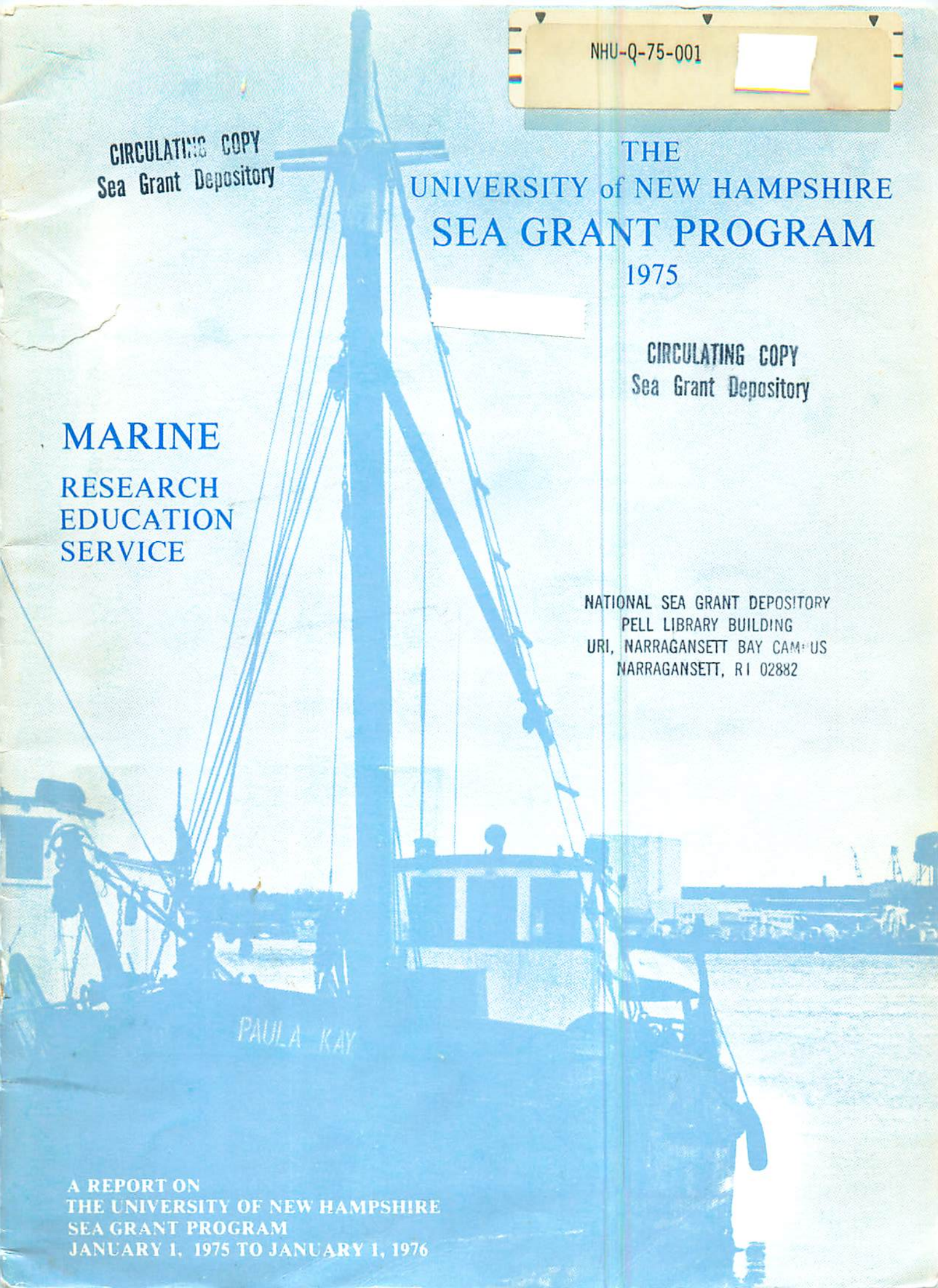
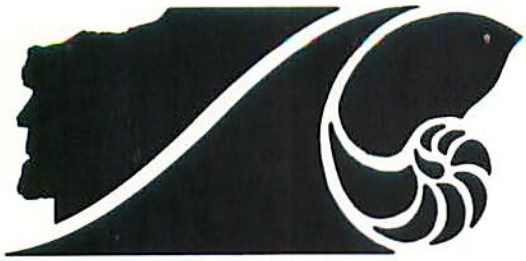
THE UNIVERSITY of NEW HAMPSHIRE SEA GRANT PROGRAM 1975

CIRCULATING COPY
Sea Grant Depository

MARINE
RESEARCH
EDUCATION
SERVICE



**A REPORT ON
THE UNIVERSITY OF NEW HAMPSHIRE
SEA GRANT PROGRAM
JANUARY 1, 1975 TO JANUARY 1, 1976**



UNH SEA GRANT PROGRAM

Behind thee tow'r the mountains.
Before thee roars the sea.

UNH "ALMA MATER"
H. F. Moore '98

All projects in this report,
except as noted,
were funded by
Sea Grant Number 04-5-158-50

Front Cover: Part of the New Hampshire commercial fishing fleet at Portsmouth, New Hampshire. (See page 27.)

THE UNIVERSITY OF NEW HAMPSHIRE SEA GRANT ANNUAL REPORT—1975

CONTENTS

The University of New Hampshire Coherent Area Sea Grant Program

This is a report of progress of the University of New Hampshire Coherent Area Sea Grant Program for the year 1975. This year, as in former years, the report covers activities in research, education, and the Advisory Program. Being an educational institution, the University emphasizes education to the extent that, not only is there a separate educational project, the Undergraduate Ocean Projects Course, but most research projects contribute to education by involving students.

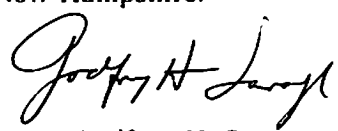
The body of the report describes the many projects that have been accomplished under the program, which continues to be supported by the National Sea Grant Program, part of the National Oceanic and Atmospheric Administration, United States Department of Commerce. As conceived, the purpose of the Coherent Area Program of 1975 was to provide a substantial basis on which an expanding commitment to marine-oriented research, education, and associated services could continue to develop at the University of New Hampshire.

The research program at the University has been focused on four functional categories. First is the development and demonstration of aquaculture techniques that can supplement natural processes to increase productivity of harvestable, renewable protein and carbohydrate resources of the sea. Second, environmental impact prediction techniques were developed, and basic data useful to preclude unnecessary despoilation of the natural environment were collected. Third, expansion and development of ocean engineering projects appropriate to the New Hampshire Coastal Zone and the North Atlantic outer shelf were continued. Finally, initiatives were developed with state officials for a New Hampshire management plan. This report is intended to provide some substance of progress and results in the pursuit of these four research goals.

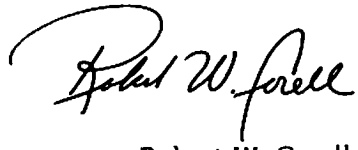
The Undergraduate Ocean Projects Course, funded by Sea Grant since 1968, continues to be of major importance in the program. Seven student projects, including both ocean engineering and ocean socioeconomics, were completed. Twenty-five students from six University disciplines were involved. Students took the initiative in all of these projects, with faculty advisors providing guidance and assisting when needed.

The Marine Advisory Program at the University of New Hampshire has continued to expand its relationship with marine interests in the state. The long-term aim of this advisory effort is to promote the practical application of marine information toward solving social, economic, environmental, and engineering problems of the state and region. A major advisory activity has been the development of seafood industries involving both underutilized and cultured species. In cooperation with two Maine agencies and an aquaculture company, a promising development aimed at establishing a sustained blue mussel industry for the Gulf of Maine has been successfully launched. Ocean engineering personnel have regularly assisted commercial organizations and state boards on a variety of specific technical questions, and University engineers provide technical consulting services to businesses and to educational programs for public schools. As residents of the seacoast become more aware of problems associated with rapid growth of population and industry, the need to coordinate and disseminate Coastal Zone information becomes more apparent. This accounts for the significant growth in the Marine Advisory Program during 1975, particularly in the critical area of Coastal Zone management.

We believe that this report of progress gives evidence of success of the Sea Grant Program at the University of New Hampshire, and of its contribution to the overall objectives of the National Sea Grant Program. We hope that you will enjoy reading this document, which relates the efforts and accomplishments of students, faculty, and staff at the University of New Hampshire.



Godfrey H. Savage
Director
to March 15, 1975



Robert W. Corell
Director

Aquaculture

Development of a Salmonid Fishery for Coastal New Hampshire: The Rearing of Coho Salmon *(Oncorhynchus kisutch)*

Co-Principal Investigators:
Professor Richard G. Strout
Professor Richard C. Ringrose
Professor Roderick M. Smith

Associate Investigator:
Mr. Erick D. Sawtelle

Assistants:
Mr. Lee H. Lohrman, Project Assistant
Mr. John J. Rosenberger, Research Assistant

Graduate Students:
Ms. Bonita Coutermarsh, Master's Program in Microbiology
Mr. Lee H. Lohrman, Master's Program in Zoology
Mr. John J. Rosenberger, Master's Program in Microbiology
Mr. Richard H. Sugatt, Ph.D. Program in Zoology

Undergraduate Students:
Mr. Raymond J. Dreyer, Zoology
Ms. Janet F. Graham, Psychology
Mr. Guy R. Knudsen, Forestry Science
Mr. Peleg Dameron Midgett IV, Parks and Recreation

Technicians:
Mr. Semih Aygun, Technician I
Ms. Bonita Coutermarsh
Mr. Michael A. Thays, Technician II

This research and development project is operating in cooperation with the New Hampshire Fish and Game Department in an attempt to determine the feasibility of both commercial culture and a self-sustaining sport fishery program for Pacific coho salmon in Great Bay and the nearby regions of the Gulf of Maine. Nineteen seventy-five was the third year of this continuing project.*

This year the first brood of 16-month-old smolts which had been hatched and reared at the University of New Hampshire freshwater production facility in Newmarket, New Hampshire, were released. These fish originated from eyed eggs imported from the Sandy River hatchery in the state of Oregon in November, 1973. Of approximately 30,000 smolts (young salmon physiologically capable of migrating from fresh to salt water) 28,000 were released in mid-April into the Lamprey River in Newmarket. These salmon have migrated to the ocean to feed for approximately 18 months. They will return to the Lamprey River in the early fall of 1976, when they will be trapped in the fish ladder at Newmarket. Some of these fish will be selected as potential brood fish and will be artificially spawned to develop a strain of salmon adapted to the environmental conditions of this region. The remainder of returning adults will be released into the river to contribute to the sport fishery. About 2,000 fish were retained in the University of New Hampshire saltwater rearing facility in New Castle, New Hampshire, for use in nutrition and disease studies.

In December, 1974, two lots, each of 50,000 eyed coho eggs, were obtained from the University of Washington School of Fisheries and the Toutle River hatchery of the state of Washington. Approximately 17,000 Toutle River fish were sent to the new New Hampshire Fish and Game anadromous fish hatchery and production facility in Milford, New Hampshire, for comparative growth studies. Some of these fish were used for nutrition studies this year.

These broods of salmon will be

Interior view of hatchery and rearing tanks at the University of New Hampshire Sea Grant Salmon Research Facility in Newmarket, New Hampshire.

released in the spring of 1976 as smolts weighing approximately 12 to 25 fish per pound.

In December, 1975, 130,000 eyed eggs were obtained, again from the Sandy River hatchery, state of Oregon. The increased population will allow the release of a greater number of smolts in 1977 to evaluate the feasibility of developing a commercial ocean ranching (range culture) program. In this type of culture program, the smolts are released at a size of 10 to 30 fish per pound into a river and allowed to migrate to the ocean where they feed freely for 16 to 18 months. They are then harvested commercially upon return to the point of release as 8- to 15- pound adults. This type of commercial culture technique is much less intensive, requires less capital expenditure, and is geared towards a different market than commercial pen type culture.

In pen culture the smolts are reared in confinement in saltwater pens and are fed a manufactured diet for about six months, or until they reach about three-quarters of a pound. They are then harvested as pan-size salmon for the gourmet restaurant trade.

Studies continued this year on the control of bacterial diseases affecting coho salmon. Isolates of *Vibrio anguillarum* have been identified and incorporated into a bacterin (vaccine) in an attempt to immunize the smolts against vibriosis before they are exposed to the disease as they enter salt water. Two methods of administering the vaccine were tried this year: oral vaccination by including the bacterin in the feed for up to four weeks, and individual intraperitoneal injection with an automatic syringe. This year about 4,000 smolts were vaccinated to determine the effectiveness of the vaccine in increasing survival of the salmon in salt water. Concurrently a procedure is being developed to standardize a means of determining the immunity levels produced by the bacterin. The antibiotic Tylosin®, effective against *Vibrio anguillarum in vitro* in the laboratory, is currently being evaluated against field outbreaks of vibriosis. There were indications this year that certain myxobacteria may be involved *in morbidity* and mortality of coho reared in confinement.

The major thrust of the nutrition research program this year was toward the development of lower cost feeds for all age classes of salmon in both fresh and salt water. Because of the need for a high level of protein (45 percent), a major portion of which is currently animal protein, fish feeds are expensive. To reduce this cost, feeds must be

New Hampshire Fish and Game Department release of yearling coho smolts into the Lamprey River in Newmarket, N.H.

The final product of pen rearing: a three-quarter pound, pan-sized coho.

developed which utilize more vegetable protein. During the year five feeds were tested in comparison to a commercial feed using fingerling salmon (parr) in fresh water. Three of these experimental feeds were superior to the commercial feed for both growth and feed conversion. When animal protein (fish meal protein) was less than 50 percent of the total protein, growth and feed conversion were inferior, but livability was not altered. Four feeds were formulated for tests with smolt-size salmon in sea water. However, after one month a bacterial invasion which could not be controlled negated the experiment.

It is planned to continue disease and nutrition work along the same lines during 1976. Tagging studies will be initiated to determine the range of the migrating salmon and their growth rates while at sea. A downstream monitoring program will begin in the rivers to determine the migratory behavior of the young salmon and their role in the food chain, and a fall release program will be initiated to determine whether the time of release affects the natural migratory behavior of the salmon.

*The work of the two previous years is covered in the reports for 1973 and 1974.

Adult male coho caught in the Lamprey River in Newmarket, N.H., by a sportsman.

An adult male coho that has returned to the fish ladder in Newmarket, N.H.

"Seed" Stock Selection and Sporic Reproduction of *Chondrus crispus* Stackhouse

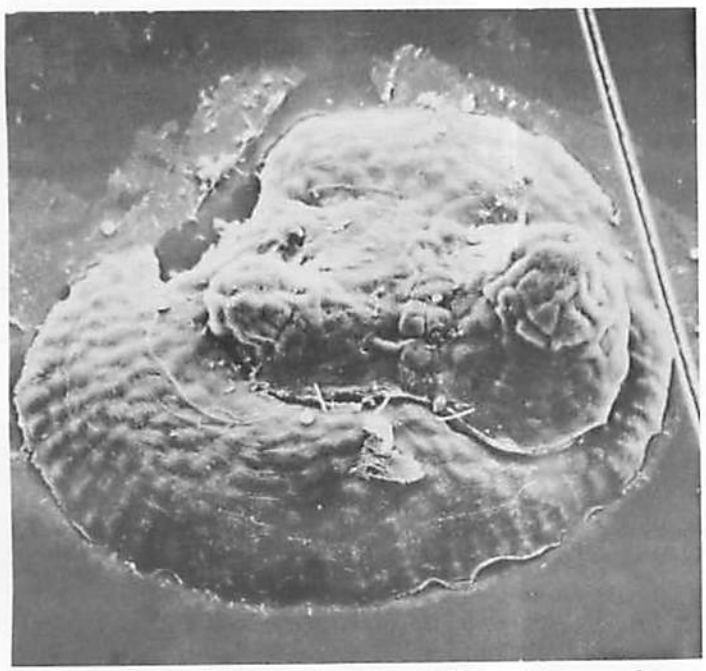
Principal Investigator:
Professor Arthur C. Mathieson

Graduate Students:
Ms. Maureen A. Daly, Master's Program in Botany
Mr. Clayton A. Penniman, Ph.D. Program in Botany
Ms. Eleanor E. Tveter, Master's Program in Botany

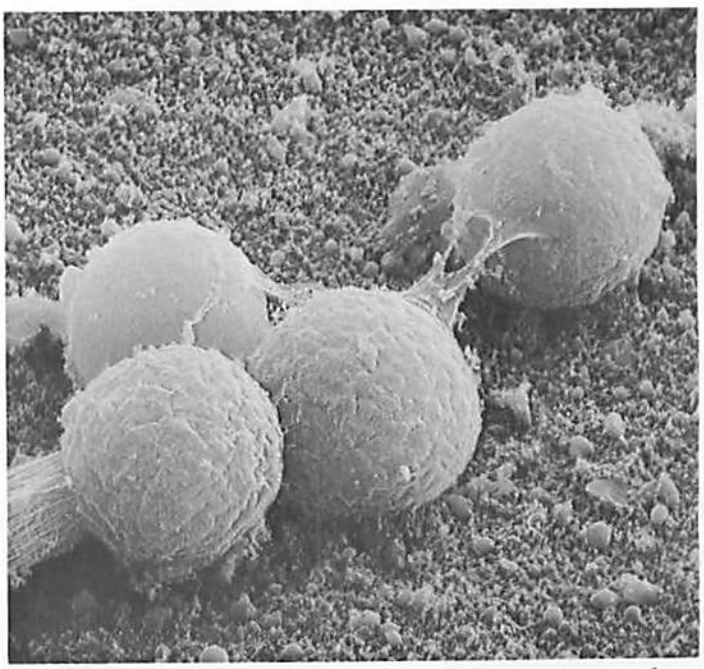
Technician:
Ms. Eleanor E. Tveter

A variety of culture experiments have been conducted during the past year in order to evaluate the "seed" stock potential of various strains of *Chondrus*. Several plants were screened to evaluate differential biochemical properties such as percent carbohydrate, carrageenan, and protein. The carrageenan enhancement potential of varying strains was also evaluated by growing the plants in a variety of different nitrogenous nutrient solutions. Estuarine plants of *Chondrus* typically have a higher protein and a lower carbohydrate (carrageenan) content than coastal populations, and the relative composition of the plant can be altered. The seasonal variations of spore discharge and viability of Irish moss *(Chondrus crispus)* were also evaluated. That is, small sections of plants were held in different temperatures, salinities, and photoperiods in order to determine their discharge potentials, viabilities, and "triggers" to major environmental parameters. The tetrasporic and cystocarpic plants of *Chondrus* show major seasonal differences in their spore ecology.

Two young sporelings of Chondrus, *approximately one month old. Each individual cell is about 5 μ in diameter.*



Scanning electron micrograph of Chondrus sporelings *three months old.*



Carpospores of Chondrus *as viewed by a scanning electron microscope. Diameter of spores, about 25 μ.*

Biology and Ecology

Some Chemical and Physical Aspects of Compacted Solid Waste Disposal in Coastal Waters

Principal Investigator:
Professor Theodore C. Loder

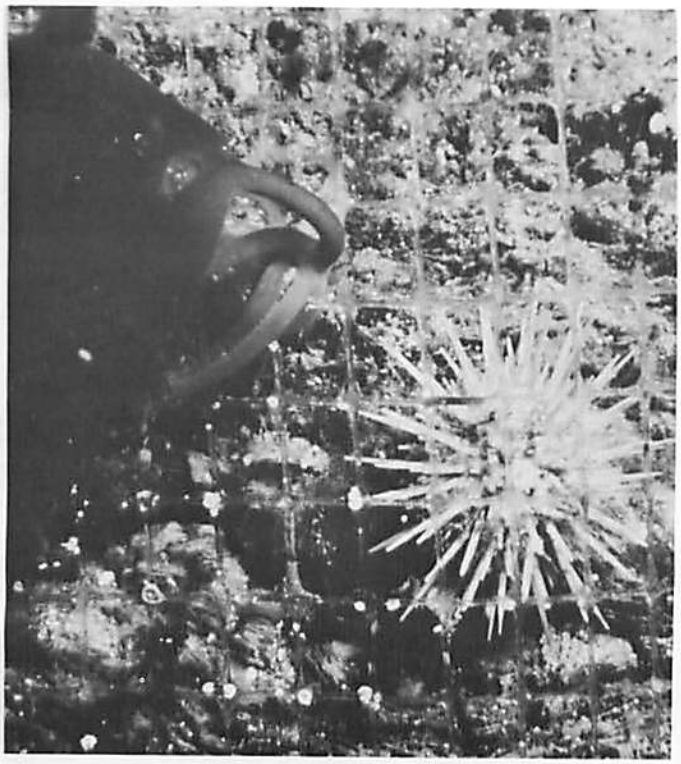
Graduate Students:
Mr. Daniel L. Cordell, Master of Science Program in Electrical Engineering
Ms. Jane S. Fisher, Master of Science Program in Earth Sciences
Ms. Patricia M. Glibert, Master of Science Program in Earth Sciences

Undergraduate Students:
Mr. Martin F. Bowen, Zoology
Ms. Elaine Calderone, Zoology
Mr. Byard W. Mosher, Chemistry
Mr. John E. St. Andre, Chemistry

This project, aimed at improving the understanding of the overall implications of placing compacted solid waste in the marine environment, was started in 1971 and is being completed this year. Compacted bales placed off the Isles of Shoals have been visited approximately bimonthly for three and one-half years with observations made on the biological, physical, and chemical changes within and around the bales.

Physically, the bales did not change much, there was no significant change in size, and the strapping and mesh for the most part remained intact. The plastic-mesh covered bales developed a hard crust of metal hydroxides and carbonates which cemented the outside of the bales, providing a hard substrate for attaching organisms, such as the mussel, *Mytilus*. The mesh was also important for the attachment of algae such as *Laminaria* and *Agarum*, which showed little or no attachment in the nonmeshed bales. The presence of a mesh covering would play an important role in slowing the rate of disintegration of a commercial bale.

Estimates were made on the expected lifetime of a submerged bale based on chemical changes within the bales and diffusion rates. Dissolved organic diffusion rates and sulfide production rates suggested bale lifetimes of 30 and 500 years, respectively. Based on the amount of surface material removed by boring organisms on the bales over three and one-half years, the bale lifetime would be about 100 years.



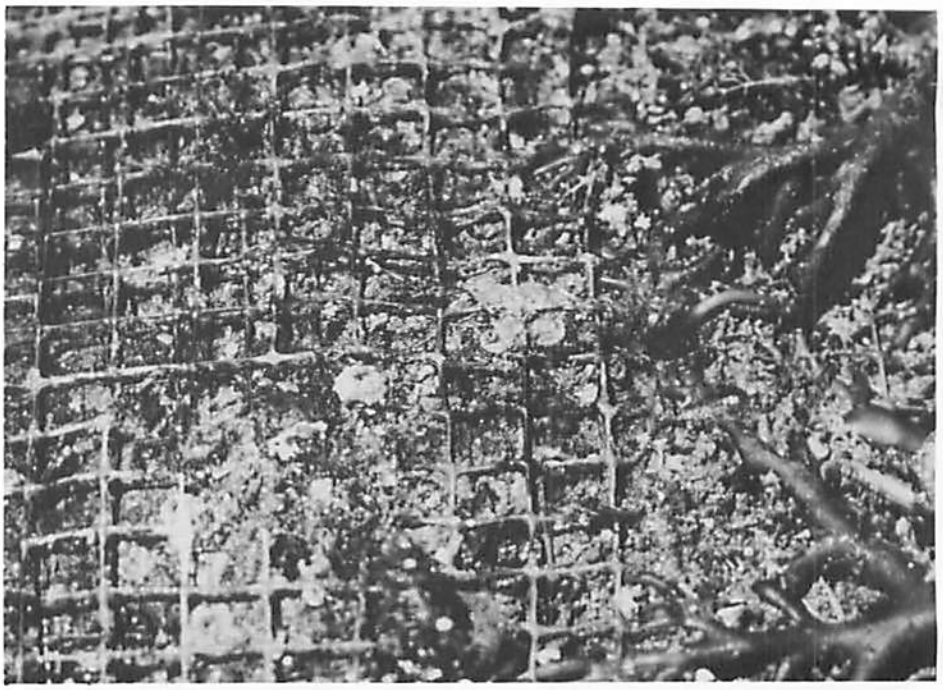
Close-up of bale mesh (1/4-inch mesh size) showing attachment of algal holdfasts and a sea urchin feeding on the bale surface.

Cross section of a solid waste bale after being submerged for nearly three years. The sabellid polychaete worm shown had penetrated the bale to a depth of nearly 5 cm.

How these short-term rates will change over the long term is impossible to estimate. It appears that physical biological destruction will be more important than chemical disintegration.

A predictive model was developed to determine the effect on water quality of a commercially feasible ocean dump. Using the short-term-based decomposition rates measured in this study, it was found that dumping baled solid waste in the ocean under the appropriate conditions would not be harmful to the water quality for the parameters examined and over the short term.

Finally, an attempt was made with DS/RV ALVIN to recover a bale - and plate-fouling rack that was emplaced in Veatch Canyon a year ago. The attempt was unsuccessful even though the rack had been equipped with a pinger to assist in locating it. The rack may have been caught in a trawler's net and dragged far from its emplacement site and out of the pinger's range.



Close-up of bale mesh (1/4-inch mesh size)showing attachment of algal holdfasts, providing a trap for sediment and shelter for organisms such as the brittle star in the lower right corner. An encrusting red alga and barnacle are seen in the center of the picture.

Chemical, Physiological, and Analytical Studies on Red Tide Toxins

Co-Principal Investigators:
Professor Miyoshi Ikawa
Professor John J. Sasner, Jr.
Graduate Students:
Mr. Lawrence J. Buckley, Ph.D. Program in Biochemistry
Ms. Nancy A. Higley, Ph.D. Program in Biochemistry

Since the disastrous red tide of September, 1972, which affected the coastlines of New Hampshire, northeastern Massachusetts, and southern Maine, studies have been conducted at the University of New Hampshire on the poison produced by *Gonyaulax tamarensis*, the causative organism of this and subsequent red tides that have occured in this region. The poison ac-

Determining red tide toxins using a thin-layer chromatographic fluorometric procedure.

cumulates in shellfish that feed on the dinoflagellate and causes the shellfish to become toxic to humans, birds, and other animals that in turn feed on them. The poison causes death by respiratory failure and is referred to as paralytic shellfish poison (PSP).

After the 1972 red tide occurred, extensive series of mouse bioassays were conducted at the University for the state of New Hampshire (Department of Public Health) to determine PSP levels in a variety of shellfish collected in the Hampton-Seabrook area and other areas along the New Hampshire coastline. Shellfish from Plum Island, Massachusetts, were also assayed for PSP. Extremely high levels of 4000-5000 micrograms of PSP per 100 grams of shellfish meat were detected during the height of the red tide in the soft-shell clam *Mya arenaria*, the principal shellfish consumed by humans in this area. This was 50 times the safe level of poison. Only the quick action of public health officials in ordering clam flats closed, confiscating supplies of suspect clams, and warning the public averted a major human disaster.

Continuous monitoring at the University of New Hampshire showed that PSP levels in mussels *Mytilus edulis* dropped to safe levels in approximately two months but that soft-shell clams remained toxic and unsafe for human consumption for a period of six to seven months after the disappearance of the red tide.[1]

During the height of the 1972 red tide a large quantity of toxic clams were collected with the help of the New Hampshire Fish and Game Department and the Parker River National Wildlife Refuge at Plum Island, Massachusetts. These were stored in the frozen state for future studies. By a series of extraction and chromatagraphic procedures three toxins have been isolated from the toxic claims[2,3] and designated minor toxin, major toxin H, and major toxin L. Minor toxin was identified as saxitoxin, the PSP previously identified in West Coast shellfish and produced by *Gonyaulax catenella*.[2]

During the course of this work a sensitive procedure was developed for assaying the various fractions for the three toxins. This method consisted of chromatographing the fractions on a thin-layer silica gel plate to separate the poisons, spraying the plates with a hydrogen peroxide solution to convert the poisons to highly fluorescing derivatives, and scanning the plates in a fluorometer and recording the fluorescence on a chart recorder. This and other chemical and physical methods are currently being investigated as alternative methods to the mouse bioassay for the rapid estimation of PSP in various marine products.

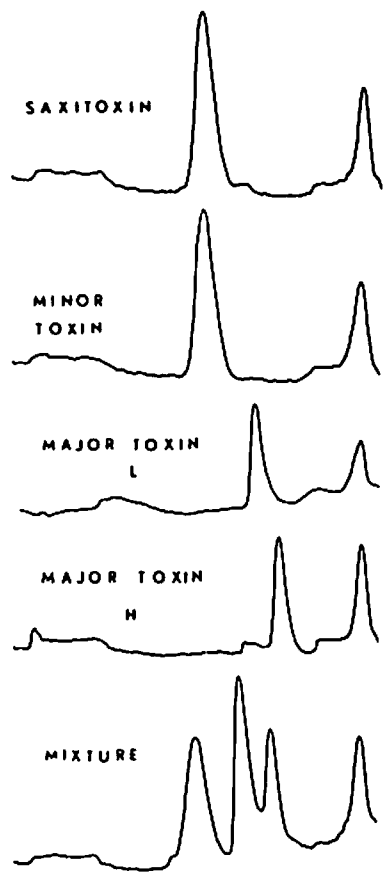
The physiological effects of the poisons from *G. tamarensis* were studied using standard neuromuscular preparations. Their general site of action appears to be at the membrane level where excitability is reversibly blocked without alteration in the transmembrane resting potential. We have, thus far, been unable to distinguish the toxic effects of *G. tamarensis* poisons from those of the Pacific dinoflagellate *G. catenella*. The latter inhibits activity of nerve and muscle membranes by specifically blocking Na^+ conductance pathways without altering the flow of K^+ through the membrane.

Methods for the detoxification of the poisons and the detoxification of shellfish are currently being explored.

[1] J.J. Sasner, Jr., M. Ikawa, and B.E. Barrett, "The 1972 Red Tide in New Hampshire," *Proceedings of the First International Conference on Toxic Dinoflagellate Blooms*, Massachusetts Science and Technology Foundation, Wakefield, Mass., 1975, pp. 517-523.

[2] L.J. Buckley, M. Ikawa, and J.J. Sasner, Jr., "Purification of Two *Gonyaulax tamarensis* Toxins from Clams," *Proceedings of the First International Conference on Toxic Dinoflagellate Blooms*, Massachusetts Science and Technology Foundation, Wakefield, Mass., 1975, pp. 423-431.

[3] L.J. Buckley, M. Ikawa, and J.J. Sasner, Jr., "Isolation of *Gonyaulax tamarensis* Toxins from Soft-Shell Clams (*Mya arenaria*) and a Thin-Layer Chromatographic-Fluorometric Method for Their Detection," *Journal of Agricultural and Food Chemistry*, 1976, pp. 107-111.



Fluorometric trace of the separation of the Gonyaulax tamarensis *toxins on a thin-layer plate.*

Ocean Engineering

The Design, Analysis, and Field-Test Verification of a Dynamic Floating Breakwater

Principal Investigators:
Professor Godfrey H. Savage
Professor Kerwin C. Stotz
Professor Alden L. Winn

Associate Investigators:
Mr. David J. Agerton, Ph.D. Candidate, Engineering
Mr. John R. Delano, Master's Program in Electrical Engineering
Mr. Dean A. Vidal, Master's Program in Mechanical Engineering

Undergraduates
Mr. Richard B. Fuller, Thompson School of Applied Science
Mr. Geoffrey S. Lord, Mechanical Engineering
Mr. Gustave W. Ruetenik, Mechanical Engineering

Assisting Personnel:
Mr. Robert A. Blake, Technician
Mr. David O. Libby, Engineer, Engineering Design and Analysis Laboratory
Mr. Paul E. Lavoie, Instrumentation Consultant

The engineering objectives of this project were: (1) to field-test the concept of a dynamic floating breakwater on a larger scale than had previously been attempted; (2) to verify the predictive mathematical model of the breakwater; (3) to test the use of elastic moorings to improve both the survivability of the system and its effectiveness as a breakwater.

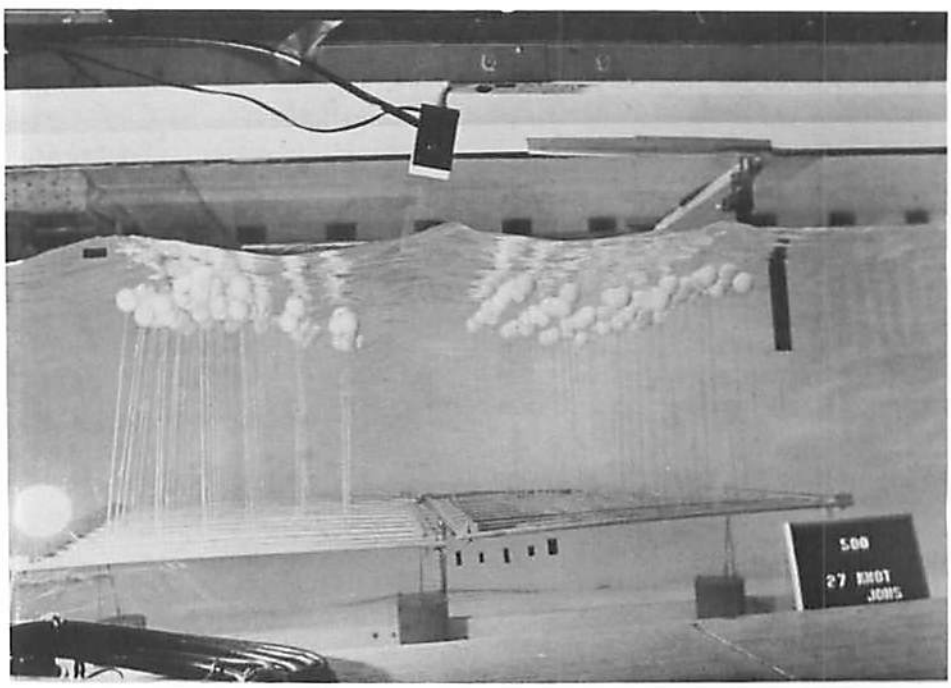
The concept of a dynamic floating breakwater, originated by Mr. Richard Seymour and Professor John Isaacs at Scripps Institution of Oceanography, consists of an array of spherical buoys held about one buoy diameter beneath the still water surface. The buoy size and wire tether length are chosen so that the resonant frequency of the tethered element is close to the predominant frequency of the anticipated storm waves. Because of its dynamic response characteristics the tethered buoy will oscillate back and forth like an inverted pendulum. The amplitude of its orbit will be greater than that of the surrounding water particles, and it will be out of phase with the surrounding water by about 90 degrees. This results in the buoy's having a high velocity relative to the water. Substantial wave energy can be dissipated in the resulting turbulence because the drag power increases as the cube of the relative velocity.

In proposing this project, it was recognized that the system, as then developed, oscillated with only one degree of freedom. Based on the years of experience using compliant moorings at the UNH Engineering Design and Analysis Laboratory (EDAL), it was reasoned that use of compliant moorings might increase not only the survivability of such a breakwater system, but also its effectiveness, because elastic tethers would permit each breakwater element to oscillate vertically as well as horizontally.

In January, 1975, student personnel tested, in a wave tank, a variety of single breakwater elements as well as several arrays of elements. An optical displacement follower was used to track the response of a single buoy. Also, the wave attentuation by the 12-row array of two-inch diameter styrofoam floats was measured in both regular and irregular waves. Both elastic and wire tethers were tested.

Results of these experiments, coupled with linear and nonlinear mathematical models of the system, gave the project team the confidence to proceed with a large-scale field experiment in storm waves in Lake Winnipesaukee, New Hampshire, at Diamond Island, site of the EDAL Ocean Engineering Station.

In May, a transmission line wave staff, designed and built by EDAL

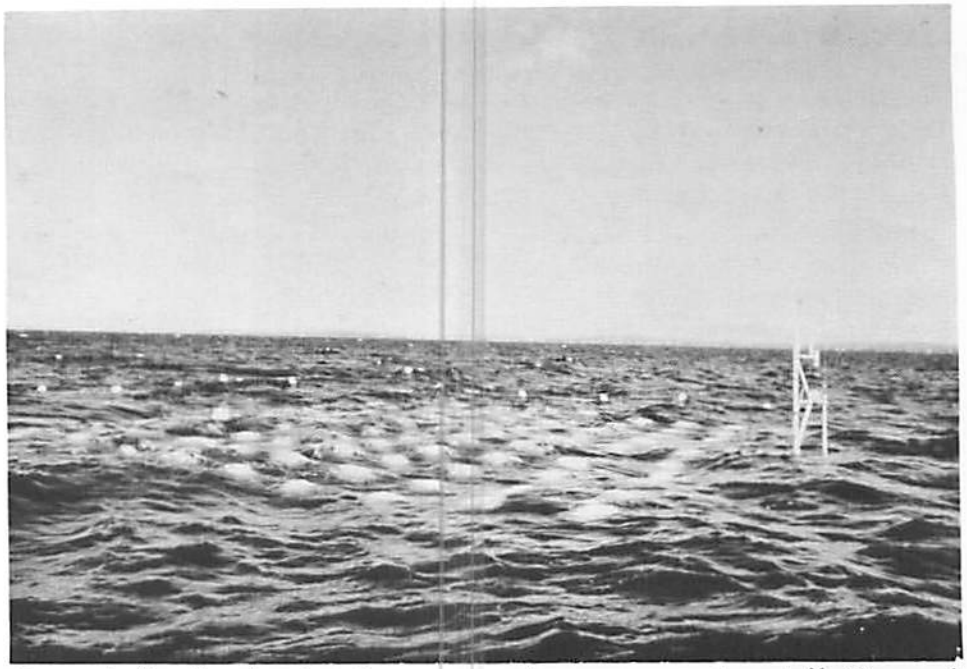


Dynamic test of the breakwater model showing wave attenuation, January, 1975. Wave is moving from left to right in the picture.

personnel, was installed on a pile driven in 35 feet of water off Diamond Island. Adjacent to it, an instrumented, elastically tethered buoy was installed. Data from dual-axis inclinometers and a tensiometer, along with the wave staff signals, were sent ashore by hard wire to a digital tape recorder located in a shore station. These data were analyzed to provide buoy response and wave spectra. Simultaneously, a variety of elastic tethers were tested for reliability of their terminals and mechanical stability.

In July and August, a test section of breakwater was constructed and installed just to the leeward of the wave staff. A forty-foot by forty-foot structural steel frame was constructed in four sections. These were transported to the site by a crane barge and joined together underwater by student divers. The frame was supported by nine adjustable legs so as to provide a level platform close to the sloping bottom. Anchoring was provided by large concrete blocks set onto foot pads at each leg. The entire assembly, installed in two days, weighed 25 tons.

Several days later 90 two-foot-diameter inflatable buoys were installed, again by divers, Each buoy was held to the fram temporarily by a releasable knot while it was inflated underwater. Upon release, the buoy rose to its position just under the surface, tensioning the dual strand, NATSYN elastic tether. Finally, a wave staff was added to the instrumentation to provide measurement of the wave field after it passed through the test breakwater section.



Dynamic floating breakwater array and wave measuring staff, Diamond Island, Lake Winnipesaukee, N.H., October, 1975.

All instrumentation was operational in September, 1975. However, it was not until late December that the long-awaited design wind conditions arrived to give the system a proper test.

Preliminary analysis indicates that the breakwater performance was within the range expected. Data are being analyzed further to refine the correlation of design criteria and performance.

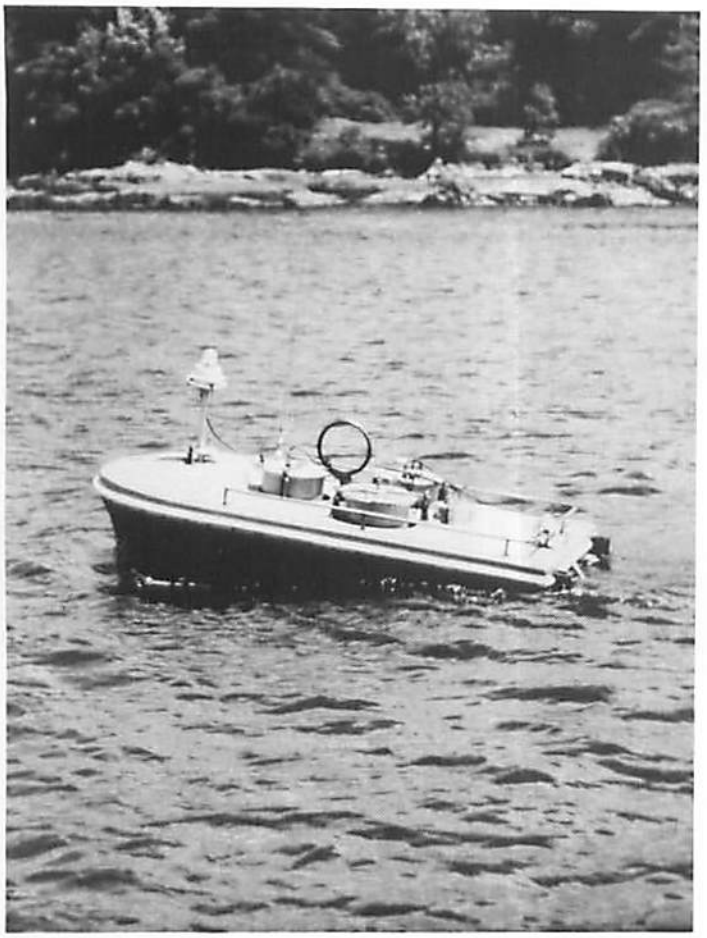
Hydrodynamic and Environmental Modeling of the Great Bay Estuary System

Principal Investigator:
Dr. Barbaros Celikkol
Field Program Supervisor:
Dr. Wendell S. Brown
Associate Investigators:
Dr. Musa Yildiz
Dr. M. Robinson Swift
Field Program Assistant:
Mr. Steven J. Szydlick
Graduate Students:
Mr. Ronnal P. Reichard, Ph.D. Program in Engineering
Mr. Erick M. Swenson, Master of Science Program in Geology
Undergraduate Students:
Mr. John L. Ayvazian, Mechanical Engineering
Mr. Kenneth C. Dallas, Mechanical Engineering
Mr. William L. Keith, Mechanical Engineering
Mr. Steven J. Szydlick, Geology
Technical Assistant:
Mr. Lee Amoroso

The purpose of this study is to understand the environment of the Great Bay Estuary System and adjacent waters, and to develop predictive models describing the dynamics of the estuary. The field data gathered during the first year of the project and the hydrodynamic models already adapted will provide the basis for the development of a dispersion model of suspended particular matter and dissolved chemicals.

During the first year of the project, a two-dimensional hydrodynamic model for the Great Bay Estuary System has been made operational. The modeling group has adapted a finite element hydrodynamic model to the estuary.

This model is currently being calibrated using data obtained in field. Further theoretical and experimental research is being carried out to understand the mixing



Surface station for a National Ocean Survey (NOS) current meter mooring. Current meter data are recorded on magnetic tape and simultaneously transmitted to a computer aboard the R/V Ferrel.

Deployment of a profiling current meter in the Great Bay Estuary. Current speed and direction for each chosen depth are recorded aboard the ship.

processes in the estuary and the interpretation of turbulence data.

The principal goal of the field work of the first year has been to describe the variability of currents at different locations in the estuary. The National Ocean Survey (NOS) has deployed an extensive moored current meter array in the estuary designed to measure currents at fixed locations for long time periods. Additional data were obtained from the Great Bay Environmental Project, a Marine Program study supported by the Leslie S. Hubbard Marine Program Fund. In the Hubbard sponsored study, currents were measured for short time periods at several selected locations across the bay.

During the coming year an attempt will be made to explain the observed current distribution in terms of sea level changes, friction, and the geometry of the estuary. The results of this program will be used to verify and refine the numerical hydrodynamic model which is being developed simultaneously. In addition, the predictions of analytical models will be compared with these results.

As a whole, this data set will provide a context for the interpretation of future studies in fluid turbulence, nutrient and sediment distribution, and biological productivity.

Recently proposed industrial development in our coastal region, combined with the demands of governmental agencies concerning the proper dispersal of sewage and other wastes, have shown the necessity for baseline information on the Great Bay to understand the effect of present nutrient loading and related pollution. The flux of nutrients through the estuary is being measured, and studies of the dynamic interaction between dissolved nutrients in the water column and the estuarine sediments are being conducted. This information will be coupled to the concurrent hydrodynamic modeling study to aid in prediction of the distribution of nutrients within the estuary.

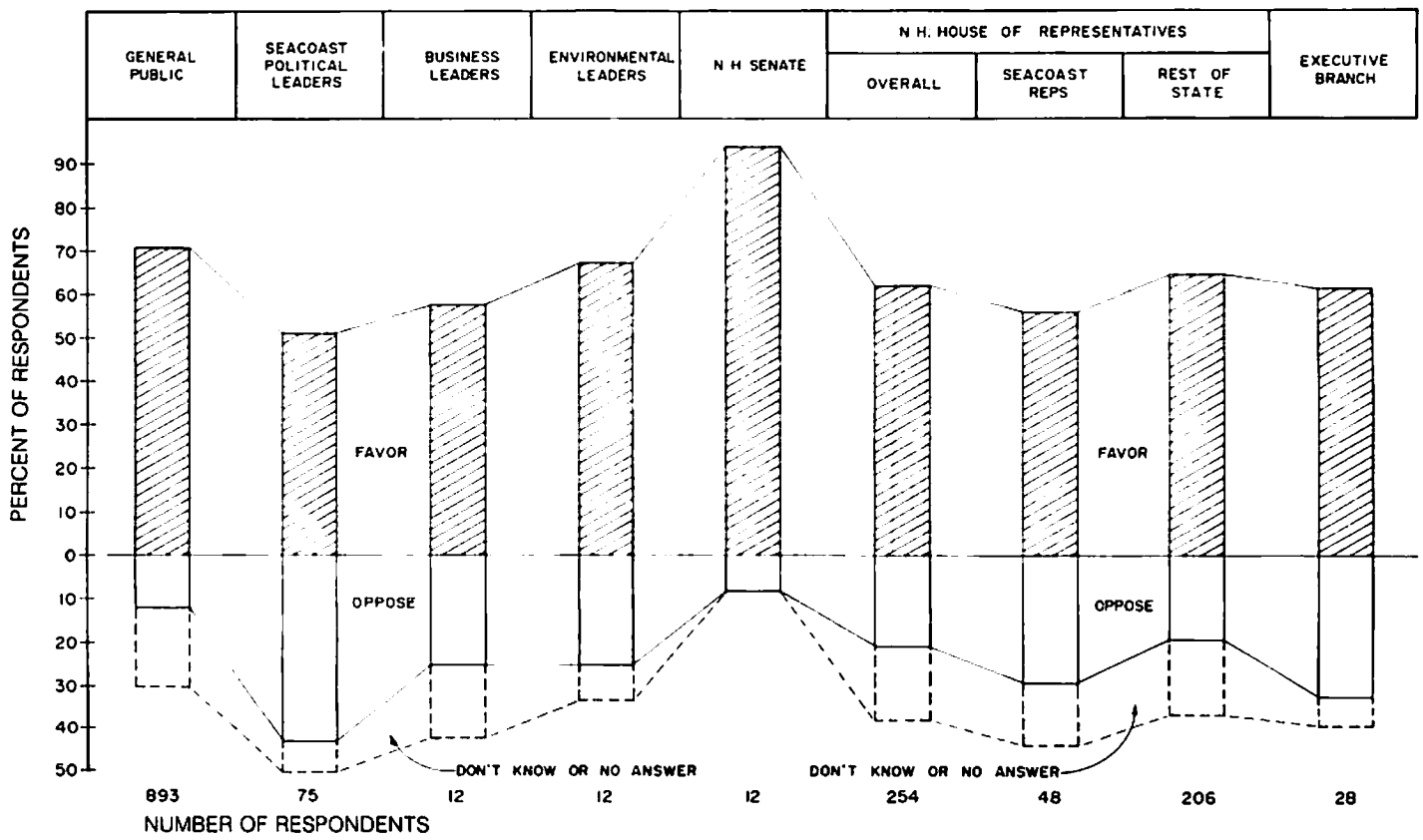
Coastal Zone Management

An Assessment of the New Hampshire Political Climate Concerning Coastal Zone Management Issues

Principal Investigator:
Professor David W. Moore
Graduate Student:
Christopher W. Herrick, Master of Arts Program in Political Science

The political climate in New Hampshire clearly supports the development of a Coastal Zone Management Plan for the seacoast area of the state. In the spring of 1975, a survey was conducted of several groups of people in New Hampshire who would have a direct interest in such a proposal. As the accompanying chart reveals, support for a Coastal Zone Management (CZM) plan is strong at every level of government. The general public in the Seacoast; local political leaders, comprising the town managers and selectmen, city mayors and managers, plus the city councils; and representatives of business and environmental interest groups concerned with Seacoast issues were all strongly in support of a CZM plan. Strong support was also expressed by members of the New Hampshire General Court (official name for the state legislature), including both the House and Senate; by selected members of the executive branch, officials directly concerned with economic development in the state; and by the five members of the Governor's Executive Council.

Various other aspects of a CZM plan, however, did not elicit the same strong consensus. Seacoast political leaders, for example, are intensely concerned with the possible erosion of home rule, or local autonomy, that a CZM plan might entail. Thus their support, although



Question: "Would you favor or oppose the establishment of a management agency to plan for the use of resources in the seacoast area?"

Desirability of a Coastal Zone Management agency.

given by a majority, is the weakest among all groups. Even among those expressing support, almost a third expressed concern for the maintenance of home rule. As a consequence, Seacoast political leaders are much more in favor of placing major responsibility for implementing a CZM plan at the local level than at either the Seacoast regional or state levels, while the general public, Seacoast interest group leaders, and the House are more in favor of placing that responsibility at the Seacoast regional level.

The importance of this home rule tradition is reflected also in the opinions about the selection of CZM agency officials. Seacoast leaders expressed strong preference for local selection—either through appointment or election—of these agency officials. Even those groups wanting major responsibility for implementing the plan at the regional level nevertheless expressed strong support for selection of agency officials at the local level.

The three regional planning commissions operating in the Seacoast area received a collective vote of confidence. Over two-thirds of the political, business, and environmental leaders indicated that these commissions should play a major role, an advisory role, or both, in a CZM agency. It is clear, however, that these leaders envision some new agency, rather than an amalgamation of the three existing commissions, since they did not give much support to the proposal that the three existing planning commissions should actually constitute the CZM agency.

Among the various levels of government, from the general public in the Seacoast to the executive branch representatives, a strong consensus emerged over some of the possible responsibilities and limitations of a CZM agency. The agency should be able to *veto* local acceptance of a new industry into the Seacoast, for example, if the industry failed to meet acceptable environmental standards or did not fit into regional planning goals, but the agency should not be able to *approve* an industry rejected by a local community. This latter "override" authority was overwhelmingly opposed at all levels of government, suggesting the pervasive influence of New Hampshire's home rule tradition. General land use regulation by a CZM authority did not receive majority support among any of the Seacoast leaders, although a plan to allow a more limited authority within a specified distance from tidal waters (such as 500 feet) received substantially greater support, and even majority support, among some of the groups of respondents.

The survey investigated two possible appeal procedures, one allowing appeal of agency decisions to the Governor and Executive Council, the other allowing an appeal to the state legislature. Both proposals were quite controversial, although the consensus among Seacoast leaders appeared to be generally against either "political" appeal procedure.

Finally, the survey explored attitudes about various development proposals that would have to be faced by a CZM agency. At all levels of government, respondents expressed strong support for encouraging both industrial and recreational development in the Seacoast area, although they differed about the relative emphasis that each type of development should receive.

With respect to specific proposals, the survey investigated attitudes about the construction of a nuclear power plant in Seabrook (in the Seacoast area) and about issues related to the construction of an oil refinery somewhere in the Seacoast region. Several oil refinery proposals have already been made by various companies, but in spite of the state administration's continued efforts to attract an oil company to the area, no definite plans now exist to build an oil refinery. A specific proposal to construct a nuclear power plant at Seabrook, however, is currently being reviewed by appropriate federal agencies. Reactions to these proposals were elicited in the survey, and the results reveal strong support among all respondents, except the environmental leaders, for the nuclear power plant. The oil refinery issue, however, is much more controversial, as is the related issue of whether to build an oil supertanker port off the coast of Portsmouth. Most Seacoast leaders are opposed to these issues, though other groups of respondents were more in favor. Strong consensus emerged among all groups of respondents, however, favoring the proposal to make the Isles of Shoals, nine miles off the coast of Portsmouth, a natural preserve by forbidding all development of them.

The results of this survey were reported to the New Hampshire State Office of Comprehensive Planning in a series of five reports, and were reviewed in the state's preparation of legislation to establish a CZM plan for New Hampshire. A final report will be distributed by the University of New Hampshire Marine Advisory Service to all respondents participating in the survey, except for the general public, and to other state agencies and officials as requested. The information will be disseminated to the general public by a series of articles in the various Seacoast newspapers.

The Economy of the New Hampshire Coastal Zone

Principal Investigators:
Professor William F. Henry
Professor Sidney E. Feld
Mr. Dennis M. King

Associate Investigator:
Professor Owen B. Durgin

Graduate Students:
Mr. John P. Browne, Master's Program in Resource Economics
Mr. Donald R. Morgan, Ph.D. Program in Economics

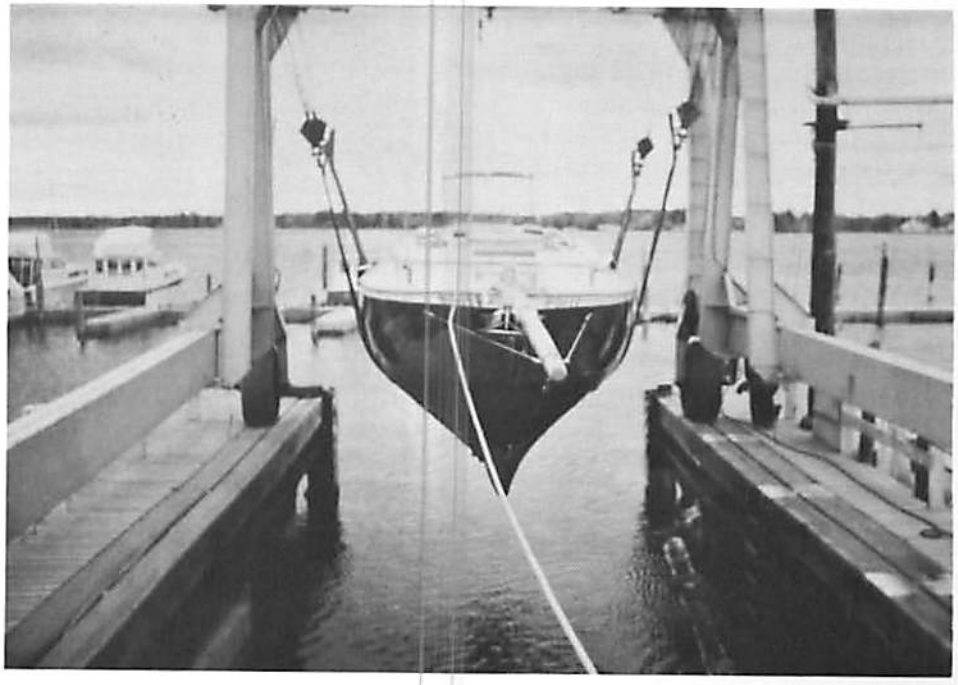
The economy of the New Hampshire Coastal Zone is being studied using a method known as an Interindustry Analysis. This approach has many advantages because it not only provides measures of the total economic activity in the region, but it also shows the ways in which the various economic sectors relate to each other and to the rest of the United States. Such analysis is also useful in determining the economic impacts of new industries, including any effects on the personal incomes of people in the region.

The research covers two major concerns: one is the general economy of the 16 municipalities in New Hampshire that make up the Coastal Zone; the other is the marine oriented industries in those municipalities. The makeup of the Coastal Zone is consistent with that established by the New Hampshire Office of Comprehensive Planning and the Southeastern New Hampshire Regional Planning Commission, and consists of all towns and cities that are adjacent to the ocean and tidal water.

A study of the general economy of the Coastal Zone requires the assembly of copious data about the purchases and sales of business and industry and the import and export of goods and services. To accomplish this analysis, all of the economic activity of the region was divided into producing sectors and consuming sectors. The analysis included twenty-four producing sectors under the four major headings of extractive, construction, manufacturing, and nonmanufacturing; and seven consuming sectors dealing with households, government, imports-exports, and inventories. Data to accomplish the analysis have come from state and regional agencies, interviews, and the updating of a study of the Coastal Zone done several years ago.

Sea Grant is particularly interested in the marine environment and the economic activity which is based on, or related to, the ocean. Therefore, this study group is conducting a special analysis of marine oriented activity in the New Hampshire Coastal Zone. Information regarding marine orientation of economic activity is almost entirely lacking, so a special survey of 2,071 firms and agencies in the 16 coastal municipalities was conducted. The results of this survey will be incorporated in the overall analysis of the Coastal Zone economy. Some of the information from the survey is:

1. Exactly half of the responding firms have some relationship to the marine environment in one or more of the following ways:
   a. handle a product derived from the water,
   b. provide a product or service that people use in the water,
   c. provide services or products to seacoast tourists.
2. Although fewer than 5 percent of the firms derive all of their income from marine related activity, about 30 percent of all Coastal Zone firms derive more than a tenth of the income in that way.
3. Whether a firm is marine oriented or not, almost a sixth of the firms found that location in the Coastal Zone is helpful in attracting employees.
4. The size of business as measured by gross receipts follows the same pattern for firms whether



A marine industry in the Coastal Zone. This marina in Newington, N.H., stores over four hundred boats each winter, approximately 85 percent sail boats.

they are marine oriented or not, so marine oriented firms are neither larger nor smaller on the average than other firms. In both cases firms grossing over $150,000 a year make up 52 percent of all firms.

The interindustry transactions matrix from this study will be particularly useful in analyzing the economic impacts of suggested or anticipated changes in the local economy. The next stage in this study will be to determine the likely onshore effects of outer continental shelf petroleum exploration and development which appears to be coming soon. It is also adaptable to analyzing the impacts of other growth and expansion plans in the New Hampshire Seacoast. Two such developments that appear important are marine oriented recreation and the port of Portsmouth, particularly the New Hampshire Port Authority Pier on the Piscataqua River.

The results of this Sea Grant project cannot be thought of as final answers to particular questions nor as a table of recommended practices for the seacoast region. Rather, the results will provide an understanding of the makeup of the regional economy, and will be used in the planning processes by public agencies and communities.

A Study to Aid State and Regional Planning for Management of the Mineral Resources in the New Hampshire Coastal Zone

Principal Investigator:
Professor Robert W. Corell
Research Assistants:
Mr. Fred Haug
Ms. Roberta J. Sanders

The purpose of this study project was to provide background information to offices of state and regional planning and policy making agencies as it related to mineral resources in the offshore region of the New Hampshire Coastal Zone. The project undertook to develop a document, now in the final phases of publication, which presents the available information on mineral resources in the New Hampshire offshore region, which describes state and federal mining laws as they relate to the New Hampshire situation, and which describes some of the economic factors related to mineral resource development and exploitation. The document also discusses important multiple use issues connected with marine ecosystems, offshore mining, and other factors which relate to the use of the waters and the ocean bottom in the New Hampshire Coastal Zone.

The general physical and geological character of the New Hampshire Coastal Zone was obtained from a variety of sources, including the open literature, proprietary information from industrial surveys, government reports, and unpublished research. This provided a composite picture of the surficial mineral deposits in the New Hampshire Coastal Zone. Ten different studies were used which described the seafloor off the coast of New Hampshire. Detailed maps were produced to depict the cobble, rock, sand and gravel, and pockets of silt, silty sand, and other mixtures of these constitutents. The only minerals in the New Hampshire Coastal Zone of any potential economic consequence are sand and gravel. The report excluded any consideration of deep subsurface deposits of any kind, such as gas and oil. The published report will provide descriptive material which identifies the location and general scope of the sand and gravel deposits in this region.

The report also discusses the current technology for offshore mining and the types of mining systems that might potentially be employed to remove sand and gravel deposits in the coastal zone. An important component of the study deals with the interrelation between the ocean ecosystem and sand and gravel mining operations that might potentially alter or influence the ecosystems. The report discusses the impact on microorganisms, plankton, zooplankton, meroplankton, algae, benthic invertebrates, and finfish.

With a coastline of about 18 miles and with active industrial, recreational, social, and political interests in the Seacoast, the interaction among the various uses of the coastal resources has substantial implications to any prospective use of offshore sand and gravel. These factors are discussed in the context of the existing activities within the New Hampshire Coastal Zone. Economic and legal factors are also described.

In addition to providing the factual background on existence of deposits of sand and gravel in the New Hampshire Coastal Zone, the project team is preparing summary guideline suggestions that might eventually be used in legislation that relates to the control and effective management of this resource in the New Hampshire coastal region.

The Marine Advisory Program

The Marine Advisory Program at the University of New Hampshire

Coordinator:
Dr. Bruce A. Miller

The Marine Advisory Program at the University of New Hampshire continues to expand its relationship with personnel from most marine interests in the state. One objective of the program is to identify the needs of state and local governments, industry, business, educational, and community organizations for information or advice concerning marine matters. The aim is to foster the practical application of available marine information toward solving social, economic, environmental, and engineering problems of the state and of the region. This may be accomplished either by dissemination of pertinent information through general reports on marine related research, by published newsletters and press releases, or by answering individual requests for information.

During the year 1975, the New England Marine Advisory Service (NEMAS) was formally established. NEMAS is a cooperative venture based at the New England Center for Continuing Education in Durham, with membership composed of the marine advisory services of all the New England states. Funded by Sea Grant late in 1974, its Board of Directors has hired a full-time director whose duty is to promote regional talent sharing and information exchange and to organize timely conferences and seminars on topics of importance to the marine community of the region. In addition to disseminating marine information through both technical and general reports and newsletters, NEMAS also sponsors educational conferences and workshops. During the past year, for example, NEMAS has hosted conferences dealing with the broad subjects of mariculture and marine recreation.

A primary effort of the University of New Hampshire Marine Advisory Program has been toward the continued development of a diversified sea food program in New Hampshire and southern Maine. Here at the University of New Hampshire, the Advisory Program has continued to cooperate with two Maine agencies and an aquaculture company in Maine in a promising cooperative development aimed at establishing a sustained blue mussel industry in the Gulf of Maine. This effort seeks not only to improve the harvesting and marketing of natural blue mussel stocks but also to assist in the development of blue mussel culture on a commercial basis. The University of New Hampshire personnel working on salmon rearing problems continue to cooperate with the New Hampshire Fish and Game Department to develop a coho salmon fishery in Great Bay and with a commercial enterprise, Maine Salmon Farms, to produce pan-sized salmon. Another Advisory Program effort, working with companies based in both Maine and New Hampshire, aims at the establishment of commercial lobster culture.

Ocean engineering personnel have regularly assisted individuals, commercial organizations, and state boards on a variety of specific technical questions, and University engineers provide technical consulting services to businesses in the state and region. Marine engineering talks on aspects of the University of New Hampshire program are periodically given to high schools and other audiences throughout New Hampshire.

A continuing activity of the Advisory Program has been to cooperate with the Office of Comprehensive Planning and with the Southeastern New Hampshire Regional Planning Commission in the development of a Coastal Zone Management plan for seacoast New Hampshire. Assistance has also been provided for environmental monitoring studies in the Great Bay estuary and at the Isles of Shoals. A survey report for the New Hampshire Marine Dealers Association which shows the impact of the marina industry on the economy of the state has been published.

As residents of the Seacoast area become increasingly aware of the problems associated with rapid population growth and an influx of new and varied industry, the need for a service to coordinate and disseminate Coastal Zone information becomes more apparent. This accounts for the significant growth in the Marine Advisory Program during 1975, particularly in the critical area of Coastal Zone Management.

Development of a Sustained Edible Blue Mussel Industry in the Gulf of Maine

Co-Principal Investigators:

Abandoned Farm, Incorporated:
Mr. Edward A. Myers
Maine Department of Marine Resources:
Mr. Reginald J. Bouchard
University of Maine (Orono):
Mr. Richard A. Lutz
Mr. Bohdan M. Slabyj
University of New Hampshire:
Mr. Bruce A. Miller

Seacoast residents are well aware of the tremendous quantities of blue mussels along the shoreline. In the past, these mussels have been neglected in favor of other abundant seafood delicacies, such as oysters, clams, scallops, and lobsters. As harvesting pressure gradually depleted the naturally occurring stocks of the more favored shellfish, an inevitable rise in price occurred, soon placing many of these once inexpensive seafoods beyond the reach of the average consumer.

In the spring of 1973, researchers in New Hampshire and Maine held several meetings to discuss projects that could help increase the yield of lower cost seafood from the Gulf of Maine. During the discussions, it became clear that a tremendous untapped resource in the form of blue mussels was available all along the coast. In Europe, this animal, one of the most popular shellfish, is collected from the rocky coasts for local consumption and is intensively cultured on poles and rafts in shallow bays and inlets for regional and foreign markets. In spite of a tremendous harvest, the demand increasingly exceeds the supply.

Why has a shellfish so popular in Europe, and found in such abundance all along the coast of North America, not been sought after in this country? The lack of interest and demand for this product arose primarily because most American consumers have never been properly introduced to the blue mussel. The high price of beef products in April 1973, set a national mood receptive to new sources of protein. In this atmosphere conducive to trial marketing of underutilized fish and shellfish, the Maine Department of Marine Resources, along with the University of New Hampshire, capitalized on the situation by inaugurating a pilot project to test the acceptance of blue mussels. The result was a widespread regional consumer interest in blue mussels, resulting in a substantial rise in Maine mussel landings. Demand dramatically increased in the traditional Boston and New York markets, and in sales by fresh seafood retailers and supermarket chains.

After viewing the positive results of this promotional activity, the decision was made to begin an all-out effort designed to stimulate all aspects of the mussel industry from the fisherman to the consumer. To this end every effort has been made to mobilize the variety of skills required to guarantee success, and to include all individuals and agencies working on any aspect of the blue mussel fishery. The project at present involves the close collaboration of research teams from the University of Maine, the Maine Department of Marine Resources, the University of New Hampshire, and Abandoned Farm, Incorporated, of Damariscotta, Maine. Working communications continue to be maintained with the blue mussel project at the University of Washington, with mussel activities

Eye-catching portable exhibits advertise the many ways of serving blue mussels.

currently in progress at the Harvard University Food Services, and with individuals in the Canadian Maritime Provinces interested in the mussel fishery. Efforts are made to communicate with individuals of other research projects and to provide assistance to anyone interested in establishing a commercial rafting venture.

Marketing and Consumer Education

With the completion of second year activities, mussels have been served, in assorted forms, to 150,000 housewives in their favorite supermarkets and to some 105,000 restaurant owners, store owners, and buyers. Results of consumer education efforts are difficult to assess because of untimely red tide closures during both project years, but in spite of adverse red tide publicity, Maine production for the period from January 1 to April 30, 1975, was 17,656 bushels, a 151 percent increase over the corresponding period in 1974.

In Maine, increased landings are far more significant than is evident from these figures. Maine dealers were previously reluctant to involve themselves in this new industry, because they felt certain that demand for mussels would not develop on a sustained basis. By the end of winter, however, previously skeptical and reluctant dealers were purchasing and selling mussels. Interest in mussels is evidenced by the increased demands for information relative to licensing, sanitation inspection requirements, and the laws governing the harvesting and processing of mussels. Thirty-two dealers, processors, and wholesalers handled mussels during the first four months of 1975, compared to two dealers who were active three years ago.

From October, 1974, to the end of April in 1975, mussels were cooked and served in 70 supermarkets throughout Maine and parts of New Hampshire. Following this exposure, more than 95 percent of the shoppers indicated surprise and genuine interest in mussels, further manifested by increased purchases. In most instances, follow-up visits were made to a store to help solve any problems that may have developed in cleaning, shipping, and packaging.

Diver sampling the 1975 crop of blue mussels from a culture raft at Abandoned Farm, Inc.

Food technologists at the Maine Department of Marine Resources developed a breaded mussel for restaurant use. The product was mass produced by departmental personnel and subsequently used at the National Hotel, Motel, and Restaurant Show in New York City. As a direct result of this exposure, utilization of mussels in restaurants, particularly in the New England area, increased almost immediately, and the rate of increase accelerated throughout the winter of 1975. One Maine processor adopted the product as a regular production line item, packaged in five-pound boxes for institutional and restaurant use.

Utilizing a limited supply of frozen breaded mussels which were processed during the winter months, the department continued to expose the product to New England consumers during the red tide closures. Mussels were also served at summer festivals and special events in Maine and New Hampshire through the summer and early fall. This helped to illustrate that, as the mussel industry matures, processed mussels will be available throughout the year.

Experimental Culture of Mussels in Maine and New Hampshire

Results of the experimental mussel culture program at the University of Maine's Darling Center continue to be most encouraging. A total of six experimental rafts, complete with mussels, were supplied to interested individuals, one private commercial operation (Intertide), and one marine biological laboratory (St. Andrews).

Graphs depicting monthly growth and mortality of mussels have been prepared for each of the

environments. Twelve experimental rafts were placed in six Maine and six New Hampshire environments including the heated effluent waters of three power plants (one nuclear plant and two fossil fuel plants), as well as in an open-water coastal environment (Isles of Shoals). Results of this study, which are currently being prepared for publication, should shed light on whether there is an aquacultural potential for mussel culture in the heated effluent waters of power generating stations.

Abandoned Farm, Incorporated, has been assisted in producing selected, hatchery reared seed mussels. Photomicrograph sequences of the larval forms of two indigenous species of mussels have been prepared and should be of assistance to commercial operations in monitoring spat-fall. Data have been obtained on the growth of mussels, as a function of vertical distance above and below the mean low water level, in an attempt to quantify the potential of increased fishery productivity when certain rafting techniques are employed.

Through a cooperative effort with Abandoned Farm, Incorporated, initial measurements have been made on the growth, pearl incidence, and meat yields of mussels held at different depths down to 3 m on Manila rope hung from an existing large-scale commercial raft. For comparative purposes, mussels of similar size were also sampled from an adjacent shore population at the mean low water level. Results indicate little or no difference in growth, meat yield, and pearl incidence among rope grown mussels sampled, but drastic differences were apparent between the shore and raft-based populations. Rafted individuals were larger in size, had no pearls of any consequence to the consumer, and had a meat yield estimated at approximately twice that of mussels from the adjacent shore population.

The results of four years of mussel research under various Sea Grant projects have been presented in the form of a doctoral dissertation (University of Maine, Orono).

Extension of Shelf Life, Storage, Handling

In an extension of studies conducted during 1974, problems of storage, handling, and taste continued to be explored by the University of Maine at Orono. Results of research aimed at determination of the best methods for long-term storage indicate that blue mussel meat can be effectively preserved either by canning or through subzero storage. A mussel acceptable in taste is obtained through canning, but the meats resulting from this process often tend to be softer than the fresh product. Rapid freezing of mussel meats and storage at -10° F appears to be the method of choice for extended storage, since mussels properly packed to prevent dehydration can be held up to one year without any significant change in quality. Length of short-term storage varies, but is primarily dependent upon bacterial load and temperature of storage. When mussels low in bacterial content are held on ice at 32° F, shelf life may safely be extended up to two weeks. Results of this and other research on mussel quality have been released in the form of a publication entitled, "Handling and Storage of Blue Mussels in Shell."

Commercial Culture of Mussels

The first commercial mussel-culture company in the United States, Abandoned Farm, a Maine corporation located at Damariscotta, was formed to produce and market mussels grown on rafts moored in the Damariscotta River. Abandoned Farm joined the Sea Grant project in 1975 to determine the economic feasibility of commercial mussel culture in Maine. Given the continuing success of the mussel promotion program in contributing to a Maine sale rate surpassing 2,500 bushels a week in 1975, it is reasonable to predict a continually increasing demand for both the natural and the cultured product.

Current work by the company, assisted by researchers from the Darling Center, seeks to provide information needed to develop raft cultivation procedures geared to Gulf of Maine waters. When combined with information already adapted from commercial mussel operations in other parts of the world, the information should establish the means to economic success for Abandoned Farm and for other commercial mussel mariculture ventures in northern New England.

It is appropriate to repeat the final statement of last year's report: "Even though investments of time and capital will be continuously necessary to establish a sustained mussel fishery within the next few years, its development to utilize both high-quality natural stocks and to develop a cultivated product can be a considerable boost to the local and regional economies. Because of these potential economic benefits, the probability for success, and the relatively low expenditures estimated as required to effect significant results, development of the blue mussel industry should continue to hold priority as a program for the New England states."

The Undergraduate Ocean Projects Course

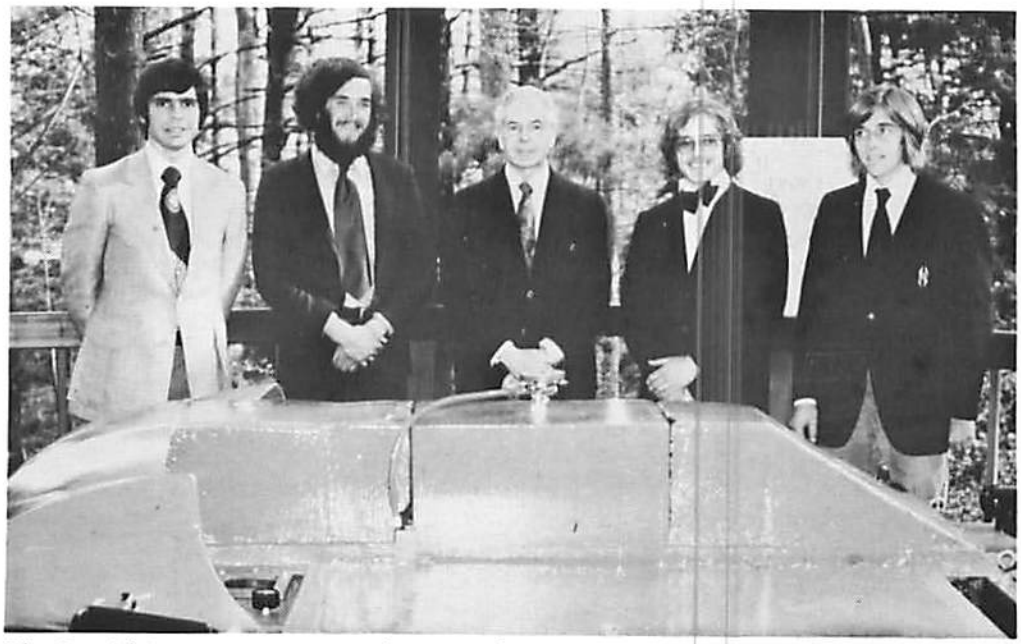
Course Director:
Professor Joseph B. Murdoch

The ocean engineering projects course at the University of New Hampshire was begun in 1965-66 and has been funded since 1968-69 by the Sea Grant Office of National Oceanic and Atmospheric Administration. It is the only academic year undergraduate education program sponsored by Sea Grant.

The projects course provides the undergraduate student with an educational experience that he would not normally receive in his academic program: the experience of working as a member of an interdisiplinary team on a meaningful ocean-related problem under real-world constraints. Projects are of three basic types: those that lead to a piece of working hardware to solve a technological problem, those that involve the gathering and analysis of biological and geological data, and those that are comprehensive studies of an ocean-oriented societal problem with recommendations for actions.

Under the guidance of a faculty advisor, each student team defines a problem, prepares and submits a budget, engages in dialogue with experts in the ocean community, makes progress reports, and writes a comprehensive final report. In addition, students on hardware-oriented projects deal with vendors and design, build, and test prototype models; whereas students in nonhardware-oriented projects meet with local, state and federal officials, do comprehensive library searches, and often conduct appropriate surveys. In May, each project group makes an oral presentation and defense of its work, with visual aids, before a jury of experts drawn from the various sectors of the ocean community.

There were seven projects in the 1974-75 projects course involving twenty-five students from six University disciplines. Five of the projects were engineering oriented, one had a societal direction, and the seventh involved a combination of engineering and science. The project voted most outstanding by the group of fourteen jurors at the May jury session was the Diver-Assist Vehicle Project, which therefore received the David W. Drew Memorial Award.



The David W. Drew Memorial Award for the most outstanding project of 1975 was presented to the Diver-Assist Vehicle Project group by the Student Ocean Projects Course jury *(see p. 26).*

The Accelerometer Buoy Project

Advisor:
Professor David E. Limbert

Technician:
Mr. Robert A. Blake

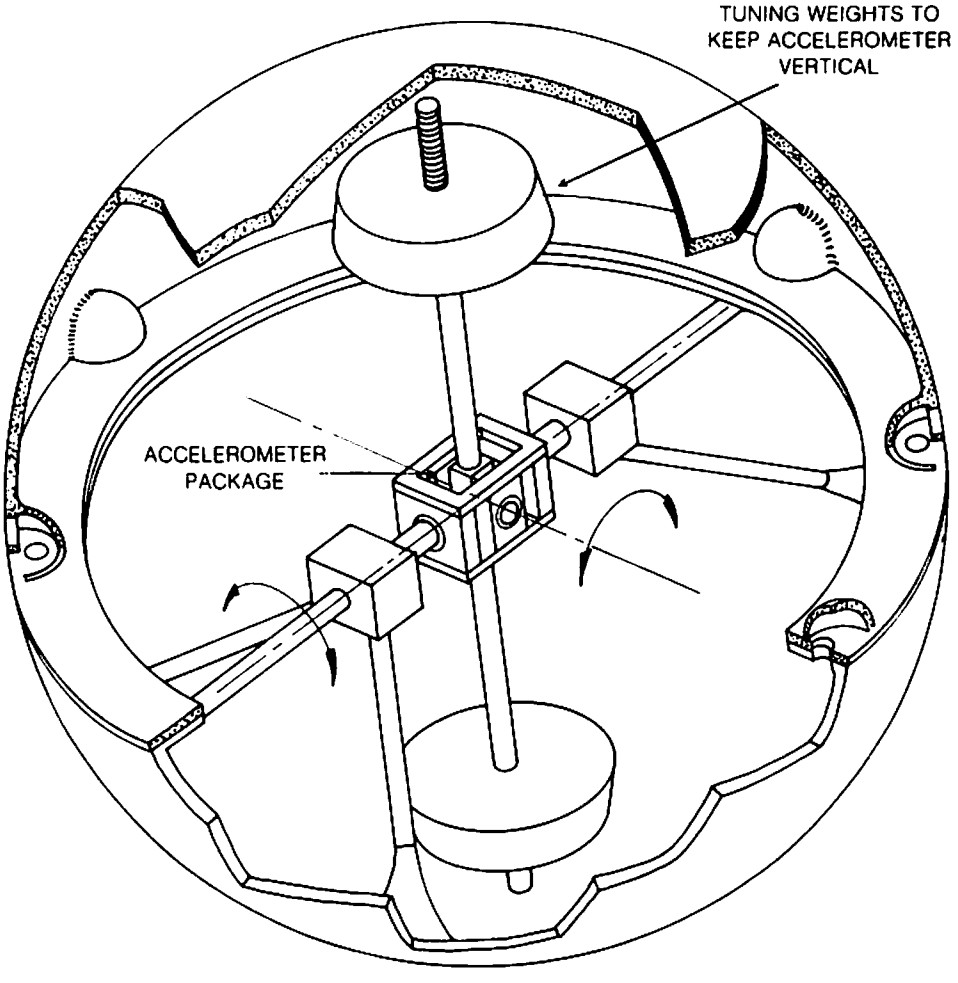
Students:
Mr. Pierre J. Corriveau, Mechanical Engineering
Mr. Niel E. Goodzeit, Mechanical Engineering
Mr. William J. Renault, Mechanical Engineering

The objective of this accelerometer buoy project was to design and construct the mechanical portion of a system to obtain time-dependent ocean wave profiles which could be transmitted to shore by a telemetry system. The accelerometer buoy was chosen after a consideration of a number of other possible devices. Design constraints were: (1) be able to report waves of two to thirty seconds period and two to twenty feet in height, (2) be small enough in size and of low weight so as to be relatively mobile, (3) have few supporting components, and (4) be low in cost so that losses resulting from placing the buoys in high-risk locations will not be serious.

After deliberation, it was decided to make use of a spherical buoy of fiberglass, elastically tethered to the sea bottom, and containing a gimbal on which the accelerometer is mounted. The gimbaled mechanism is tuned, by adjusting two weights attached to rods extending from the top and bottom of the accelerometer package, to have a natural period of response larger than that of the wave input. Thus the gimbal will not rotate in response to exciting forces in the wave field and will maintain a vertical orientation within a reasonable tolerance. The design allows the buoy to tip 45 degrees while the accelerometer package retains its vertical orientation.

A mathematical model of the dynamics of the gimbal mechanism was made. From this model equations relating the tilt of the accelerometer to the motion of the buoy were developed. Analytical and computer techniques were then used to obtain the parameters relating accelerometer tilt to buoy motion. The analysis showed that no damping need be built into the system. Computer results first showed that the gimbal will not tilt more than 7 degrees for a maximum wave height of 11 feet at a frequency of about 0.4 radians per second. The analysis showed that buoy tilt had little influence on tilt of the accelerometer package in the final design.

A stress analysis followed the dynamic analysis. The mass of the entire gimbaled package, including the weights, was set at 115 pounds. A buoy was finally designed to keep the accelerometer angular deflection within 5 degrees of the vertical when subjected to "normal" wave inputs of 2 to 30 seconds period and an amplitude of 2 to 20 feet. The buoy was built and received a wave tank test to observe response of the buoy and tether. Complete full scale testing of the total buoy system waits on the construction of the telemetry system, which was not a part of this project.



Conceptual design of the accelerometer buoy.

An Acoustic Anemometer

Advisor
Professor Albert D. Frost
Consultant
Professor Ronald R. Clark
Students:
Mr. David A. Eck, Electrical Engineering
Mr. Marc F. Petrin, Electrical Engineering
Mr. Robert M. Reed, Electrical Engineering

Technicians:
Mr. Richard D. Jennings
Mr. Donald MacLennan

Classical techniques used to measure wind speed and direction involve the motion imparted to mechnical objects; rotating cups, propellers, or vanes. The response time of these mechnical devices is long, which somewhat limits the observation of higher frequency fluctations of the wind. Acoustic measurement eliminates time lag and permits more accurate observation of these higher frequency wind fluctuations.

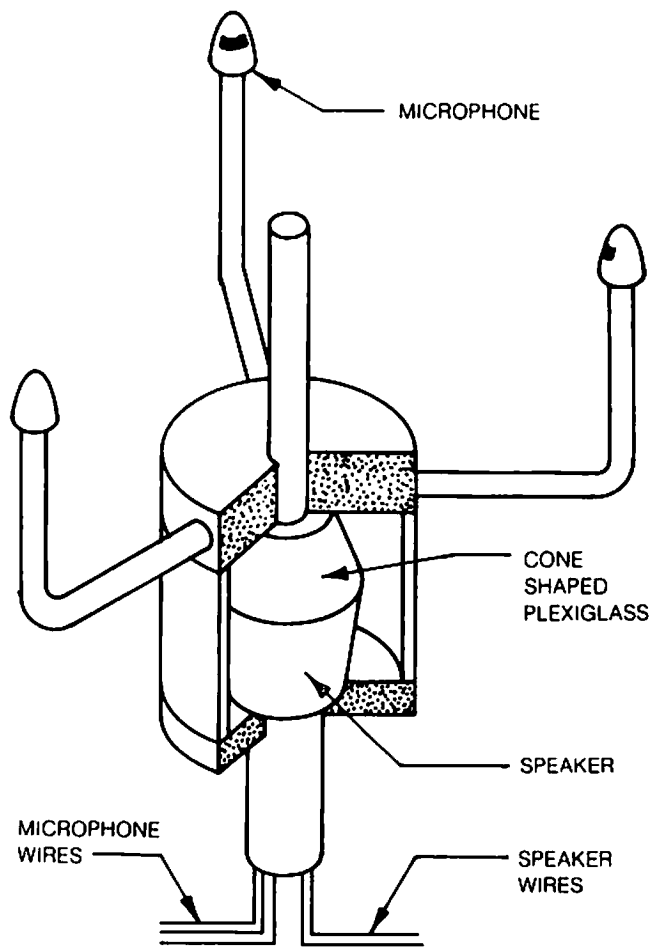
Acoustic methods for measuring wind speed rely on the fact that the velocity of sound in the air is superimposed upon the wind velocity. Acoustic anemometers basically consist of a sound source and a microphone separated by a known distance. From this basic arrangement several schemes exist for measurement of wind velocity.

The method selected for this device involves the transmission of a continuous sound wave of constant frequency. When the air is still, this sound wave has a wavelength, λ, equal to the speed of sound in still air, Vo, divided by the frequency of the signal, f: $\lambda = v_0 / f$. In this system, a microphone at some distance from a speaker will receive a signal of constant frequency but with a phase different from that of the source. When the wind blows in a direction from the speaker to the microphone, then the wavelength will change: $\lambda = (v_0 + v_w)/f$, where v_w is the wind speed. There will be a consequent change in the phase difference between the speaker and the microphone. A continuous reading of this phase difference provides data proportional to the speed of the wind.

If two pairs of microphones and speakers, their paths in opposite directions, are used, then the change of the speed of sound in still air will produce the same apparent deflection in both sensor pairs. When the resulting signals are applied as input to a differential amplifier, they will cancel. A wind blowing along the path of this microphone-speaker arrangement will produce a positive deflection in one sensor-pair and a negative deflection in the other sensor-pair. When these signals are applied as input to a differential amplifier, they reinforce each other, and factors, such as temperature or humidity, that affect the speed of sound are cancelled.

The previous discussions have been based on a sensor array with a one-dimensional path, capable of measuring only the component of the wind speed along that path. An array consisting of one centrally located, omnidirectional sound source with three equally spaced microphones in the same horizontal plane and equidistant from the sound source, can produce signal components, which can be used to yield both the wind speed and direction.

The instrument that was con-



Acoustic anemometer microphone array.

structed had one central source and three microphones, all in the same horizontal plane, the microphones arranged on arms about one foot long, 120 degrees apart. Speaker and microphones used were the smallest commercial size available to avoid introducing turbulence into the wind stream. For this reason the sound from the speaker was "piped" to the plane of the microphones to avoid having the rather large speaker located in the plane of the microphones.

The phase-shift-method phase detection system makes use of the fact that wavelength is a function of velocity. In operation, a constant frequency signal is fed into a transducer and received by another transducer an integral number of wavelengths away. Using the phase detection scheme; the frequency is held constant; therefore, the velocity is a function of the wavelength only.

The velocity of sound in air is 331.3 meters per second. This gives a wavelength at 4KHz of 8.28 cm. For considerations of strength and rigidity the distance between the transducers was chosen as three wavelengths, 24.84 cm. This results in a maximum measurable velocity of 67.3 miles per hour and a minimum of 0.062 miles per hour.

The working units were constructed of plexiglass. The electronics of the anemometer are held in a twenty-pound metal carrying case. This case contains four six-volt batteries as power supply and six printed-circuit boards containing: (A) the filtering and amplifying circuits for the phase detection system; (B) the phase-lock-loops; (C) the magnitude and angle modules; (D) all the compensation potentiometers; (E) the Fairchild 7400 quad nand gates, used to determine wind direction, and two operational amplifiers used for summing; and (F) a sine wave generator and a National 380N two-watt amplifier.

A review of preliminary test data showed that an anemometer of this type could give very accurate measurements of the wind speed and responds to changes in wind speed faster than does a mechnical anemometer. A complete system could be built for under four hundred dollars, which is somewhat lower than the cost of a good mechanical system.

The Arctic Coring Project

Advisor:
Professor Robert W. Corell

Principal Consultants:
Mr. D. Richard Blidberg, Ocean Research Equipment Company, Inc., Falmouth, Massachusetts
Mr. Paul E. Lavoie
Professor D. Allan Waterfield

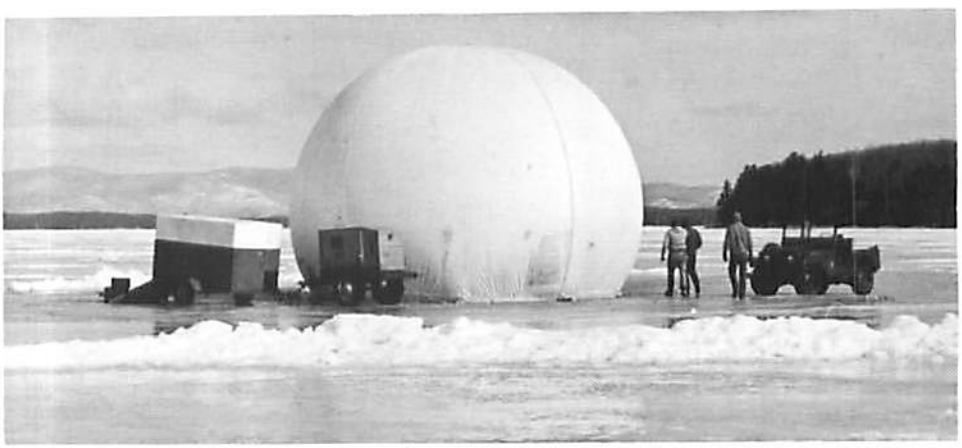
Students:
Mr. Bruce R. Fortnam, Project Leader, Electrical Engineering
Mr. Kenneth W. Davis, Electrical Engineering
Mr. Earl C. Dodge, Mechanical Engineering
Ms. Roberta J. Sanders, Geology
Mr. Thomas C. Schwandt, Civil Engineering
Mr. David R. VanHouten, Mechanical Engineering

Technicians:
Mr. Robert A. Blake
Mr. Richard D. Jennings

Ocean sediment cores have yielded a wealth of information about the geological history of the earth. In recent years increased attention has been directed toward coring in the Arctic Ocean for defense purposes, for oil, and for scientific exploration. Arctic sediments are particularly productive of information. Because of the slow rate of Arctic sedimentation, each meter of recent sediment contains the history of approximately one million years.

This student project focused on three problems related to taking sedimentary core samples in the Arctic Basin:

1. the development of an instrument to measure the orientation of the sedimentary core in the earth's magnetic field so that the geomagnetic properties of the core can be ascertained;
2. an evaluation of the use of lubricants on and within the core barrel as a method to increase core penetration without increases in coring apparatus weight;
3. an assessment of the distribution of sedimentary core data known to have been acquired by United States, Canadian, British, and Russian Arctic expeditions.



Ice station on Lake Winnipesaukee with inflatable dome within which tests were conducted for the student Arctic Coring Project.

Gyroscopic Detection of Core Orientation

The problem of indicating the corer orientation was solved by mounting a directional gyro within a pressure housing on the corer weight, with a camera to make a permanent record of the orientation. The gyro chosen operates as a free gyro from 24 volts DC and contains a built-in caging mechanism. Position is read with an accuracy of ten degrees by means of a circular potentiometer with a wiper that rotates with the spin axis of the gyro. The system is housed within a standard eleven-inch glass sphere made of one-half-inch thick Pyrex glass rated to 21,000 feet of water. Magnetic reed switches are used to avoid making mechanical penetrations of the sphere.

The system was field tested on April 22, 1975, from the University's R/V Jere A. Chase. The object was to determine whether the gyro was capable of maintaining its directional reference throughout an actual coring operation, being unaffected by the spinning of the corer during its descent, and by the shock of seafloor impact. Upon taking three successive cores, it was found that the gyro did maintain its reference as expected.

When this device is used in high latitudes and in the deep ocean where descent times are long, compensation must be made for the earth's rotation.

"Ice Station '75"

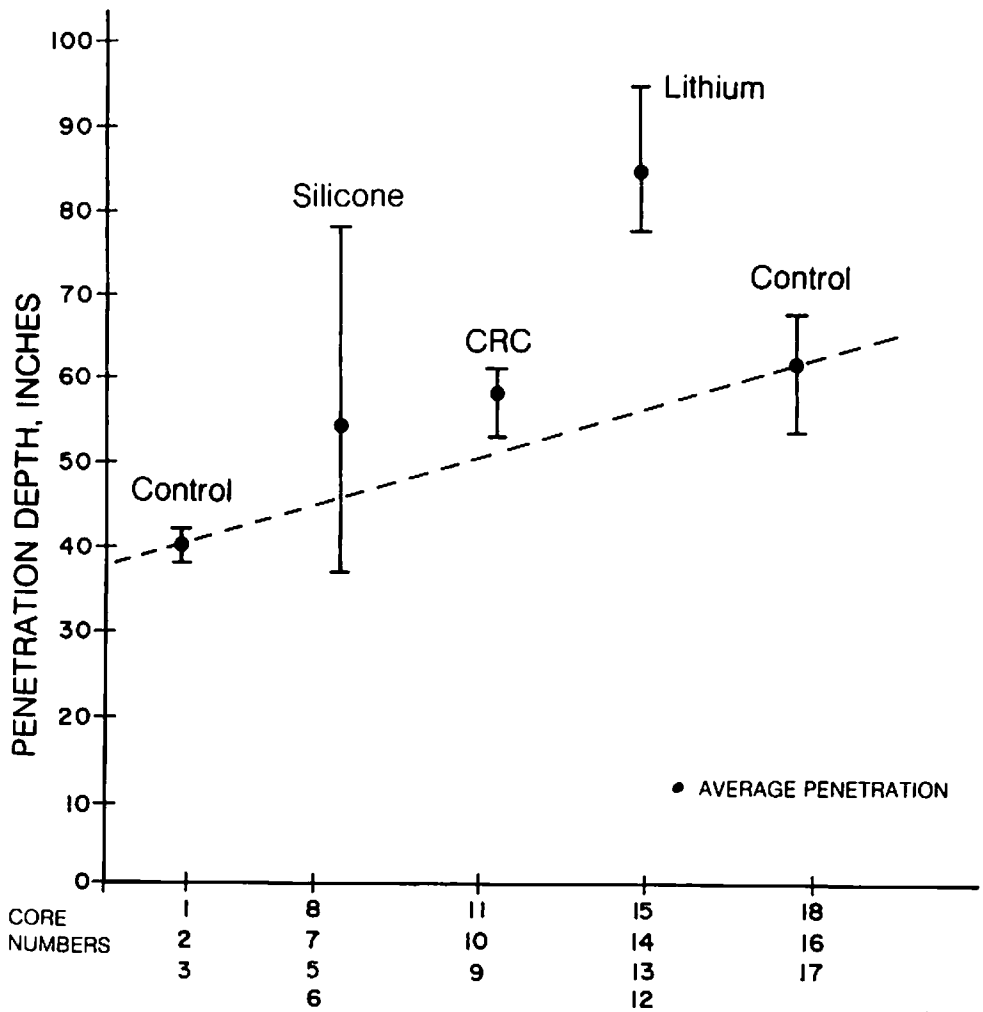
In order to gain experience under simulated Arctic conditions, the group operated a coring station on the ice of Lake Winnipesaukee, New Hampshire, from February 22 to March 4, 1975. A 27-foot radar dome was erected on twelve inches of ice to house the coring equipment. The interior of the dome was maintained at about fifty degrees F to provide for comfortable working conditions and to provide a warm place for divers preparing to dive.

The site was over water twenty-eight meters deep where there were sediment deposits of about eight meters. The site proved unsatisfactory for the coring experiments as the site was over highly unconsolidated silty sediments. A previously obtained acoustic record of this area of the lake did indicate a layer of sediment. The simulated Arctic coring station made the experiment highly worth while, as extensive field and logistic experience, under cold weather conditions, was obtained.

Effectiveness of Lubricants

To test the influence of lubricants on corer penetration, a site was chosen in Great Bay where the clay and organic material of the sediment approximated those of the open ocean. The corer used was supplied by the University's Earth Science Department, which was a standard gravity corer with a weight stand of 300 pounds. The most reliable tests were made April 22, 1975, with results as shown.

Lubricants tested were silicone, CRC, and a lithium, all in the form of greases. STP was eliminated from consideration because it was obviously too viscous for Arctic conditions. When lubricants were tested, the barrel and the liner were



Corer Lubricant Tests - Great Bay, April 22, 1975
Corer penetration ranges using three different lubricants, compared with control tests made without lubricant.

coated with the lubricant and the test made with a free fall of five feet and for the same time between free fall and withdrawal as for the control drops. Eighteen drops were made. It was noted that the average penetration during the control drops increased during the testing period, possibly because of a slight progressive drift to a location having a softer bottom. Nevertheless, it can be said that the lithium lubricant was the most effective, while the silicone and CRC lubricants were less effective and about of equal effectiveness.

A generous estimate of the cost of lubricants and of the solvent to clean barrel and liners would approximate fifty cents per core indicating the cost feasibilty of using lubricants to increase core penetration.

Compilation of Existing Core Data

In order to improve our understanding of the sediments distrubutions in the Arctic Basin as revealed by seafloor cores, a survey has been prepared of all the known data. This atlas of knowledge can serve as a standard text of the localities researched in the past by Russian, American, and Canadian scientists. Future coring, dredging, seismic, and magnetic studies will be able to visualize where physical data is available.

The student report includes a compilation of all the known core data in the Arctic Basin for Russian, Canadian, and United States scientific expeditions. The location, dates, and type of core data are tabulated for the 500 cores that have been known to have been acquired. A summary description of the geological inferences from these core data has also been prepared and is contained in the student report.

A Diver-Assist Vehicle

(The David W. Drew Memorial Award Project for 1975)

Advisor:

Professor E. Eugene Allmendinger

Consultants:

Mr. Paul E. Lavoie, UNH Diving Safety Officer

Professor D. Allan Waterfield, Diving Instructor

Students:

Mr. David W. Durfee, Project Leader, Mechanical Engineering

Mr. Stephen E. Barakis, Mechanical Engineering

Mr. James E. Haller, Chemical Engineering

Mr. Gary W. Krook, Mechanical Engineering

The project team designed, built, and tested a prototype, wet-type, diver-assist vehicle capable of carrying two SCUBA divers with equipment and cargo underwater. The vehicle greatly extends the divers' range and air supply and, therefore, their work capabilities. This particular vehicle differs greatly from others of this type in that it has a controlled, self-compensating, variable ballast system permitting it to carry a variable cargo load. Power supply and cargo holds are adaptable to permit the vehicle to serve as a mobile base for diving operations, providing electrical power, lights, and a reserve air supply. In short, it is a useful tool to the working diver.

In conferences with the project consultants, the mission requirements for the diver-assist vehicle were set and subsequently met as shown by test results.

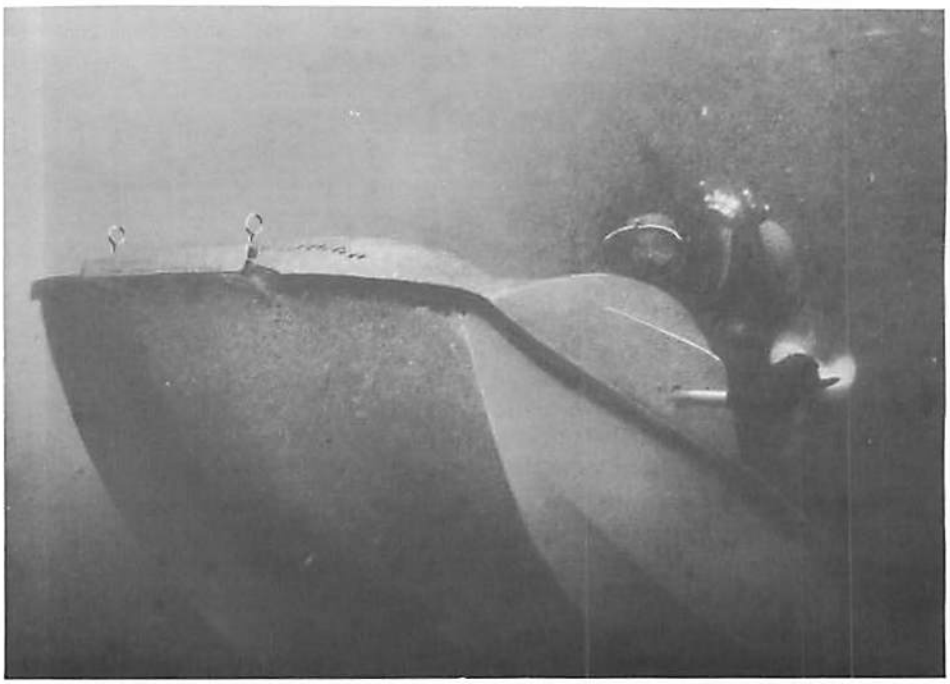
Mission Requirements:

Maximum submerged speed — 2 knots.

Payload — 2 divers plus 100 pounds of equipment (dry weight).

Vehicle weight limit — 100 pounds, dry weight (actual weight, 750 pounds).

Maximum operating depth — 200 feet (actually estimated at 250 feet



A student diver puts the diver-assist vehicle through its proving tests in Lake Winnipesaukee, N.H., April, 1975. (All University diving is under the control of the UNH Diving Safety Officer.)

based on the tested crush resistance of the foam flotation material used; no actual full scale test).

Submerged endurance — one hour at full speed (actually two hours continuous running time).

Variable ballast capacity — to 100 pounds weight of water.

Rate of ascent — approximately one foot per second, ballast tanks blown, no load, motors off.

Diver support — air supply and regulators for two divers, provisions for low pressure ports for hookah rig, underwater lights, and DC power.

Transportability — easily trailered and handled from a standard boat-launching ramp.

Four possible designs were considered. The one chosen has a streamlined fiberglass fairing with the ballast tank carried in the center near the top and the battery compartment low for stability. Batteries are housed in pressurized boxes. The entire system is pressure compensated and carries its own air supply. Divers ride prone to reduce drag and, for safe escape, are unenclosed.

As a design preliminary, the required thrust was estimated at 63.72 pounds. Full-scale towing tests on the completed hull indicated a thrust requirement of 69.73 pounds.

Thrust is provided by four Minn Kota, Model 65, trolling motors rated at 17 pounds of thrust each. Three Sears Diehard batteries provide power.

After the tentative frame design was completed, it was subjected to a Structural Design Language (STRUDL) analysis as an aid to making final decisions relative to the frame designs.

A marine anticorrosive coating was used over an epoxy primer to protect parts subject to corrosion. Whenever possible, dissimilar metals were electrically isolated to avoid galvanic corrosion.

The hydromechanic analysis considered stability, center of buoyancy, and center of gravity relations, from which the amount of fixed ballast, the amount of flotation foam, and their dispositions were determined.

All motor housings, battery boxes, and electrical switching cases are pressurized to ambient water pressure, or above, to avoid inleakage of water. The system makes use of fairly inexpensive regulators adapted from standard SCUBA gear. The battery box is isolated from the rest of the system to avoid possibility of trouble from hydrogen gas. A catalyzer above the battery in each battery box limits the hydrogen concentration to a safe minimum.

The self-compensating variable ballast system gives this vehicle its unique cargo carrying versatility. The uniqueness of the system lies in the fact that it can maintain a given condition of variable ballasting over a wide range of depth. It automatically injects or vents air to maintain near-ambient pressure. The amount of ballast water in the tank is manually controlled.

The four propulsion units use a 12 volt DC power source, and each draws 23 amps at full power. In the present design, the motors are controlled by a single on-off-reverse switch, but the motors are wired so that an individual variable-speed control could be added later. Directional control of the vehicle is achieved by pivoting the port and starboard forward motors to change depth and pivoting the port and starboard aft motors to accomplish turns.

This prototype vehicle was tested in the UNH field house pool and in open-water conditions in Lake Winnipesaukee. During the tests the vehicle demonstrated good stability, maneuverability, and control and met the original mission requirements.

The New England Fishing Industry: Proposals for Revitalization

Advisor:
Professor David W. Moore
Students:
Mr. Roy R. Annis, Political Science
Mr. Richard W. Burkholder, Political Science
Mr. Timothy P. Mulhern, Political Science

Since World War II the New England coastal fishing industry has been declining. Its vessels and their crews are old. Incomes are far below those in other industries. Insurance is expensive and difficult, if not impossible, to obtain. The small United States coastal industry competes with increasingly large, government subsidized fleets in the same waters. The state of the fishing industry is well known, but the less-known reasons behind the problems inspired this study.

The model for this paper is a policy alternatives model detailed by Harold D. Lasswell.[1] This model calls for specification of a goal to be pursued, discussions of the problems trends, and discussions of several alternative futures. Following Lasswell's model, the problems of New England's fishing industry were explored by this student group. Proposals for its revitalization are offered.

Goal and Overview

Revitalization, the goal of this study, here means bringing incomes and returns to levels comparable with those of other industries in the United States. This does not

necessarily involve increasing employment in the industry. A realistic proposal for revitalization must work within the constraints of the resource's ability to reproduce, minimal cost to the federal government, acceptability to the international community, and domestic political feasibility. Revitalization would benefit the nation and the world.

The National Marine Fisheries Service estimates that one million metric tons of fish could be harvested annually from Atlantic waters adjacent to Canada and New England if the stocks were allowed to rebuild to their optimum population levels. This goal can be realized only if existing knowledge of fishery biology is applied. For each possible level of fish population there is a corresponding level of fishing mortality that can be achieved through fishing effort.

Yield from the resource is related to the effort expended to harvest the resource. Yield increases with effort up to a point called the optimum sustainable yield (OSY), after which increase in effort brings about a long-term decrease in annual yield. The vast majority of marine species of value to man are limited by natural conditions and are not economically susceptible to conservation practices.

Means of increasing the incomes and profits of the New England fishing industry must be sought.

Concurrently, available food will be increased by improving yields from the resource.

Trends: Profits and Incomes, Employment, Insurance, Vessel Financing, Domestic Political Assistance, International Law

A return on investment below those of other industries is indicative of economic problems in an industry. In the fishing industry declining labor incomes also indicate economic problems because rates of return to labor and to capital are connected through the lay system. The lay system is a profit sharing system by which the crew of a vessel is paid on a percentage basis according to the value of the catch on each trip. A study[2] of Georges Bank fishing in 1964 concluded that the average vessel could not be considered a particularly lucrative venture. By 1974 the situation had worsened to the point where commercial fishing was characterized by a marginal or break-even operation. For this reason, new fishermen have not been attracted to these fisheries and the average age of fishermen is steadily rising.

To improve recruitment of younger fishermen, training programs, improved working conditions, wage increases, and increased nonpay benefits are suggested. These can only be implemented in a healthier industry.

Fishermen face the problem of high insurance rates or the inability to acquire any insurance at all. The problem might be hastily laid to greedy underwriters. According to National Marine Fisheries Service, this is not the case. A sampling of underwriters showed that they were paying 92 cents in hull damage claims for each dollar of preimums. Old equipment in disrepair leads to increased accidents and higher claims. A revitalized industry should correct the insurance problem.

A major reason for high fishing vessel construction cost is a 183-year-old federal statute which requires domestic fishermen to purchase American-built vessels. A 35 to 50 percent construction subsidy by the federal government has not been enthusiastically received. Aversion to government control of specifications and a dislike for, and distrust of, bureaucratic procedures are cited as reasons for the lack of enthusiasm. In addition to high construction costs, overall costs are increased by the high cost of bank loans. Banks generally require Coast Guard inspection and approval of construction plans before approval of loan, with a down payment of up to 30 percent and a true interest rate of 11 to 12 percent over a seven-to-ten-year term. Until the commercial fishing industry yields higher returns on the investment, vessel costs may remain largely prohibitive.

Federal assistance is frequently sought as a remedy for troubled industries. Fishing legislation falls into three broad categories: jurisdiction and enforcement, financial assistance, and research and development. One bill in the first category extended United States fishery jurisdiction from three to twelve miles. Other legislation dealt with restrictions on foreign fishing effort which were justified as conservation measures. Although strongly worded, these bills have not been enforced by the Coast Guard and the federal administration.

Bills extending assistance for medical expenses, vessel purchases, and ransom for vessels seized in foreign waters were cosmetic in

Part of the New Hampshire commercial fishing fleet at Portsmouth. (Front cover picture)

nature and did not reach the underlying problems. Legislation aimed at research and development has not always been successful. The fish Protein Concentrate bill was funded to nearly nine million dollars. As finally implemented, a plant to produce the high protein flour was built on the West Coast while the bill called for the processing of a type of trash fish abundant only on the East Coast. The project was thus foredoomed to failure.

Contending that the industry is poorly managed and overcapitalized, the Office of Management and Budget has impounded a total of 43 million dollars earmarked for various programs administered by the National Oceanic and Atmospheric Administration. Overall, it was the lack of a well-coordinated approach by Congress to the fisheries management effort which led to the impoundment of funds by the Office of Management and Budget.

International Law

Historically, the doctrine of free and open access to the sea and its resources was based on the presumed inexhaustability of these resources. Particularly in fisheries, modern innovations have removed the argument of inexhaustability. In spite of this fact, the United Nations Conference on Law of the Sea as lately as 1958 reaffirmed the freedom of the high seas including freedom of fishing. However, the harsh tone was relaxed somewhat by a provision stating that ". . . any coastal State may . . . adopt unilateral conservation measures . . . to any stock of fish on the high seas adjacent to its territorial sea, . . ." with certain restrictions. Thus, in spite of the fact that, historically, the United States has long been a proponent of the freedom of the seas, changing conditions dictate that a fresh look should be taken. The fact that about 15 percent of the United States fishing catch (1959-1963) was taken off the coasts of countries claiming territorial waters to 200 miles complicates the problem.

Despite the historic strength of the notion of freedom of the seas, nations have agreed to various management schemes. These agreements undertook to investigate, protect, and conserve the fisheries of the northwest Atlantic Ocean to make it possible to maintain a maximum sustained catch from those fisheries. Scientific data were collected, as a basis for action. Such management measures as open and closed seasons, closing of spawning grounds, and regulations as to fish size limits and types of gear were made. The effort has been largely offset by problems of underreporting catches, increasingly high incidental catches, and outright violations which often go unpunished.

International law is both a partial cause and a possible solution of the New England fishery problem. The International Commission for Northwest Atlantic Fisheries (ICNAF) has apparently slowed the devastation of the fishery resource, and the Convention on Living Resources provides justification for unilateral action by a coastal state.

Economic, Domestic, and Foreign Policy Conditions Underlying the Trends

Thus far, the fishing industry has been shown as an ailing industry, with incredibly high costs and low incomes. The marked increase in foreign fishing effort in mutually fished waters has been noted. These trends and their economic interrelationships can be explained by an economic model which considers the nature of the common property fishery resource. The problems of inconsistent political assistance, increased foreign efforts, and ineffective international law are problems of domestic and foreign policy.

The present economic situation of the New England fishing industry is one in which the fishing effort expended, in a futile attempt to increase the catch, exceeds the effort for an optimum sustainable yield (OSY). Depletion is inevitable because of the effects of increases in demand and improved technology on a common property resource. National quotas imposed by ICNAF, even if scrupulously adhered to, only divide up the catch among nations. This may encourage overcapitalization because of the need to fill quotas for a given stock before the fish are dispersed. Thus, the ICNAF national quota scheme will not solve the problems of the New England fisheries industry. The problem lies in the fact that the fish represent a common property resource. A program which attempts to revitalize the industry must deal with the common property program. Limitation of access to the fishery resource has been repeatedly suggested as a means of dealing with the economics of common property.

Entry limitations by taxation use economic disincentives to restrict effort, which would drive out marginal firms. The poltical problems involved would be immense and such a tax would only further reduce incomes and force people out of work.

Effort restriction would allow only enough units of effort into the fishery to meet the optimum catch level. Such a system is scientifically difficult to set and its cost would be tremendous. The plan is economically unsound in that it provides no incentive to increase production efficiency. It also forces a decision about who would be allowed to fish, with insurmountable political ramifications.

Limitation of catch is a third type of entry limitation. Catch quotas would be set on the basis of some optimum yield, would be transferable, and would be given to

all initially active fishermen. An objection to this plan is that it would allow unearned income through sales of fishery rights. The catch quota system, as a solution to the problem, seems most acceptable politically.

Federal government assistance in the organization and financing of a fisheries management plan will require legislative approval. Fisheries legislation enjoys a high degree of support in Congress with support by Democrats and coastal Republicans. Ironically, however, the New England fishing industry has continued to decline despite support by Congress. This is a political failure. The high degree of support and the failure of Congress to deal effectively with the management problems of the fishery stems from the fact that fishermen have been unwilling to support a domestic management program that involves any regulatory legislation, so congressmen have been willing to sponsor cosmetic legislation to take advantage of the political capital therein.

International questions such as the Studds 200-mile limit bill, have brought the State and Defense Departments into legislative consideration of such bills.

The fact that the largest part of the New England industry's resource lies in international waters forces the fishing industry to seek representation in the foreign policy process of the federal government. For the northwest Atlantic, the ICNAF Commissioners make policies on an annual basis, while the policy formulation for the Third U.N. Law of the Sea Conference has been under direction of the Department of State. In both instances, the New England fishing industry enjoys fairly strong, sometimes unsolicited, representation.

In 1967 a rising number of tuna boat seizures by foreign countries inspired a process of memoranda writing and queries about possible solutions within the Defense and State Departments. A similar process was underway in the USSR which suggested a series of talks with the US. Issues were limited to questions of breadth of the territorial sea, passage through straits, and fisheries. Fisheries were included as they were recognized to be the chief motivating factor behind large unilateral claims. There was no direct involvement by the United States fishing industries in the policy making for negotiations with the Russians or the Latin Americans, possibly because the fishing industry simply did not know that discussions affecting its interest were under way, as well as because of the internal differences in the industry — between coastal and distant water fishing interests. When negotiations failed in January, 1969, the question of straits, territorial seas, and fisheries lay dormant. Ironically, coastal fishery interests have been best served, not by foreign policy pressure from the New England industry, but by a growing international trend favoring broad economic zones with exclusive resource rights going to the coastal state.

Thus, it is the international community, specifically the other signatories, that limit the United States' ability to promote an effective management scheme in ICNAF. By the same token, it is the international community, specifically other coastal states, which is serving the interests of the New England fishing industry so well by promoting a broad economic zone.

A large part of the pressure being exerted on Congress is for extension of resource jurisdiction. Both the Studds 200-mile limit bill (HR200) and the Sullivan conservation action bill (HR1070) provide for extension of jurisdiction. The Studds bill is based on one of the draft articles being considered by the Third UN Conference on the Law of the Sea (LOS III) while the Sullivan bill is based on the extended management provisions in the 1958 Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas. The latter seeks to avoid the appearance of "unilateralism" and to ground actions on international law via an existing convention. Experts, however, generally agree that some form of 200-mile limit will be adopted by the U.S. in the near future.

Recommendations

The management plan detailed below can be divided into two stages. The initial stage is a period of internal growth for the industry. The second stage is the permanent stage of economic management of the resource.

During the initial stage of ten years, problems of high insurance rates, high vessel costs, declining employment, and declining returns to capital and labor would be corrected. Exclusive resource rights would foster high profits allowing the modernization desperately needed by the antiquated industry. The growth would be directed, excluding horizontal mergers of fishing vessels and allowing only people presently fishing access to the fishing resource.

The initial stage would also be a period for rebuilding fish stocks. Under-reporting and indiscriminate exploitation of foreign fishing would be eliminated. The U.S. management would have authority to close fisheries for species not being allowed to reproduce sufficiently, resulting in a higher yield capacity.

The final stage of management would economically limit entry into the fishery, retaining competition; set a catch level at the optimum sustainable yield; and collect economic rents to pay for itself. Rents would be based on an auction every three years to let market competition decide who will fish.

The New England fishing industry should continue to support the Studds 200-mile limit bill as a

first step toward comprehensive management of U.S. fisheries. With or without an international treaty, pressure for passage of the Studds bill will have to be increased. The personnel in the Office of Fisheries in the State Department are aware of the weaknesses of ICNAF and are sympathetic to the needs of New England fishermen. Thus, the State Department is more likely to support unilateral extension. The Defense Department will have to be assured that there would be no denial of free passage of foreign vessels through waters now international and that the Studds bill claims only fisheries jurisdiction.

Licensing is an important part of this fisheries management plan. Fees should be nominal and at first licenses would be issued for three years and only to those presently fishing. A principle purpose in licensing is to collect information useful in fisheries management, such as

1. type(s) of fishing activity engaged in by the vessel:
   a) fixed gear (lobster or crab),
   b) trawling or seining (for fin fish),
   c) dredging (oysters and clams),
   d) any combination of above;
2. size and age of the vessel;
3. absolute capacity, by volume, of the vessel to bring fish to port in one trip;
4. estimates of total number of fishing trips taken in the past year;
5. vessel fuel bills (to be returned to the vessel owner when the necessary information has been tabulated).

Licensing would be handled by the National Marine Fisheries Service and enforcement, by the U.S. Coast Guard. In this initial period foreign fishing would be reduced to that part of the catch which U.S. fishermen are incapable of catching.

Congress should repeal the provisions of the Jones Act which prohibit purchase of foreign vessels. Additional federal assistance should be given by directing a portion of the Sea Grant appropriation toward research and development studies for gear improvement and species selectivity.

Further management provisions should:

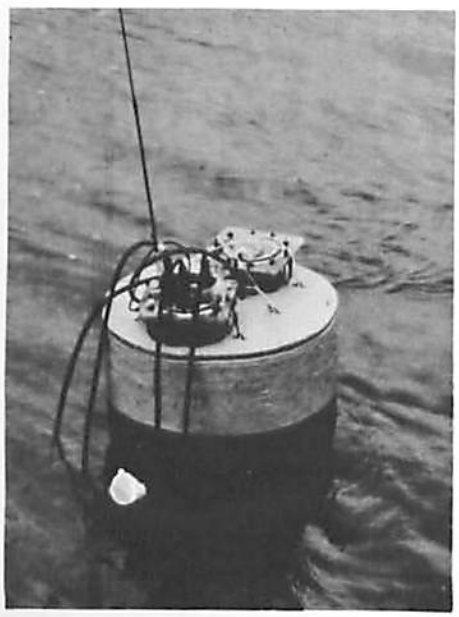
1) regulate the kind of gear used in fishing,
2) give fishery biologists the power to close specific fisheries or spawning grounds,
3) outlaw the use of support vessels in the jurisdiction area,
4) limit ownership to one vessel by any one person or firm.

1 *A Preview of Policy Sciences*, Harold D. Lasswell, New York, American Elsevier Publishing Company, 1971.

2 The student report cites supporting references for this and similar statements.

A Telemetering Buoy

Advisor:
Professor Ronald R. Clark



Completed telemetering buoy emplaced in Great Bay, N.H., April, 1975.

Consultant:
Professor Wendell S. Brown

Navigation Consultant:
Captain Edward D. McIntosh

Students:
Mr. John L. Cowles, Electrical Engineering
Mr. K. Michael Mitrakas, Electrical Engineering
Mr. Gregory W. Papadeas, Electrical Engineering

Technician:
Mr. Robert A. Blake

This student projects group undertook to put an inoperative temperature telemetering buoy system built by a previous group into operating condition. A shore receiving station was included. Data channels were added and the number of temperature probes increased. Digital data recording at the shore station was incorporated. A new mooring system was designed, constructed, and deployed. A prototype current flow probe was designed.

The Mechanical Components of the Telemetering Buoy System

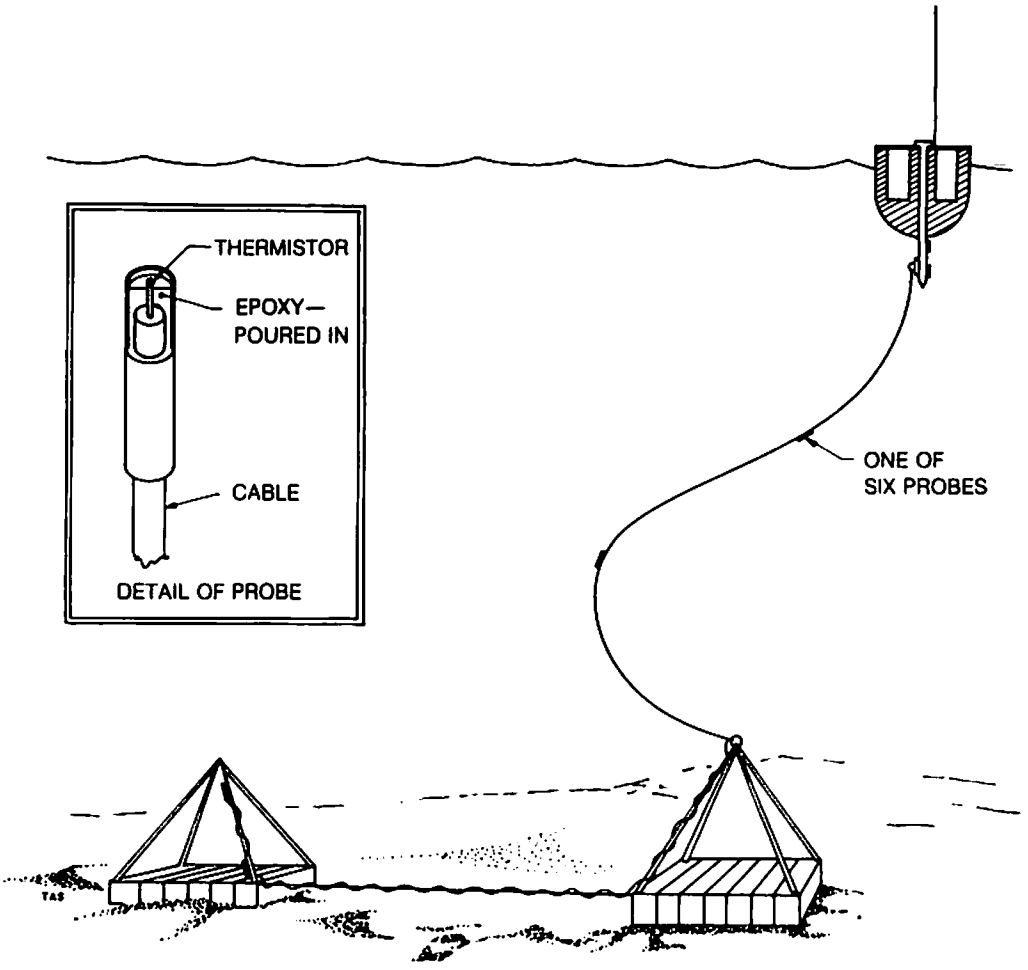
A cylindrical buoy with a hemispherical bottom, constructed by the 1972-1973 projects group, was already on hand. It was made of two shaped styrofoam blocks covered with fiberglass cloth. Two cavities, sealed by a cover, accommodated a battery canister and an electronics canister, both made of PVC pipe. A transmitting antenna is mounted on the cover, which also seals the battery and the electronics canister cavities.

Electronics cable assemblies were designed to replace the existing third and fourth temperature probes and to increase the number of probes to six. The cable to replace probes three and four was 20 feet long and terminated in a plastic molded shell which was also the terminus of a one-foot length of cable carrying the third probe and of a 55-foot cable assembly which carried the fifth and sixth probes. Probes

one and two were original equipment.

A 200-pound main anchor and a 100-pound secondary anchor were constructed. The buoy is attached to the main anchor while the secondary anchor, placed 15 feet away, is used to deploy temperature probes five and six. Both anchors were designed to suit Great Bay data provided by personnel at the UNH Jackson Estuarine Laboratory: average current velocity, 2 knots; maximum current velocity, 5 knots; and maximum wind velocity, 50 miles per hour (43.5 knots). These conditions dictated that, for a 35-foot depth of water and a scope of 20 feet, a 3/8 inch nylon rope 50 feet long would be required to insure that the buoy would not be submerged by wind and water forces.

Each anchor can be handled by two people. In launching, a hand line which is free to move through the ring is reeved through a ring on the secondary anchor to restrain it until the main anchor is put overboard. The secondary anchor restraining line is then withdrawn and both anchors are lowered until the secondary anchor bottoms. The boat is then advanced about 15 feet, with the main anchor still off the bottom, and the main anchor is set. Divers check the placement of the anchors. The buoy system is retrieved by simply hauling the buoy aboard, followed by the main and the secondary anchors, care being taken that the attached cables are not stretched or tangled.



Deployment of the telemetering buoy and anchors.

The Electrical System

Eight channels of information are sequentially sampled by two quad switches. Information from each probe is in the form of a square wave whose unique frequency is proportional to the temperature. To start transmission a frequency shift keyed (FSK) 2KHz "on" signal activates the shore station decoder and chart recorder. Signals are sent from the quarter-wave vertical antenna on the buoy to the shore station over the FM band at 89.2 MHz with a power of 100 mw. Power is supplied at 12.5 volts from two powerpacks of ten nickel-cadmium batteries good for 20 days of operation. The installation meets FCC regulations for unlicensed transmitting stations.

Each astable multivibrator temperature probe is identified by a unique frequency controlled by a precision thermistor. Accuracy is improved by having all the circuitry of each astable multivibrator located at the point of temperature measurement, and therefore at the same temperature. The frequency range of each probe allows 18 to 20 Hz for each 0.1 degree centigrade. The probes were encapsulated in polyester resin leaving the thermistor head half exposed. Probes were then calibrated in a water bath.

Multiplexing circuitry switches each channel "on" for five seconds for transmission of information. The two quad switches are actuated by a logic "1" which is shifted along an eight-stage ring counter. When the control lead of each switch is high, the output at the switch is transferred to the output of a discrete OR gate using diodes and a transistor. The output from this gate frequency-shift-keys the transmitter. The timer that is used to set the "off" time between transmissions consists of an astable multibibrator with an adjustable

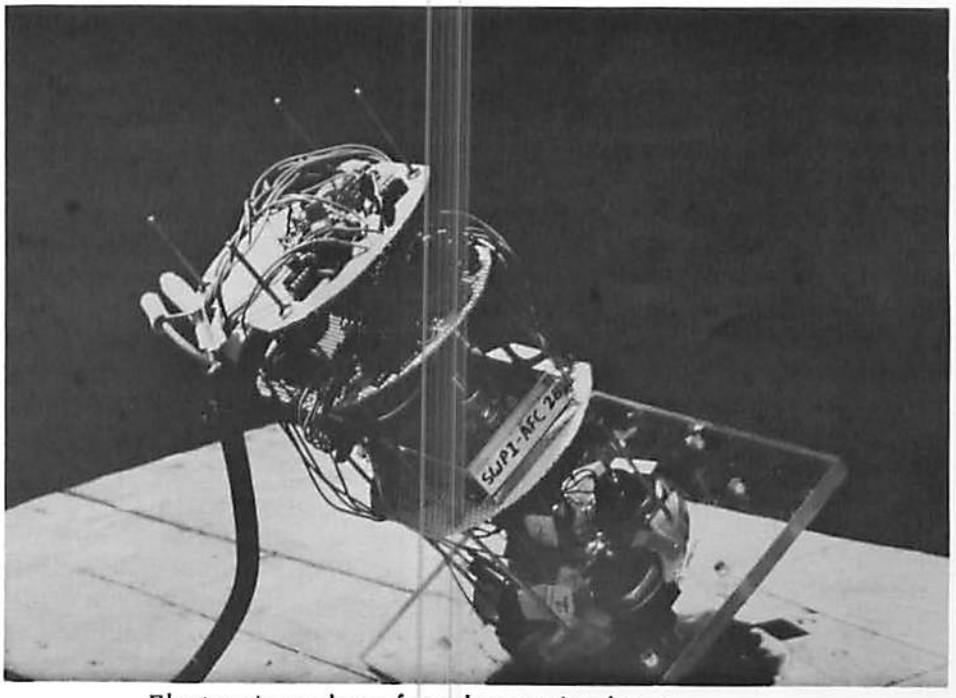
period of 15 to 30 seconds, and seven divide-by-two flip-flops can be selected to give an adjustable "off" time of between 4 and 64 minutes.

The Shore Station

A ten-element Yagi antenna, cut for the transmitting frequency of 89.2 MHz receives the FM signal from the buoy station. This antenna gives 12 DB gain over a half-wave reference dipole, roughly equivalent to increasing the power transmitted at the buoy by 16 times. The shore station equipment consists of a standard FM broadcast band receiver with decoder circuitry separately mounted. The shore station's function is to accept the turn-on signal from the buoy station, sample, decode, and store the information from each probe on a chart recorder. In addition to being recorded, the frequencies received are also displayed on a four-segment LED.

During tests of the shore station, the existing emitter-follower was changed to an op-amp type, and an adjustable dc-level control was incorporated in the assembly. These changes overcame faulty operation of the emitter-follower between the diode detector and the integrator. It was also found necessary to design a sharper band-pass filter for the center frequency of 2 KHz using two 741 op-amps to avoid sporadic activation of the station by "noise." Excellent operation resulted.

The entire system as originally projected was made operational. Four additional temperature probes were constructed and an electromagnetic current probe was designed. The system's data handling capacity was increased from four to eight channels. Turn-on and turn-off difficulties with the original system were corrected. The buoy and anchors were deployed in Great Bay ready for a test of the complete system under actual operating conditions.



Electronic package for telemetering buoy.

A Wind Driven Battery Charger

Advisor:
Professor Kerwin C. Stotz
Students:
Mr. Richard J. Doda, Electrical Engineering
Mr. Harry J. Nielson, Mechanical Engineering

Power for instrumentation and other purposes at an isolated site, such as an island or a buoy at sea, is commonly supplied from storage batteries. Batteries have to be recharged or replaced frequently. An example is the University's instrument shelter on Smuttynose Island, Isles of Shoals. The battery banks there were recharged by thermal generators fueled by propane gas taken to the island in cylinders which are carried in a small boat.

This wind driven battery charger project was undertaken to use wind power instead of thermal energy for such situations to alleviate problems attendant on the use of thermal energy or other replenishment schemes. The goal was to transfer about 100 watts to a bank of 12-volt, automobile type, lead-acid batteries. By using a modified Savonius roter to supply the power to an automobile alternator, and making use of the strong sea winds, it was anticipated that an effective charging device could be built.

Wind Characteristics

There are two well-defined types of wind, the predominant or prevalent winds, the normal light breezes, and the so-called energy winds. The energy winds, gusts, account for 75 percent of the total energy available. Gusts are the real power winds. The latent power in the wind is not great. The average or prevalent winds do not contain much energy because their velocity is low. A wind with a velocity of 7 miles per hour yields a power of less than 2 watts per square foot, while a 15-mile-per-hour wind has a theoretical power potential of about 16 watts per square foot.

Wind direction is also a very important consideration in power generation. While prevalent winds may be reasonably constant in direction, the more important energy winds vary in direction. In an Ohio study the wind velocity varied ±28 percent in ten seconds and 50 percent in 38 seconds. Wind direction changes with similar rapidity. This rapid change in wind direction shows the need for a windmill that has a high degree of directional responsiveness or is omnidirectional. It was decided to use the omnidirectional Savonius rotor design for this project where the generator would have to run untended for long periods.

The Savonius Rotor

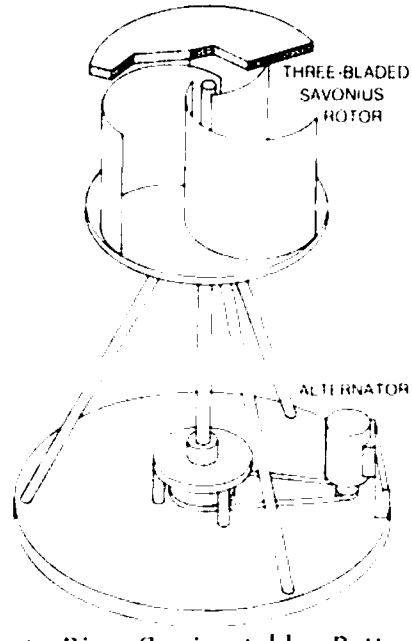
The Savonius rotor, as originally designed, consisted of an S-shaped plate, mounted with an axis of rotation through the mid-point of the S. With this design, excess pressure is developed on the portion of the S which exposes its concave side to the wind. A lesser pressure is exerted on the portion presenting a convex surface to the wind. This results in a turning moment on the rotor. This turning moment is lessened because a vacuum is developed behind the vane which presents its convex side to the wind.

To obviate this effect Savonius split the S at the axis and separated the vanes in such a way that air could pass from the pressure surface to overcome the vacuum behind the opposite vane. This two-vaned S rotor, when provided with end plates, showed a marked improvement in effectiveness and an efficiency only slightly lower than the 30 percent efficiency of the standard 12-vaned farm windmill. A shield could be used to improve efficiency, but this would have meant that the omnidirectional feature would be lost. To improve starting torque, which is zero at some positions of the two-vaned rotor, three vanes were used.

Elements of the Assembly

As stated, the vertical windmill was chosen primarily because it was omnidirectional. This form would be easier to build and to maintain and the mechanics of converting wind power to electrical power could be handled by means of a simple belt drive. A high efficiency, 95 percent, positive or timing type of belt drive was used.

A breaking method is needed to prevent wind rotor overspeed. Various available schemes were discussed. (1) Introducing movable panels in the end plates would allow the air to spill. These spill-plates would be operated by centrifugal force. (2) Electrical braking was considered. A centrifugally operated relay would cut in a large resistive load to the alternator which would tend to slow the rotor. This device would be dependent on the integrity of the belt drive between the generator and the driving rotor. (3) The favored device consisted of spring loaded flaps, operated by the forces of rotation, which would move out and block off the central air passage. The resultant drag on the vanes would act as a brake on the rotor's speed.



Test Rig, Semiportable Battery Charger, Employing a Modified Savonius Rotor.

The Electrical System

An alternator was employed for two main reasons. It is more reliable and it can produce a charging current for a greater speed range than a generator. It also has a low field current consumption.

Alternating current is converted to direct current by a rectifier containing six diodes mounted on heat sinks. The charging circuit includes an alternator tachometer and a regulator. The voltage regulator contains a double contact relay which, when energized, applies full field current to the field winding. The alternator requires that its field be initially energized from an outside source. Performing a function similar to the act of turning the key in the ignition system of a car, the tachometer will produce a small current when the wind turns the impeller. This trips a relay connecting the field winding into the circuit. The control of the charging current is now in the hands of the voltage regulator.

Results

A rig was built but there was insufficient time to construct a proper tower to put the rotor and its attendant gear above obstructions. The wind during the period available for testing was insufficiently strong to turn the rotor effectively. Hand turning of the rotor showed that the stator coils should be rewound to produce more output at low rotative speeds.

The major problems of the design were twofold. The areas presented to the winds were too small for low speed winds and the rotor was too heavy, giving it too much inertia. This fact tends to show the main problem with the Savonius rotor. To reach medium power levels it must be large and becomes no longer cost efficient. However, the design adopted in this project can be modified, without extensive changes, to yield the needed low power.

PERSONNEL OF THE SEA GRANT PROGRAM ANNUAL REPORT — 1975

Faculty and Professional Associates

E. Eugene Allmendinger, M.S., Associate Professor of Naval Architecture; Executive Officer, University of New Hampshire Marine Program
D. Richard Blidberg, Ocean Research Equipment Company, Inc., Falmouth, Massachusetts
Reginald J. Bouchard, Information Representative, Maine Department of Marine Resources
Wendell S. Brown, Ph.D., Assistant Professor of Earth Sciences
Barbaros Celikkol, Ph.D., Assistant Professor of Mechanical Engineering
Ronald R. Clark, Ph.D., Associate Professor of Electrical Engineering
Robert W. Corell, Ph.D., Professor of Mechanical Engineering; Director, Coherent Area Sea Grant Programs; Director, Marine Program
Owen B. Durgin, M.A., Professor of Resource Economics
Sidney E. Feld, Ph.D., Assistant Professor of Marine Economics
Albert D. Frost, Sc.D., Professor of Electrical Engineering
William F. Henry, M.S., Professor of Resource Economics
Miyoshi Ikawa, Ph.D., Professor of Biochemistry
Dennis M. King, M.S., Instructor of Marine Economics
Paul E. Lavoie, B.S., University of New Hampshire Diving Safety Officer
David O. Libby, M.S., Engineer, Engineering Design and Analysis Laboratory
David E. Limbert, Ph.D., Associate Professor of Mechanical Engineering
Theodore C. Loder, Ph.D., Assistant Professor of Earth Sciences
Richard A. Lutz, Ph.D., Research Assistant, Ira C. Darling Center, University of Maine
Arthur C. Mathieson, Ph.D., Director, Jackson Estuarine Laboratory; Professor of Botany
Edward D. McIntosh, Ships Captain
Bruce A. Miller, Ph.D., Director, University of New Hampshire Sea Grant Marine Advisory Services; Coordinator, Maine-New Hampshire Blue Mussel Project
David W. Moore, Ph.D., Assistant Professor of Political Science
Joseph B. Murdoch, Ph.D., Director, Undergraduate Ocean Projects Course; Professor and Chairman, Department of Electrical Engineering
Edward A. Myers, D. Bus. Adm. (H), President, Abandoned Farm, Inc., Damariscotta, Maine
Richard C. Ringrose, Ph.D., Professor of Animal Science
Roberta J. Sanders, B.S. Research Assistant, Sea Grant Coherent Area Program
John J. Sasner, Jr., Ph.D., Associate Professor of Zoology
Godfrey H. Savage, Ph.D., Engr., Director, Coherent Area Sea Grant Programs (to March 15, 1975); Director, Engineering Design and Analysis Laboratory; Professor of Mechanical Engineering
Erick D. Sawtelle, B.A., Research Associate, Sea Grant Coherent Area Program
Bohdan M. Slabyj, Ph.D., Assistant Professor, Department of Food Science, University of Maine
Roderick M. Smith, Ph.D., Assistant Professor of Zoology
Kerwin C. Stotz, Ph.D., Associate Professor of Electrical Engineering
Richard G. Strout, Ph.D., Professor of Animal Science
M. Robinson Swift, Ph.D., Lecturer in Mechanical Engineering
Steven J. Szydlick, B.S., Field Program Assistant, the Great Bay Environmental Project
D. Allan Waterfield, M.S., Assistant Professor of Physical Education
Alden L. Winn, S.M., Professor of Electrical Engineering
Musa Yildiz, Ph.D., Visiting Professor in Applied Mathematics

Doctoral Program Students

David J. Agerton, Engineering
Lawrence J. Buckley, Biochemistry
Nancy A. Higley, Biochemistry
Donald R. Morgan, Economics
Ronnal P. Reichard, Engineering
Clayton A. Penniman, Botany
Richard H. Sugatt, Zoology

Master of Arts Program Student

Christopher W. Herrick, Political Science

Master of Science Program Students

John P. Browne, Resource Economics
Daniel L. Cordell, Electrical Engineering
Bonita Coutermarsh, Microbiology
Maureen A. Daly, Botany
John R. Delano, Electrical Engineering
Jane S. Fisher, Earth Sciences
Patricia M. Glibert, Earth Sciences
Fred Haug, Earth Sciences
Lee H. Lohrman, Zoology
John J. Rosenberger, Microbiology
Erick M. Swenson, Geology
Eleanor E. Tveter, Botany
Dean A. Vidal, Mechanical Engineering

Technicians

Lee Amoroso, Earth Sciences
Semih Aygun, Sea Grant Salmon Project
Robert A. Blake, Engineering Design and Analysis Laboratory
Bonita Coutermarsh, Sea Grant Salmon Project
Richard D. Jennings, Electrical Engineering
Donald MacLennan, Electrical Engineering
Michael A. Thays, Technician II, Sea Grant Salmon Project
Eleanor E. Tveter, Botany

Undergraduate Students

Roy R. Annis, Political Science
John L. Ayvazian, Mechanical Engineering
Stephen E. Barakis, Mechanical Engineering
Martin F. Bowen, Zoology
Richard W. Burkholder, Political Science
Elaine Calderone, Zoology
Pierre J. Corriveau, Mechanical Engineering
John L. Cowles, Electrical Engineering
Kenneth C. Dallas, Mechanical Engineering
Kenneth W. Davis, Electrical Engineering
Richard J. Doda, Electrical Engineering
Earl C. Dodge, Mechanical Engineering
Raymond J. Dreyer, Zoology
David W. Durfee, Mechanical Engineering
David A. Eck, Electrical Engineering
Bruce R. Fortnam, Electrical Engineering
Richard B. Fuller, Thompson School of Applied Science
Niel E. Goodzeit, Mechanical Engineering
Janet F. Graham, Psychology
James E. Haller, Chemical Engineering
William L. Keith, Mechanical Engineering
Guy R. Knudsen, Forestry Science
Gary W. Krook, Mechanical Engineering
Geoffrey S. Lord, Mechanical Engineering
Peleg Dameron Midgett IV, Parks and Recreation
K. Michael Mitrakas, Electrical Engineering
Byard W. Mosher, Chemistry
Timothy P. Mulhern, Political Science
Harry J. Nielson, Mechanical Engineering
Gregory W. Papadeas, Electrical Engineering
Marc F. Petrin, Electrical Engineering
Robert M. Reed, Electrical Engineering
William J. Renault, Mechanical Engineering
Gustave W. Ruetenik, Mechanical Engineering
Roberta J. Sanders, Geology
Thomas C. Schwandt, Civil Engineering
John E. St. Andre, Chemistry
Steven J. Szydlick, Geology
David R. VanHouten, Mechanical Engineering

Secretaries

Juliann M. Husman
Karen J. Morneau
Jean G. Pierce

UNH Coherent Area Sea Grant Program
January 1, 1975 — January 1, 1976

PROGRAM BUDGET BY CATEGORY (NOAA)

	NOAA Grant Funds	*University Matching Funds*
RESEARCH		
Marine Resources Development	$238,000	$143,500
Marine Technology Research and Development	$ 82,700	$ 48,200
Marine Environmental Research	$ 8,000	$ 7,400
Socio-Econmic and Legal Studies	$ 64,500	$ 20,500
EDUCATION		
Marine Education and Training	$ 24,000	$ 26,300
ADVISORY SERVICES		
Marine Advisory Program	$ 25,950	$ —
PROGRAM MANAGEMENT AND DEVELOPMENT		
Program Administration and Development	$ 57,200	$ 28,300
TOTAL	$500,350	$274,200

The material for this report
was compiled and arranged by
Edward H. Stolworthy

Printed by
Seabrook, N.H.