mortgaged vessels, amounts of outstanding mortgages, ownership patterns, etc. Thirdly, it can be analyzed in conjunction with other data to yield insight into the debt burden of the fleet."

Potentially, the project could be expanded to address the question of how regulations and stock assessments — management and the biological environment respectively — affect capital investment. Work is currently continuing under contract with the National Marine Fisheries Service. ■

FOOD FOR THOUGHT



When Robert Bayer and W. Huntting Howell go fishing, they're not thinking of dinner. Rather, they hope to find out what their quarry — Maine lobster and yellowtail flounder larvae — like to eat. How these two marine species taste on the plate is secondary to what tempts their respective palates.

Take Hunt Howell's Sea Grant project. A zoologist at the University of New Hampshire, he knew that the yellowtail flounder, *Limanda ferrugina*, was a valuable species, in normal years bringing in as much as $15 million to New England fishermen. But he also knew that over the past fifty years there have been wide fluctuations in the availability of this species.

"The causes of these fluctuations are still unknown," says Howell, "but it's likely that they're due to yearly differences in the percent survival of the early life-history stages. This in turn affects year class strength, the amount of fish available in any given year. There are any number of variables which could be influencing these survival percentages, but I feel that one of the most important is food availability, not only the supply but how it's distributed."

When the tiny crustaceans are offered an appealing chemical attractant, they try to eat the needle.

To test his theory that prey density affects yellowtail growth and survival, Howell made a series of four cruises between the Isles of Shoals and Stellwagen Bank off Cape Cod during the spring and summer of 1982. "We used special nets — bongo nets — designed to catch larvae and their food simultaneously. These were towed in pairs behind the boat with meters in the middle to determine water flow. Because it was known that larvae migrate up at night, and downward during the day, we tried to maximize our catch by fishing shallower (3-4m) at night and deeper (20-30m) during the day."

While the numbers caught in these initial tows were not as abundant as Howell had hoped, there were sufficient quantities to draw some preliminary conclusions. "It seems as if there's at least a possibility that the larvae and their food do not co-occur in some instances." Both the larvae and the microzooplankton on which they feed are minuscule, he notes, and drift freely at the mercy of the tides and currents. It may be sheer luck that results in their paths crossing at the appropriate times in the growth stages.

Some of the tows yielded less than one prey organism per liter. "That's an awful thin soup they're living in," Howell says, adding that in the lab, yellowtail fed in such minute quantities would literally starve.

One explanation for the ability of yellowtail to endure this seeming paucity of rations is that they may occasionally come across large patches of plankton and spend enough time within them to gorge themselves enough so that they can survive periods of scarcity. It is a theory Howell will test eventually in the lab by introducing large quantities of food to his cultured larvae "as if they had drifted into a plankton patch."

Conversely, another aspect of the work is to see how long a larva can be deprived of food following its yolk sac absorption and still develop successfully when food is introduced. By feeding the cultured specimens different food concentrations, Howell also will be working towards establishing morphological or histological criteria which could be used to identify starved larvae. "Generally, you get atrophy of everything. The gut is atrophied, lots of the muscle tissue is absorbed. By collecting larvae in the ocean, and comparing them to purposely starved laboratory specimens, we hope to find out if starvation is a common problem in these larvae."

Data on the tow specimens is being entered into a computer for analysis. "All the yellowtail have been identified and their gut content analyzed. In addition, all zooplankton have been identified and counted. By comparing gut contents with available food, we'll be able to determine whether or not larvae are selective in what they eat."

Surprisingly, while one might surmise that larvae would gratefully gobble up any and all food that drifts past, just the opposite may be the case.

"Preliminary indications are that they are somewhat selective. Some things are very abundant, but they're not eaten even though they're the right size. At this point, we know that larval yellowtail eat primarily copepod nauplii, and it appears that diet changes relatively little with larval size."

Howell cautions that two years of the project remain before any definitive conclusions can be drawn about the relationship between yellowtail larval growth and survival and exposure, spatially and temporally, to available food. However, he is optimistic that this study of feeding ecology will yield results valuable to the New England fishery.

"The sale of yellowtail, which is sold as flounder or sole, is big business in New England. The city of New Bedford, for instance, relies heavily on yellowtail to support its fishing fleet, and in terms of finfish, it's probably second or third in dollar ranking. But until now, only a limited amount of research on what may be responsible for the observed population fluctuations has been done.

While one might surmise that yellowtail larvae would gratefully gobble up any and all food that drifts past, just the opposite may be the case.

"Results of our research should ultimately enable us to more wisely manage the yellowtail flounder fishery. If prey availability and distribution *are* largely responsible for larval population dynamics, it may be possible, after much more research, to predict year-class strength given larval food availability. This predictive power would allow the managers of the fishery to make their management decisions sooner. If a bad year seemed to be coming, the quotas could be lowered in advance or the fishermen could, at least, be told they should plan to retrench or adapt their gear to a different, more abundant species."

Up the coast a few hundred miles, Bob Bayer and Peter Daniel of the Department of Animal and Veterinary Sciences at the University of Maine are tackling the problem of finicky marine appetites from a different angle.

"Our objective is to come up with an alternative to fish scrap as lobster bait," Bayer said. "At present, lobstermen are faced with an increasing cost of bait and with seasonal availability. There are always times of bait scarcity in any given fishing year. There's also the everpresent risk that bait species may, at some time, be totally unavailable as the result of imposed quotas. As it is, lobstermen have to waste both their time and gas money searching out existing bait supplies or in catching their own."

A major portion of this Sea Grant-sponsored project is to identify the specific classes of chemicals in natural baits (such as herring and redfish) that are attractants which entice the valuable crustaceans into the lobsterman's traps. When isolated, these chemical attractants would be combined with low cost fish waste or agricultural by-products. The successful mixture would produce an inexpensive, stable bait that a fisherman could keep on hand for periods when conventional bait was scarce.

The project grew out of an earlier Sea Grant search for a balanced feed for lobsters being stored seasonally in pounds and cars. The researchers had assumed that the most nutritious feed might not be the tastiest, and that they might have to add attractants to the feed.

In the end, impounded lobsters didn't need added chemical enticement to eat the nutritional diets that were developed. But by then it was evident that the parallel attractant project had a high potential in the development of compounded baits.

In studying this latter use for attractants, Bayer had two goals: to investigate the role that bacteria play in the degradation process of natural baits and to identify specific classes of chemicals as feeding stimulants.

To test for various attractants, Bayer put the test animals on a fast for two to four weeks, then placed them in a darkened tank to simulate their ocean-bottom feeding environment. They were then exposed to chemical solutions injected into the opposite end of the tank. If a test lobster moved down the tank towards an attractant, its reaction and rate of response were monitored as it interrupted beams from photoelectric cells along the way.

To speed up the testing process, graduate student Peter Daniel has recently been working with a small, multi-chamber system rather than one large tank. "He's using juvenile lobsters that are about one inch long, so he can do lots of them at once with this device," explains Bayer.

According to Daniel, when the tiny crustaceans are offered a chemical attractant that's appealing, their ultimate reaction is dramatic. "They'll try to eat the needle."

This feeding behavior is markedly different from that of the control lobsters. "The little antennules in the middle will start flicking a lot . . . and there'll be this rapid flutter of various mouth parts. They'll do things like wipe their antennae with their small claws. Then their big claws will raise, and they'll raise their body up with their tail extended. Finally, they'll start to approach the stimulus source and walk upstream. You'll also see gathering movements with the big claws. They'll bring them close to their mouth and kind of snap the claws together."

Some of the attractants that achieved positive reactions have already been field tested by Bayer. He used ordinary high gluten baking flour as a binder because of its ability to stay in water "a good long time" without crumbling. Then the flour and attractants were mixed with fish by-products or discarded organs from local slaughterhouses. The resulting dry, cylindrical pellets were given to Maine lobstermen to test.

"We'd hand out samples of bait and see what we got back for catch. We also handed out a sheet, a record sheet, asking for results. Maybe once or twice a year I would go out with a fisherman who'd set his traps with our bait and see what came up. They'll tell you what works and what doesn't, and they'll do it fairly soon. But there were only a few fishermen who really had the patience to stick it out with us through the good stuff and the bad."

At this stage of the research, Bayer is not yet able to predict what tempts a lobster's taste buds when it comes to compounded baits and chemical attractants. "So far in any field tests, the results have been inconsistent. Sometimes it works, sometimes it doesn't. It may be because the fish by-products we use are at different stages of freshness." Lobsters, it seems, like their food dead but not too dead.

While his bait work continues, Bayer is increasingly confronted with commercial spinoffs from previous Sea Grant research. His artificial diet for lobsters in pounds is being registered with the Department of Agriculture and should soon go into production at a family firm in Hancock, Maine. Using a Sea Grant-developed technique, a Beals Island woman is making the rounds of pounds and cars to clinically test for gaffkemia, a fatal bacterial disease of lobsters. And a medicated diet with Oxytetracycline which Bayer devised may hold the key to containing this dreaded disease, commonly known as redtail. (Residue studies for the Food and Drug Administration are currently being conducted.) No wonder the UMO researcher says with satisfaction, "I really like seeing the conclusion (of a project) . . . to see someone capitalize on what the University has developed." ■

A Sardine Solution

What do various marine species like to taste? That question is the focus of research by Hunt Howell and Bob Bayer (see accompanying story). But Bohdan Slabyj's Sea Grant research is the opposite, if ungrammatical, side of that coin: what do marine species taste *like?*

Specifically, the UME food scientist is concerned with herring and how to keep this economically-important fish from turning rancid before processing. There is always a troublesome time lag between landing and canning, particularly during the warm summer months. The culprit in causing spoilage in herring is not bacteria, but lipid peroxidation — a process, perhaps enzymatic, triggered in fatty acids in microsomes through exposure to the air.

Microsomes are those portions of the cell membrane left when Slabyj has centrifuged the cell debris out of the cell homogenate. "Fatty fish like herring have fat deposits throughout the muscle. The microsomes are known to oxidize the lipid fraction that is part of the microsome itself. The question that needs to be answered is whether the microsomes can cause oxidation of lipids outside the membrane, the fat deposit throughout the muscle. We have found that they can."

The steps necessary to reach this conclusion were complex. Cooperative captains, out of ports such as Lubec and Eastport, set aside fresh herring in ice-filled coolers provided by Slabyj. The fresh, unsalted fish were then taken immediately to the Orono campus and Slabyj's lab. "We filleted the fish, separated the dark and light tissue, and removed as much of the fat layer as possible. Then this was ground in a meat grinder, homogenized in a tissue homogenizer and centrifuged at a relatively low speed to remove the large, particulate fraction. Next the homogenate was spun in an ultracentrifuge, the microsomes were removed, suspended in a high salt concentration, spun again, and resuspended in a standard buffer solution. Because these preparations were at times contaminated by other cellular structures, we had to spend a lot of time on this procedure but our last preparations, using sucrose gradient, seem to be exceptionally pure."

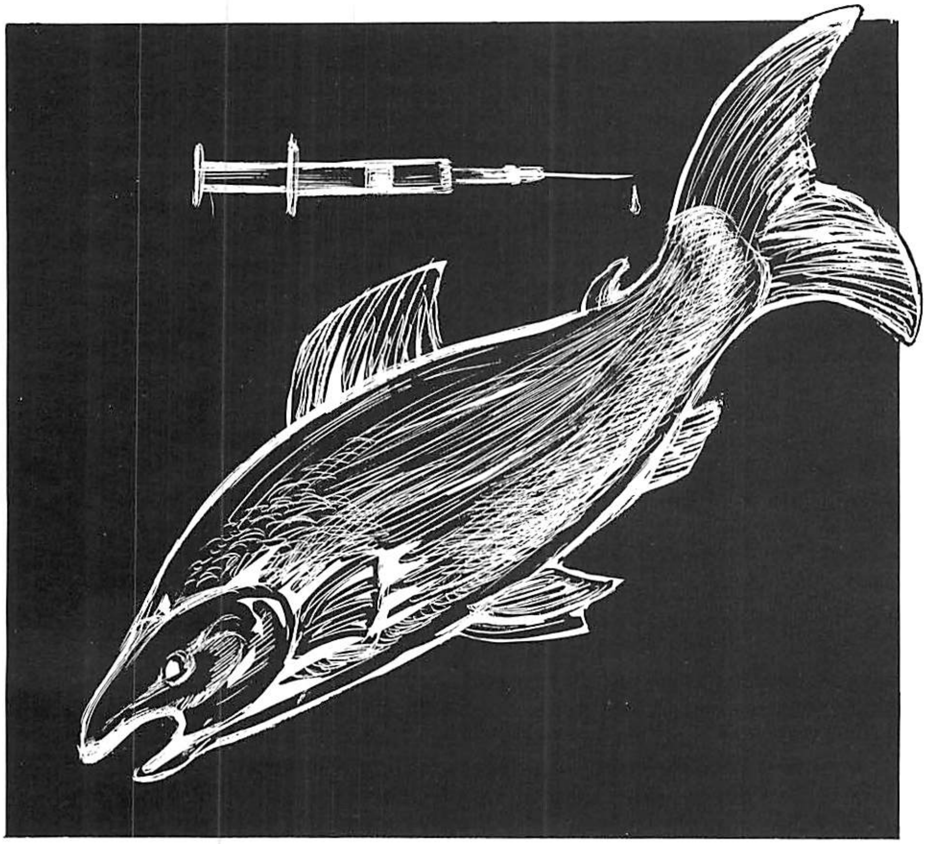
Evidence of lipid peroxidation's persistance at refrigerated temperatures can be seen in that Slabyj's studies were conducted at 43°F (6°C) and the reaction rate was very fast. It is no wonder then that the canneries are hard-pressed to solve the problem. "At the moment, all they can do is to try to streamline the process, get the fish into the cans as soon as possible, keep the temperatures down, and have it (the herring) adequately salted. The problem with salting is that it must be closely controlled since the smaller fish absorb more salt than is considered desirable by the consumer."

To offer an alternative to high salting, Slabyj has also been investigating compounds used to improve the shelf life of frozen seafood, i.e. antioxidants. He hopes to determine whether these compounds would have an effect on lipid peroxidation of microsomes and the potential use of such compounds in the preservation of fresh herring. (Edible acids were one possibility but the treated fish broke up when later heated in the canning process.)

In addition to Sea Grant support, funding has also come from the Maine Sardine Council for this portion of the project.

Already Slabyj and his graduate students have been able to present some intriguing findings at forums such as the annual meeting of the American Chemical Society. One such finding concerned the role of free fatty acids. "We did not expect unsaturated fatty acid to inhibit lipid peroxidation," Slabyj recalls. "People have always said that these fatty acids do not interfere, but we've found that they do."

A long road of research lies ahead, however, before such findings can be applied back at the cannery. This is new territory and there are many basic, scientific paths to explore along the way.



Label them "fish-icians" and they — understandably — wince. But the fishy pun is not far from the truth when it comes to understanding the impact of salmonid research being done by University of Maine microbiologists Bruce Nicholson and Paul Reno. The goal of their Sea Grant projects has been to pinpoint the serological groupings of and eventually find a vaccine against infectious pancreatic necrosis (IPN), a virus that frequently results in ninety to ninety-five percent mortality in affected hatchery populations.

IPN was the first fish virus discovered, and Paul Reno describes it as "a very resistant virus. It can stay in sea water a long time and can stand fairly wide temperature and pH fluctuations without being inactivated." And, Reno adds, the situation is "getting more and more confusing," because IPN or IPN-like viruses are now being found in other than salmonids, in marine life such as eels, menhaden, summer flounder, striped bass, golden shiners, and even oysters and other shellfish. (A commonality with hatchery populations is that the disease in the wild tends to occur in large schooling populations that lend themselves to rapid transfer of the virus.)

"IPN has been found all over the world, with the exception of Australia and New Zealand, wherever salmon are raised in aquaculture facilities. When fish come down with this disease, they're very small — fry — with their yolk sac still attached. They swim erratically around in circles, then fall to the bottom, dead. If dissected, you can see the hemorrhages on their organs. Those that survive always seem to carry the virus with them in their bodies in a detectable way, but without any obvious, adverse effects."

The catch is that while the carrier salmonid may seem healthy, they will infect other fish with which they come in contact and can pass the virus on to their progeny. One solution is to kill all survivors and disinfect the hatchery. A second is to have rigid screening to prevent the transportation of carriers. Precise serological tests would be invaluable to state and federal pathologists seeking evidence of IPN.

Such tests are also needed to be able to group IPN isolates and work towards an effective vaccine. While most virus groups (such as polio in humans) have very strictly delineated cross-reactivity, IPN is "vague" and resists easy categorization. This may be because the virus is indeed different in each geographic location. Or it may be because the existing testing is not precise enough.

According to Reno, the department's early Sea Grant emphasis was to increase the sensitivity of the testing process. "Over the years, Dr. Nicholson has been working on the serological test aspect of the problem; what would be the best test to use, the best methodology to use to be able to classify and identify these viruses." Recently, however, the team has been exploring an exciting new path, the use of monoclonal antibodies to produce serum for serological reactions.

Traditionally, serum had been obtained from rabbits, but there had been problems with this approach. "When you inject a rabbit with something like IPN virus, the virus is broken up by the cells of the rabbit's immune system. Basically, pieces of the virus come into contact with the immune cells which are capable of producing antibodies against them. So what you have in an animal, a whole animal, is a mixture of cells that are producing antibodies directed against many different antigenic sites on the virus. Also, you might get only twenty-five milliliters of serum from it. When you run out of that, you're going to have to go through the whole process again. And each animal is slightly different genetically, so the response is slightly different and you're not always going to get the identical antibodies from rabbit to rabbit or from time to time."

The hybridoma technique which produces monoclonal antibodies starts with the injection of an inbred BALB/C mouse with IPN. Like the rabbit's, the mouse's cells produce a lot of different antibodies directed against different sites on the virus. But then "we separate these cells out, just by breaking up the spleen, into single cell suspension. These spleen cells, which are producing antibodies, are fused with a tumor cell from mice which is capable of dividing infinitely in culture. This eliminates the problem of having to inject a number of rabbits and getting a range of antibodies. What you're going to get is one very specific antibody that you can keep going *ad infinitum*. We then test that antibody to see precisely what it's made up against and using that, we can cross-type all of these different virus isolates."

"One of the reasons we began this project," Paul Reno continues, "and one of the difficulties people brought into this characterization of IPN virus is that the rabbits they inject in England to produce their antisera aren't the same as the rabbits we inject here, aren't the same as the rabbits in Maryland or Canada or Japan . . . and the variations, large or small, are unpredictable. With these monoclonal antibodies, you eliminate all of that problem, too." As a result, in a collaborative move to avoid duplication of effort, Maine and Maryland researchers are already exchanging the particular MCAs their labs have produced to IPN, and the two universities are rapidly building up a "library" of European and United States isolates.

While the hybridoma technique of producing MCAs can be reduced to a paragraph or two on paper, it's a complex approach that takes over a year before researchers new to the technique get to the utilization and application stage. To accelerate this process, research associate/graduate student Prudence Caswell-Reno has attended a workshop on monoclonal antibody production in Washington, D.C., and has applied the new techniques and methods she learned there to the IPN project with significant results. Nicholson and Reno are now at the applications stage and looking forward to working with this exciting new research tool.

"The results we've gotten already are markedly different than those obtained by conventional serologic techniques. It's disconcerting at first, but we've realized we're working in a whole new paradigm . . . it's a completely different ball game." ■

ANIMAL BEHAVIOR

In April and May in Maine it is still cold, and the wind off the water chills even at mid-day. But for several springs now, James McCleave and his research associate, Robert Kleckner, have spent their nights fishing for juvenile eels — elvers — in the frigid waters of the Penobscot estuary.

Why nights? Simple, says McCleave, "We were doing it at night because we were afraid the animals might see the nets during the day and avoid them."

Describing the technique used, McCleave credited it to Joe Graham of the Division of Marine Resources. "He devised it to study movements of herring larvae in the Sheepscot estuary, and basically, it consists of a string of plankton nets set to use the flow of the tides to do the straining. We chose nights when there would be a slack tide at midnight, set the nets at dusk, and let them fish. Then we pulled them at midnight, took the elvers from the net and preserved them for counting later, reversed and reset the nets, and did the same thing again at dawn."

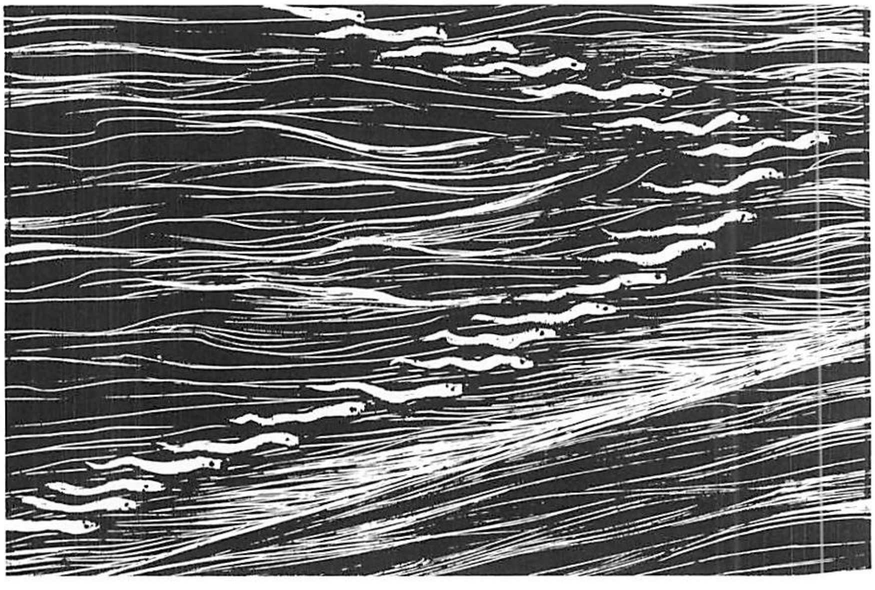
Besides catching elvers, a juvenile stage of the American eel (*Anguilla rostrata*), the UME zoologist and his team also did salinity, water temperature, and current profiles at the four depths to gain a picture of what the water was doing in relation to the catch. A flow meter in the mouth of each net enabled them to convert the number of animals caught into the density of animals per unit of water.

The aim of all this intense activity was a Sea Grant-funded project to see whether the tiny elvers or glass eels were duplicating the behavior of their European counterparts in using selective tidal transport to migrate upstream against the prevailing currents. In addition, McCleave wanted to carefully document for the first time how the behavior of the animals related to the hydrographic situation.

McCleave also hoped such information might be used to commercially exploit the species in northern New England. In fact, when the project started, there was a brief but strong demand from China and Japan. Buyers there sought young eels which were then flown live to the Orient where they were put in ponds to raise as part of an aquaculture effort. Although that particular market has dwindled, McCleave feels there is still a potential for eel export.

"Eels are quite a good fish, like salmon. Unfortunately, in this country, their food potential is vastly underutilized. Here, the adult eel is used mainly in low-priced cat food, while overseas it's considered a gourmet item, particularly when smoked. And since the size of runs in Europe has been affected by lower water quality, they may become increasingly anxious to import American eels."

If an export market ever does open in New England, the data McCleave collected could be very useful in sup-



plying the young eels which are particularly prized in the Far East.

The work confirmed that American elvers did indeed use selective tidal transport to move upstream against the current. It also showed that the young "glassies" took advantage of the halocline, or salt wedge, to hitchhike an express-lane ride on the flood tide.

"We fished in two places. One was around Winterport where there's good stratification in the water, a good salt wedge. Then we also fished further up the river where there's a strong tidal flow, but no salinity stratification."

In both places, McCleave found that the eels tended to drop very near or onto the bottom of the estuary on the ebb tide to avoid being swept back. Similarly, at both study sites, the elvers took advantage of the flood tide to jump ahead upstream. The difference was that at the higher, fresh water site, where there was no differential flow, the elvers could be found throughout the flood tide water column. At the stratified site near Winterport, they concentrated deep in the salt wedge where the current was moving upriver the fastest.

"We also wanted to see if the elvers were moving horizontally as well as vertically on the flood and ebb tides. So two of us spent some time in a small boat pushing nets for 15 to 30 minutes right next to the shore, then again in mid-channel," McCleave recalls. "We found they *are* more abundant near the shore, probably due to the funneling effect of the more shallow water. If there ever is a premium to be paid for the very early stages, this indicates it would be better to fish near shore with push nets rather than at the traditional head-of-tide sites where the animals will be a week or two older."

McCleave says the Sea Grant documentation of elver behavior with respect to the tidal regime has enabled him to get a National Science Foundation grant to continue his study of the species. This will concentrate on the sensory mechanisms that let the eels know when to come up in the water, when to drop down.

In an article published in the *Journal du Conseil international pour l'Exploration de la Mer* (the European journal in which the tidal transport mechanisms had first been mentioned), McCleave and Kleckner note that some of the possibilities for the behavior may be olfactory cues, a decrease in turbulence, or a decrease in the induced electric field in the water. It is also possible that the glassies might have an inner tidal "clock" which they use to time the flood tide. To check his premises for the NSF grant, McCleave intends to build a circular tank approximately four feet in diameter. The tank will have adaptable features that would allow him to change such factors as salinity, odor, and water patterns to see which might be the triggering action or actions.

McCleave also hopes to eventually fill in the knowledge gap of what happens between the continental shelf and the mouth of the estuary. "We know they're spawned in salt water several hundred miles south of Bermuda and that at the larval stage — when they look like a willow leaf with a bunch of teeth at one end — they drift passively on the ocean currents. We know that they metamorphose to the glassy stage somewhere at the edge of the continental shelf, but we don't know how they get to the coast."

To study this question, McCleave plans to take advantage of another Sea Grant project on net circulation in Penobscot Bay. "Bay areas like that may well be the areas where the animals make a transition from simply drifting on residual currents to actively doing something with the tides."

The modeling data, he says, could also be useful in tracking the downstream migration of young salmon on their way to the sea. "In previous studies, before Bryan Pearce's work was available, we got as far as the mouth of the Bay with the salmon. At some point, I'd like to pick up the project again and follow their movement to what I'd call 'offshore' and try to relate that to the circulation patterns in Penobscot Bay."

In the meantime, however, McCleave will continue his work with young eels to see if he can discover just what makes them choose life in the fast lane on their way up the rivers of northern New England. ■

MYA

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As the process of decomposition continues, oxygen is taken from the surrounding aerobic zone, tending to make even the surface of the flat black. As this zone pushes outward, the nematode distribution increases at the edge. "Either they're being pushed away (from the anaerobic zone) and all just piling up, or this zone could be good for bacteria and they're congregating to feed on them," Watling says.

Changes in population distribution like this are probably the most important result of digging. Graduate student Bill Mook conclusively demonstrated that you could change the distribution of animals on the flat depending on how and at what time of year you dug. If you left a depression and a mound, different animals (at different seasons) recruited to the different areas. *Mya* set more easily from March to June, and recruit in greater numbers to depressions. Mook's research on flats in June and August revealed that recruitment to the flat varies from early to late summer.

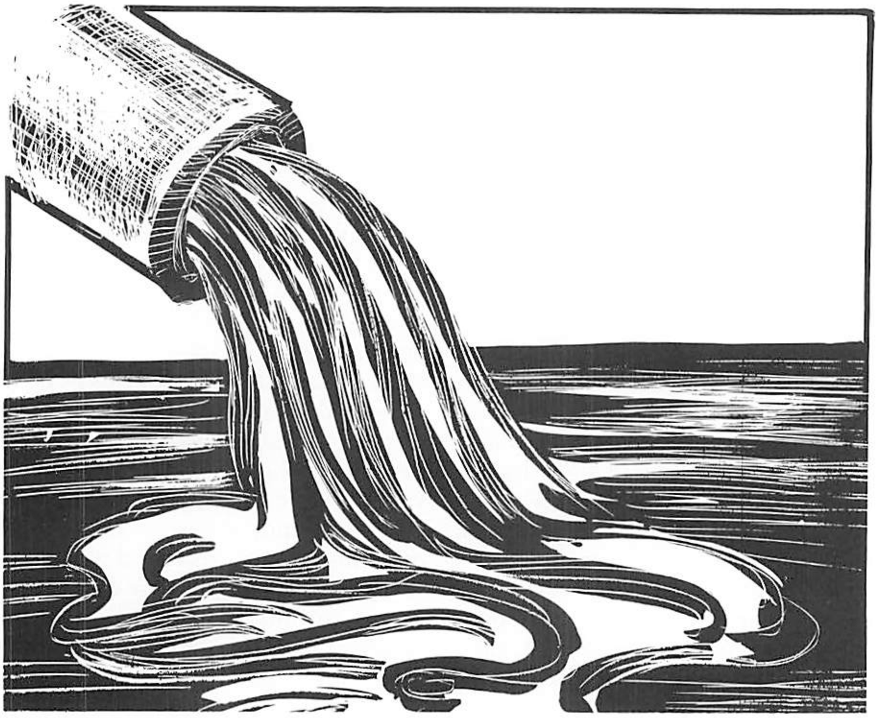
According to Watling, "June is a very nice time for all the animals." Temperatures are moderate both in the water and on the flat's surface. By August, however, the river temperature is up to about 15°C and the flat, on a sunny day, will get to 40°C (at 50°C, some proteins break down). Animals left high, dry, and bare this time of year, or in the water, have a very poor chance of survival.

Good research inevitably uncovers more questions than it answers. "We've just scratched the surface," Watling admits. In his opinion the single most important thing that needs to be done now is to look at what happens to the *Mya* in its first year of life.

Still, many will ask, "Was it a success?" "Did they achieve their objectives?" The answer — "Yes, but not all of them."

"We weren't able to come up with the answers that are going to be needed for clam management," Watling says. "But we will be able to give towns which want to regulate digging for any reason, some assessment of what digging does to flats."

Perhaps more importantly, this three-year Sea Grant investigation opened the door to a better understanding of a highly complex, dynamic ecosystem — the mud flat. ■



Call them polynuclear aromatic hydrocarbons. Call them PAHs. The long and short of it is that many of these chemical compounds are dangerous.

When it comes to crude oil, "PAHs are minor components in terms of bulk," notes Galen Jones, a University of New Hampshire microbiologist and director of the Jackson Estuarine Laboratory. "But they are biological recalcitrants of high toxicity." And, he adds, there is even evidence that high PAH levels may cause tumors in bottom-dwelling fish.

Toxic. Highly insoluble. Persistent in the environment. No wonder PAHs are "on the EPA's priority pollution list." But what scientists *do* know about PAHs is miniscule compared to what they *don't* know.

That's why a Sea Grant project on the transport and fate of toxics (including methylated trace metals as well as PAHs) in northern temperate estuaries is of such importance and urgency. Still in its developmental stages, the project has involved Jones; Barbaros Cellikol and W. Robinson Swift, mechanical engineering; James Weber, inorganic chemistry; W. Rudolf Seitz and C.L. Grant, analytical chemistry, all of UNH; and Charles Officer and D.R. Lynch of Dartmouth College.

Each of the teams has been dealing with a different aspect of the problem. Officer and Lynch, for instance, have been investigating core samples of sediments to determine the presence and distribution of the radioactive isotope, cesium. Weber has been studying high concentrations of lead and tin found near marinas to determine how the various methylated compounds are formed and degraded while Cellikol and Swift are developing a transport model that will take into account the effects of suspended particulate matter. So far, a box model approach has been tested on chromium data from the Saco River estuary in Maine, but further refinement of chemical partition coefficients is required prior to application to organics.

Further modeling is also contingent on data to be provided by the chemical/microbiological members of the team. As Grant (the project coordinator) puts it, "We're still in the process of finetuning the analytical methodology." Not only must these techniques be accurate, he adds, but ideally, they must be less expensive than current methods.

"Reliable analyses at realistically low concentration levels are exceptionally expensive. It was, and remains, our conviction that it is not cost effective to spend thousands of dollars to generate numbers of questionable integrity."

Grant defines the project's parameters this way: "Assume there are toxic organics released into the water by whatever means . . . agricultural runoff, dumping of industrial wastes, oil spills, degradation of lead and tin from boat fuels and anti-fouling paints. If you want to predict where these things will go, you have to answer a fairly fundamental question: what percentage of that material will be present dissolved in the water and what percentage will be found on the surface of suspended particulates in the water? We've found the vast majority is on the latter, often times as much as 98-99%."

Like most scientific inquiries, answering one "fundamental question" opens a Pandora's box of others. Grant ticks them off:

- An estuary starts with relatively fresh water and ends in close to full strength sea water. To what extent does this partitioning of dissolved versus adsorbed organics vary with the salinity change? What happens when the temperature changes? Are there consistent and predictable seasonal differences?
- To what extent is a molecule of a toxic organic substance susceptible to biodegradation when it is adsorbed onto the surface of a particle compared to when it is free in solution? Galen Jones and the microbiologists have isolated phenanthrene degrading bacteria and are trying to establish comparative rates of degradation.
- To what extent is the binding of toxic organics to particulates dependent on the source of the organic material in the particulates? We're finding particles with a land derivation, particles from terrestrial runoff, are high in their so-called aromatic content and also high in their ability to bind toxic substances.
- Just how permanent is that binding? Are PAHs irreversibly bound? Are they susceptible to microbiological degradation? Are they susceptible to photodegradation (from sunlight) in shallow areas?
- Are the degraded substances as

toxic, less toxic, or even more toxic in their subsequent stages than their parent compound?

- How do storms, dredging or pier construction affect toxic-bound substances that have settled to the bottom of an estuary or harbor?
- Consider an oyster which ingests toxic particulates. Are the chemical conditions in its gut such that the oyster can metabolize these bound toxic compounds and they are then, in turn, taken in by someone who consumes the oyster? Or does this stuff simply pass through the oyster unaltered?

The questions extend even into the methodology used. How do you extract offshore core samples and get a complete and accurate analysis? How do you measure the concentration of PAHs on those sediments? How do you know you've gotten it all off in the extraction process?

At present, according to Grant, "All you can do is try to draw an analogy to known lab data and apply an assumed 'correction factor' to your field work. One of *our* objectives has been to get at how these compounds are immobilized and find what we would have to do to get 100% extraction. We haven't been able to do it yet, but I think we've made some progress in developing analytical procedures."

Grant sums up the impact of the multidisciplinary project by noting:

"The ultimate significance of such measurements relates to the health and well being of all sea dwelling organisms and to humans. If toxic substances concentrate and remain in sediments, then biological productivity will inevitably be impaired. Even without productivity reductions, there may be significant chronic effects due to the slow accumulation of high concentrations of toxic substances in the food chain. Although such changes are not very evident because the process is slow, potential damage is more insidious than a more dramatic spill. Clearly, we need sound measurement capability and good toxic substances disposal. The application of data we are attempting to generate is not restricted to Great Bay or even New England. It could be used throughout the world." ■

WILSON

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and try new species, if only such species were readily obtainable.

One possibility that intrigues Wilson in working towards this ideal world of species substitutability would be to give the *buyers* more flexibility. At present, dockside buyers

The ocean's "crop" is mobile and unevenly distributed.

purchase whole boatloads of fish, then have only one to four days to find markets for the less desirable, non-contracted species. The skipper, who has neither access to the direct market nor an up-to-date sense of pricing, is dependent on the dockside buyer to act as middleman. The buyer, in turn, is bound to accept all that is delivered to him.

Wilson would like to see the fish offloaded before they are sold, and an auction structure by species set in place. This "display" auction, with an emphasis on high quality, would clear the market quickly and should dampen sharp price changes.

With direct market access, fishermen would gain a sense of the variables of desirability and would be rewarded as much for the quality of their fish as for species. They also would have an immediate knowledge of prices.

As for the buyers, the system would allow wholesalers and retailers as well as the traditional dockside buyers to have access to large numbers of fish for specific, direct purchases. And because they would have more of an overview of abundance and scarcity, buyers at the auction would be able to anticipate coming declines and seasonable variations and renegotiate contracts quickly. They should also be able to encourage *their* markets to try some of the more abundant, relatively cheaper, unusual species.

Self-admitted maverick he may be, but Jim Wilson is getting increasing attention for his theories and research. He is on a committee setting up just such a display auction at the new Portland Fish Pier. And he is helping prepare testimony for a 1984 presentation before the World Court on the U.S./Canadian boundary dispute in the Gulf of Maine.

But he is aware that his theories are still considered far from conventional. Asked what he considered the most exciting thing about his Sea Grant research, he answered, "Anticipating the fights to come." ■

"I know it's a cliche, but 'there aren't any boundaries in the sea,'" says Alison Rieser, director of the Marine Law Institute of the University of Southern Maine in Portland. She is explaining to an interviewer why the interpretation and application of marine law is more complex than its land-based equivalent.

"The law is less clearcut," she continues, "because of the migratory nature of fisheries resources and the fact that the fishing industry itself is highly mobile. So fixed jurisdictional lines such as the three-mile limit are really arbitrary. It's a lot easier to clarify issues when you can draw a line, an actual boundary."

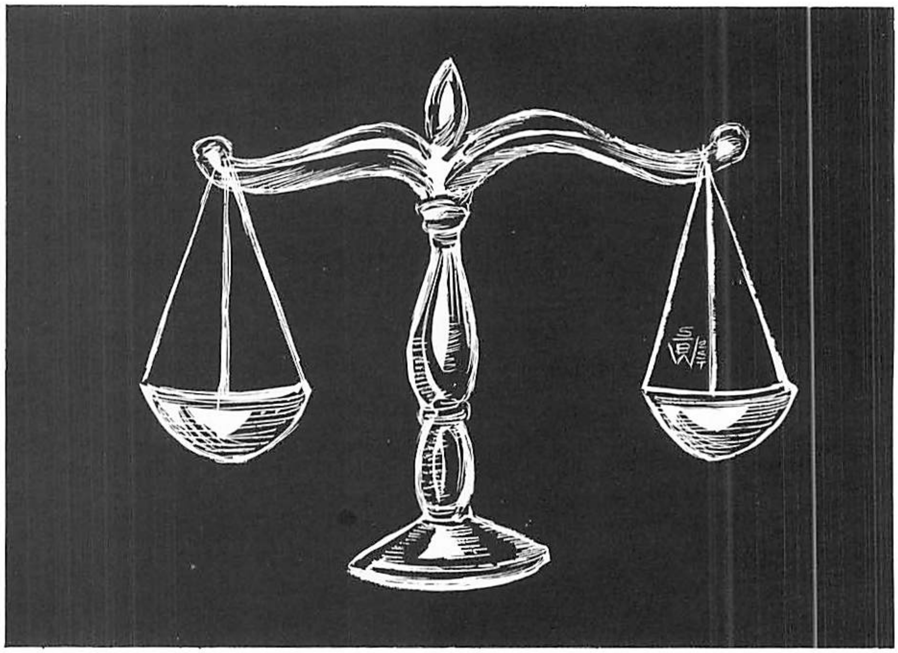
Despite the difficulty, Rieser's recent Sea Grant research efforts have been devoted to just that goal: the clarification of conflicts between state and federal jurisdiction, particularly over fisheries, and the communication of these findings to a growing audience of government agencies and others concerned with marine resources.

The tool she uses is a carefully researched newsletter, *Territorial Sea*. In existence only since late 1980, the newsletter has covered such controversial issues as regulation of the northern shrimp industry, residency restrictions on the taking of Chesapeake Bay blue crabs, and the presence of foreign processing vessels in territorial waters.

Impetus for starting *Territorial Sea* was passage of the Magnuson Fishery Conservation and Management Act (FCMA) in the late 1970s. Rieser points out, "It preserved a role for the states at the same time it adopted a comprehensive federal management regime." As a result, the potential for interjurisdictional disputes was vast.

This was especially so in the area of fisheries resources. "Oil and gas development on the continental shelf also raises significant federal-state issues, but they were being fairly well covered in other publications. But the fisheries niche wasn't being occupied by anyone else and it needed to be analyzed."

A mailing list for initial issues of *Territorial Sea* was developed from a list of those attending two national conferences on the Magnuson Act



and from lists maintained by the regional fisheries councils. Rieser and her colleagues also were successful in establishing an information network that now reaches as far west as California and Alaska and as far south as Florida and Louisiana, enabling them to find important topics for analysis in the newsletter.

"We target our articles towards state attorneys general and management agencies. We're talking to an informed audience, people who work with these laws and regulations on a daily basis, who have a need for a higher level of analysis than you could give in a general circulation magazine. As a result, we can be a lot more analytical, without losing the timeliness of our topics."

Although *Territorial Sea* does offer legal interpretations, Rieser says that she and her staff remain neutral on the issue of state versus federal jurisdiction. "We don't favor one level over another," she says. "We like to be able to point out the strengths and weaknesses on both sides of any argument and which interpretation is most consistent with sound public policy." Requests for reprints are frequent, and, Rieser adds, "I think our article on northern shrimp led the Atlantic States Marine Fisheries Commission to investigate some of the recommendations we made. They even asked for permission to reprint the article to distribute to their membership at an annual meeting."

Rieser finds that interjurisdictional fisheries problems are diverse yet there are many common problems from state to state. "We expected that to be the case but we were surprised at the extent to which our expectations were correct. Often the state agencies don't know what is going on in other state agencies and we're frequently the first person to mention it to them. For instance, we may call Alaska and say, 'We were just talking to someone in Florida and they have exactly the same problem.'"

Territorial Sea is not the only way in which Rieser has used her Sea Grant research to address questions of marine law. A 1982 pilot study with Dalhousie University in Nova Scotia resulted in a draft report entitled *Descriptive Analysis of U.S. Fisheries Law*. While the projected Canadian version has not yet been completed, the cooperative venture did develop into a joint project involving Rieser, Judith Spiller of the University of New Hampshire, and Dalhousie researchers. This study of Fundy tidal power and its potential effects on the Gulf of Maine and the coast of New England was funded by a private foundation.

Rieser is also continuing the development of a text on ocean and coastal law which grew out of a course she

THE LAW

teaches at the University of Maine Law School. "Every time I teach the course I find ways to improve the text. But the adoption of the final Law of the Sea treaty language puts some closure on it. We're now discussing publication possibilities with a couple of publishers. It should be ready after this next revision."

Now a permanent feature of the law school curriculum, the course itself is unique in that it combines both international and domestic law. "It starts off with an historical analysis of international laws of the sea: the evolution of zones of jurisdiction, including where the three-mile limit came from, the development of national jurisdiction over the continental shelf, all the way up to the emergence of the Exclusive Economic Zone (EEZ). Principles of maritime boundary delimitation are examined closely. We spend a lot of time on the Gulf of Maine/Georges Bank boundary dispute with Canada that will be decided by the World Court.

"Next, there's a full analysis of the problems and history of federalism and the principles of constitutional law affecting state-federal relations in marine resources regulation. Then we shift focus to U.S. federal law and look at all marine resources legislation adopted in the past fifteen years. Principles of maritime boundary delimitation are examined closely.

"Finally, we study problems in implementing federal domestic statutes like the Marine Mammal Protection Act, the Coastal Zone Management Act, the Ocean Dumping Act, the Magnuson Act, and oil spill control legislation."

As comprehensive as the course is, Rieser is already exploring the possibility of establishing another. The new course, whose development would be funded by a private foundation, would look at state and local laws as they pertain to land use control in the coastal zone.

She is also considering expanding the topics covered in *Territorial Sea*. "Ocean pollution, especially the recent proposals for ocean incineration of highly toxic wastes, has raised some significant interjurisdictional issues. So we may have our first nonfisheries article coming soon." ■

MARINE EDUCATION
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view by faculty and community experts before being put on for the public. Docents are also expected to take part in workshops run by science educators who teach new ways to interact with children.

Skills developed in the latter area are put to good use in intensive Day of the Coast programs at public schools. Again, like Mawson, Meeker strongly believes that the most successful program is one in which a school's teachers are totally involved. "I make it clear to them, we don't just come in as a traveling show." She encourages teachers to make the day interdisciplinary and multi-age, to let students schedule their own projects for the day so that fifth and first graders are interacting together to learn the anatomy of a squid or what lives in a tidepool tub. Docents are there, but only as adjuncts, not as teacher replacements.

Although based in New Hampshire, the Sea Grant programs are open to students from outside the state's borders, and groups from Maine and Massachusetts have participated in the various activities. As 1982 drew to a close, for instance, docent Persis Plaisted was making plans to visit schools in the Madawaska, Maine area up on the Canadian border! More familiar with moose than marine life, students there would be exposed to ocean specimens brought from the New Hampshire coast and have a chance to learn about life within the intertidal area. High school students participating would also have an opportunity to learn about marine careers and ecological problems connected with the ocean.

As mentioned before, the marine education efforts cater to adults as well as students. Summer programs and marine exhibits at Odiorne draw as many as 3500 visitors annually. A Coastal Forum lecture series has also been established. In 1981, it examined the needs and impacts of various coastal uses at a time when New Hampshire was considering a Coastal Zone Management bill. In 1982, it highlighted Sea Grant research having impact on northern New England issues.

Whatever the age level, when it comes to sea and shore, Sea Grant's marine educators want everyone to get their feet wet. ■

THE LAST WORD

The woman on the phone was apologetic.

"I know it sounds impossible," she said, "but I think there's a walrus in my back yard."

The "walrus" (probably a hooded seal) had vanished by the time our marine mammal specialists had arrived at the scene. The incident, however, is a typical one. When it comes to marine in northern New England, the reflex action is to contact the Sea Grant offices in Maine or New Hampshire.

The reflex within those offices is to give the off-the-wall queries to the communicators. As a result, each day is a bouillabaisse of disparate tasks.

Like our Sea Grant counterparts across the country, our mail often contains generic requests from fifth graders for "all the information you can send me on the ocean." Often, though, the questions are very specific ones — from property owners seeking help with an eroding shoreline, from commercial fishermen wondering how to establish a co-op, from teachers seeking marine activities to use in the classroom, from faculty wanting to check parallel research at other Sea Grant institutions, from the press wondering who in the program might have a comment on the latest herring management plan or threatened oil spill. Sometimes we function as traffic cops, pointing people in other directions. Sometimes we can answer the questions ourselves or send the printed material that will.

At the University of New Hampshire, this means the maintenance of a 5000-volume Marine Resources Center. Using computers to gain access to geographically remote libraries such as the Sea Grant Depository is also being explored; it is conceivable that in the future it will no longer be necessary to physically house the shelves and shelves of material now available in the MRC.

The shelves that won't be taken down, however, are the ones that house our own publications. If anything, we hope to see them grow, since an essential core of any communications effort is the production of informative publications, and we distribute approximately 2000 copies annually. In practical terms, this may mean supervising the reprint of something as esoteric as "The Potential of Fluorescence Polarization for Measuring Sorption Isotherms of Organics" or finding appropriate artwork for something as colloquial as a poster that's "All About Red Tide." One day we may be editing a technical report on declining soft shell clam populations, the next, writing appealing brochure copy on the seagoing Floating Lab experience. It all adds up to about 25 new publications a year and (since we're still hovering on the fringes of the The Word Processor Age) lots of discarded typewriter ribbons.

Some of that ink is worn out writing pieces for *Windward*, the program's eight-page newsletter. The development of an artificial diet for lobsters, the future of federal funding for Sea Grant, the potential effects of the projected Bay of Fundy tidal power project, a look at how UNH's marine docents are chosen and trained for their volunteer work with the public . . . these are just a few of the topics that have been covered in recent issues. Approximately 7400 readers are reached quarterly by *Windward*. To ensure that this audience is receiving the type of marine information it needs, a readership survey was taken in 1981. The statistics and comments garnered are helping us chart new directions for the newsletter.

Of course, not all the writing we do culminates in a Sea Grant publication. We write press releases — about eighty a year — that regularly appear in inland as well as coastal newspapers. We write features for *Sea Grant Today* and columns for *Commercial Fisheries News*. We write Public Service Announcements for radio and television and narratives of program accomplishments for the Sea Grant Task Force. We write scripts (and wield cameras) for videotapes on surviving hypothermia and on the resources of the Gulf of Maine. And when we're not writing, you can find us scheduling a press conference or interviewing a researcher doing work on toxic pollutants or setting up a seafood exhibit or meeting with colleagues at Sea Grant Week to discuss ways we can improve our communications efforts.

Dull, it isn't.

Not even on the quiet days when we don't hear about the walrus in the back yard. ■

THE BOTTOM LINE

	NOAA Funds	Matching Funds
Research for the Development of Marine Resources	778,832	399,727
Research Addressing Conflicting Demands for Marine Resources	555,127	315,970
Education for the Development and Use of Marine Resources	1,163,200	775,422
Program Management and Development	527,841	227,683
TOTALS	$3,025,000	$1,718,802

SEA GRANT

University of New Hampshire
University of Maine
Sea Grant College Program