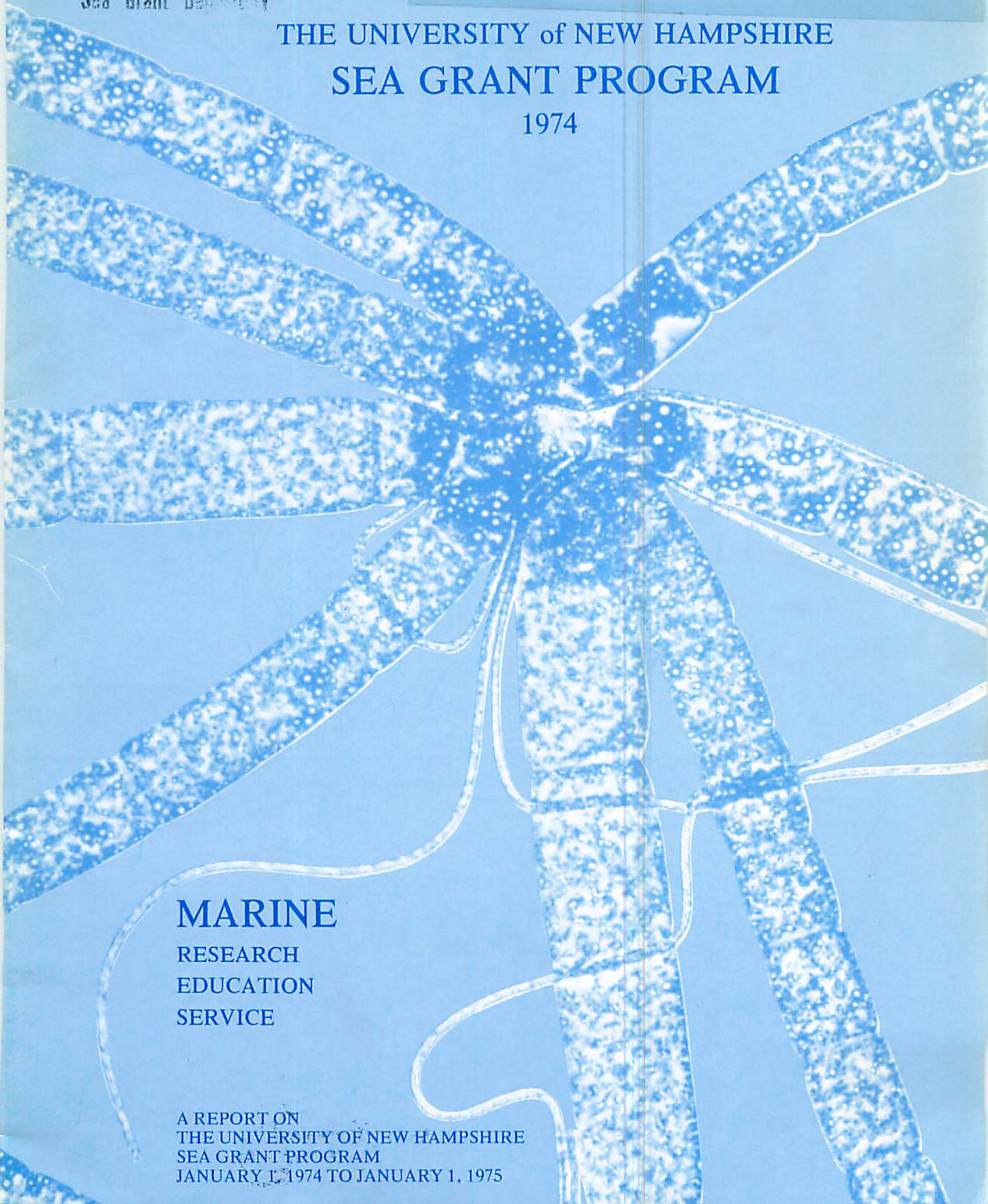
THE UNIVERSITY of NEW HAMPSHIRE
SEA GRANT PROGRAM
1974



MARINE

RESEARCH
EDUCATION
SERVICE

A REPORT ON
THE UNIVERSITY OF NEW HAMPSHIRE
SEA GRANT PROGRAM
JANUARY 1, 1974 TO JANUARY 1, 1975

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 03-4-158-38

Front Cover: Species of sulphur oxidizing bacteria, *Thiothrix* and *Beggiotoa,* found on the outside of solid waste bales placed in sea water. Microphotograph by Dr. Sheril D. Burton, Brigham Young University, Visiting Faculty Investigator, 1973. (See page 9.)

THE UNIVERSITY OF NEW HAMPSHIRE SEA GRANT ANNUAL REPORT — 1974

Contents

A Triple Tribute

This Sea Grant Annual Report is dedicated to Professor Herbert Tischler, chairman of Earth Sciences; to Dean William H. Drew, associate dean of the Graduate School; and to Professor E. Eugene Allmendinger, associate professor of Naval Architecture. Professor Tischler, for seven years chairman of the University Marine Affairs Committee; Dean Drew, for the past eight years University Coordinator of Research; and Professor Allmendinger, during the past eight years Executive Officer of the University Office of Marine Science and Technology have all played key roles in the formulation of the UNH Marine Program. This program was finally approved by the University's Board of Trustees early in 1975.

Professor Tischler

Dean Drew

Professor Allmendinger

With the formal adoption of the UNH Marine Program as an academic as well as a research effort, and the reorganization of the University Research Office during the past year, all three of the marine related offices formerly held by Professor Tischler, Dean Drew, and Professor Allmendinger have ceased to exist. Their goals have been realized or their functions absorbed into the new order. Organizations change, but we are fortunate that these valued colleagues will continue to lend their abilities and energies to marine affairs. This 1974 Sea Grant Annual Report is dedicated to you Herb, Bill, and Gene in recognition of your long and successful service to all of us at UNH who are engaged in marine research and education.

Thank you, gentlemen!

Director,
UNH Coherent Area Sea Grant Programs

The UNH Coherent Area Sea Grant Program and the Future Maine — New Hampshire Sea Grant Institution

What is a Coherent Area Sea Grant Program? Since 1971 at the University of New Hampshire, it has meant an opportunity to create and carry out a group of research and educational projects aimed at serving important regional needs in northern New England's coastal zone and continental shelf. It has been a challenge to prove by our accomplishments that we can serve the basic purpose of the National Sea Grant Act: to add to the wealth and well-being derived from our region's marine territories. We have focused our applied research and teaching efforts on ocean engineering questions about offshore structures and regional mineral resources; aquaculture of salmon, mussels, and crustaceans; modeling of regional environmental prediction questions; and economic/social science research to help our state's Coastal Zone planners. Partners in our various Sea Grant ventures have been: six regional private companies plus the Woods Hole Oceanographic Institution; the Maine Department of Marine Resources and the University of Maine; and the State of New Hampshire Department of Fish and Game, Department of Resources and Economic Development, and Office of Comprehensive Planning.

Bolstered by the action of our University's Board of Trustees which established a special Marine Program Budget (subsequently funded by the State legislature in 1973), we are now looking forward to joining with the University of Maine to become the Northern New England Sea Grant Institution by 1976. Our nation's Bicentennial Anniversary Year seems a most suitable time for institutions of the two states to form a federation cooperating in marine enterprise.

Two hundred years ago, marine activities formed the principal industry of this region. Now there is a great need for our nation's universities to reestablish their credibility in the public eye and reassert rational thinking and high principle in the body politic. What better way then for the faculties and administrations of two state universities to lead the way in economizing, by cooperating and sharing programs and facilities, eliminating or avoiding expensive duplication of capacity, and concentrating on giving higher quality opportunities and service to their regions' youth and taxpayers.

We would like to think our Sea Grant accomplishments, goals, and organizational thrust would please Ben Franklin as well as Athelstan Spilhaus, the father of the Sea Grant idea.

Godfrey H. Savage
Director
July 1, 1971 — March 15, 1975

Aquaculture

Development of a Salmonid Fishery for Coastal New Hampshire: A Pilot Program — The Rearing of Coho Salmon

Principal Investigators:
Professor Richard G. Strout
Professor Richard C. Ringrose

Associate Investigator:
Mr. Erick D. Sawtelle

Graduate Student:
Mr. Richard H. Sugatt, Ph.D. program in Zoology

Undergraduate Students:
Mr. John E. Lorentz, Biology
Mr. Peleg Dameron Midgett, IV, Parks and Recreation
Mr. Robert J. Moore, Zoology
Mr. Joseph D. Murdoch, Zoology

Technician:
Mr. Michael A. Thays

This cooperative research and development program between the University of New Hampshire and the New Hampshire Fish and Game Department was originally initiated in 1972 in an effort to establish the feasibility of developing self-sustaining salmonid rearing programs for both viable commercial operations and sport fishery programs in northern New England. Research and development studies were based primarily on stocks of the pacific Coho salmon, *Onchorynchus kisutch.*

The success of both phases of the program depends on such factors as the establishment of genetically desirable strains of Coho adapted to this region, the development of functional disease detection and control programs, the development of optimal diets used in culture operations, and the establishment of functional management practices for all stages of production.

Work to date has included the construction and implementation of an experimental salmon rearing station in Newmarket, New Hampshire, including hatching, rearing, and research facilities, with a capability of holding 80,000 smolt size (20-25 gm) salmon per year. These fish are used for nutrition research and disease control programs being carried out both at the Newmarket facility in fresh water and in floating net pens in New Castle, New Hampshire, at the United States Coast Guard Station where the sea water "grow-out" facilities are located. The remainder of the fish not used in these experiments are tagged and released into the Great Bay estuary system for evaluation of the potential of an ocean ranching program (open range culture). These fish range freely for six to eighteen months in the open ocean and then are harvested upon their return to the location where they were originally released. The majority of the returning fish are sexually mature. A selection is made of those fish showing desirable characteristics. These are artificially spawned to provide eggs from fish that are adapted to the environmental conditions of this region. Currently most of the eggs are obtained from state and federal agencies in the Pacific

Hand vaccinating smolt-size Coho against Vibrio, *a saltwater bacterial pathogen.*

Fin clipping smolt-size Coho for identification of stock.

Northwest. However, in 1974, 100,000 eggs were spawned from Coho returning to the Lamprey River in Newmarket, New Hampshire. These fish had been stocked as part of the New Hampshire Fish and Game Department sport fishery program. Various strains of Coho have been screened both at the Newmarket station and at some of the New Hampshire Fish and Game Department hatcheries to determine the suitability and adaptability to conditions encountered in this region.

This year the main emphasis in this project centered on nutrition and disease problems. The nutrition research evaluated five experimental artifical foods during the growing period in fresh water. By feeding various levels of protein at a constant energy to protein ratio the results indicated that Coho need at least 45 percent protein in the feed for best growth in 10°C water. In relation to a commercial salmon feed used as a control, all five experimental feeds gave growth equal to or better than the commercial feed. Three of the five experimental feeds exhibited an improved feed conversion ratio (feed consumed to weight gained). Valuable leads were obtained toward development of an improved artificial diet for salmon culture.

Work to date on disease research has centered around isolation of strains of *Vibrio anguillarium* from the environment and limited production of a bivalent bacterin for smolts reared or released in sea water. In the summer of 1974 a small trial involving approximately ten thousand vaccinated Coho belonging to Maine Salmon Farms in Wiscasset, Maine, withstood a natural field exposure which caused eighteen percent mortality in unvaccinated fish but only 3 percent loss in the immunized group.

Work will continue in 1975 on nutrition and disease problems encountered in both fresh and saltwater during the "grow-out" period and on the development of saltwater rearing systems. Evaluation of the feasibility of open range ranching in this region will be made, together with environmental impact studies concerning the release of juvenile Coho salmon, both for sport fishery and ocean ranching. General management factors for all phases of production will be considered.

A marketable Coho salmon, about two years old, fifteen inches long and weighing one pound. Reared at the Coast Guard dock, New Castle, New Hampshire. (John Harrigan, New Hampshire Sunday News photos.)

A Study of the Genetics of Winter Flounder and Their Culture in the Heated Effluent of a Nuclear Power Plant

Co-Principal Investigators:
Dr. Evelyn S. Adams
Professor Frank K. Hoornbeek
Professor Philip J. Sawyer

The winter flounder *Pseudopleuronectes americanus* is an important commercial species of off shore New England. The species is also popular among sport fishermen during the summer. Successful attempts to improve the stock of this species, therefore, would be of benefit to a variety of persons. Thus the objectives of this study are: (1) to study the growth of flounders in heated power plant effluent; (2) to begin a program aimed at selecting those specimens that are the largest, healthiest, and best individuals for culture; (3) to grow triploid flounders from eggs; and (4) to develop an inbred strain which would eliminate the size variability occurring in naturally spawned flounders. Thus, the emphasis in (2) to (4) will be on the genetics of the winter flounder rather than the raising of flounders for supplementary stocking purposes.

Flounders Reared in Heated Water

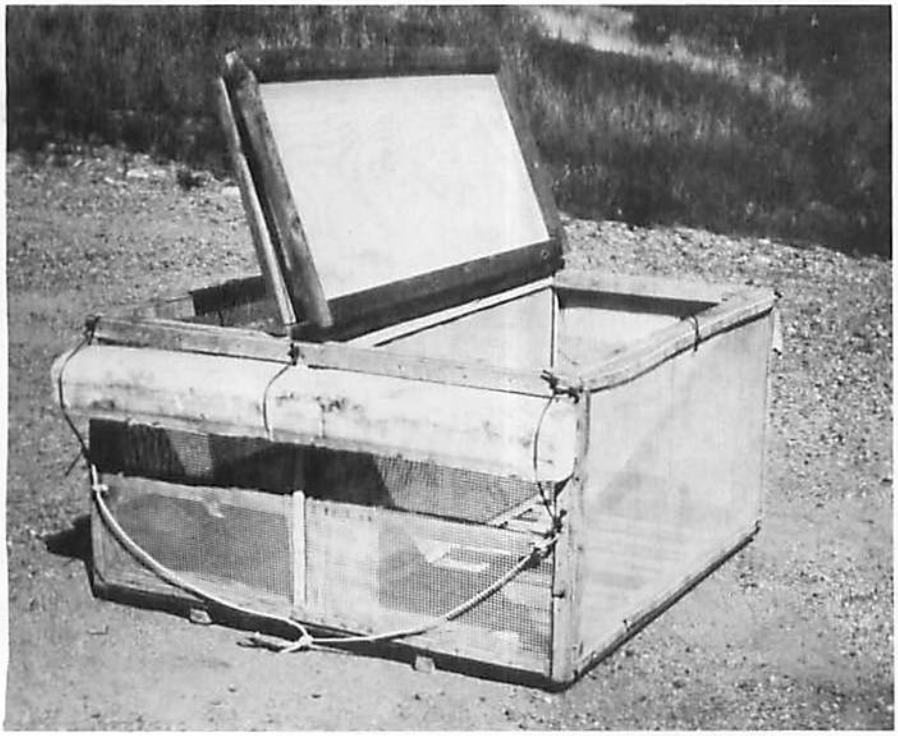
Since July 1974, part of the flounder project has been conducted near an atomic power plant in Wiscasset, Maine. The objective is to test the feasibility of commercial flatfish culture, including studies of: (1) the effects of heated water from the plant; (2) cage design and fish density; (3) diet; and (4) disease control. Several hundred wild flounder (5-8 cm) comparable in size to those a hatchery system would produce, were placed in cages 0.6 meters, (2 feet) by 1.2 meters, (4 feet) by 0.6 meters (2 feet) in depth in water warmed by the power plant an average of 5°C above ambient. A control group of flounder was held at ambient water temperatures a mile up the Sheepscot river. During the first 60 days of the experiment, fish in the warmer water grew from an average of 1.0 g to an average of 4.4 g, and the control fish from 2.8 g to 4.5 g. Further measurement will be necessary before conclusions can be drawn.

Diet for the fish was a frozen food ball made of herring meal, ground shrimp waste, redfish oil, vitamins, and a binder. This diet proved best of three preparations so far tried. As they thaw, the frozen food balls act as automatic feeders.

Bacterial disease, especially the genera *Vibrio* and *Pseudomonas*, appear to be the major problem in flatfish culture. Although disease outbreaks were controlled with medication, future research will be on more permanent solutions such as vaccines and high vitamin nutrition.

Species Improvement by Selection

The classical way to improve a strain of animals is to grow many generations, selecting from each the individuals that meet the criteria sought. Eventually, if successful, the desired characteristics



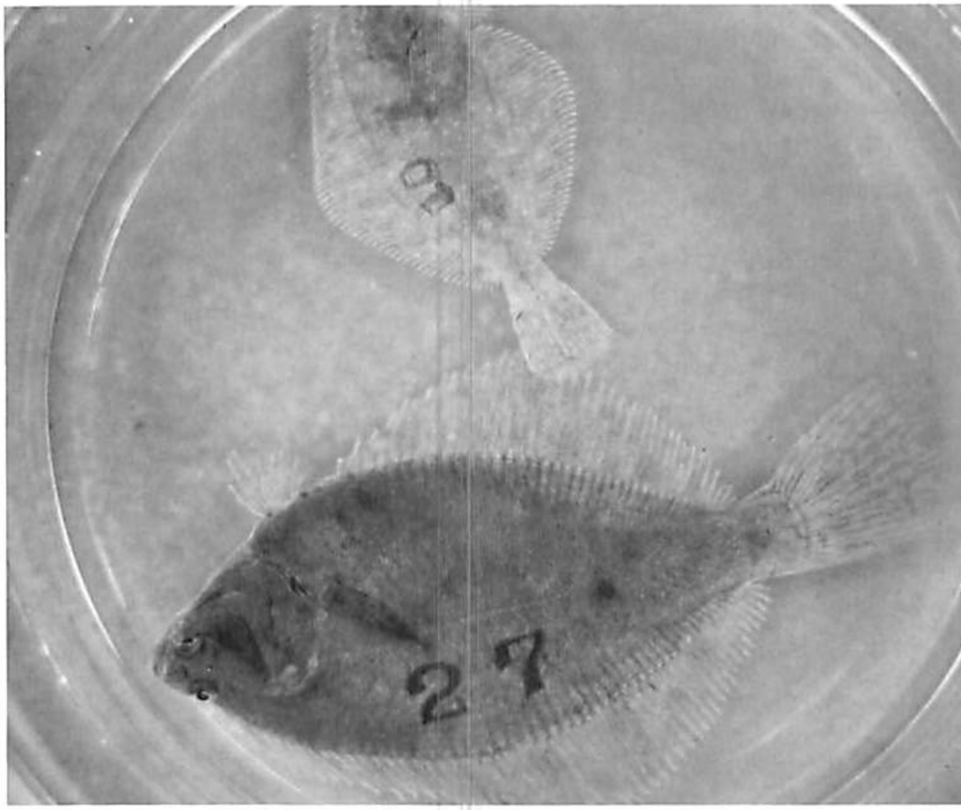
Flounder cage showing slatted bottom of right side.

Flounder cage in position down stream from the nuclear power plant, Wiscasset, Maine. Flagged buoy beyond cage marks continuous water temperature recorder.

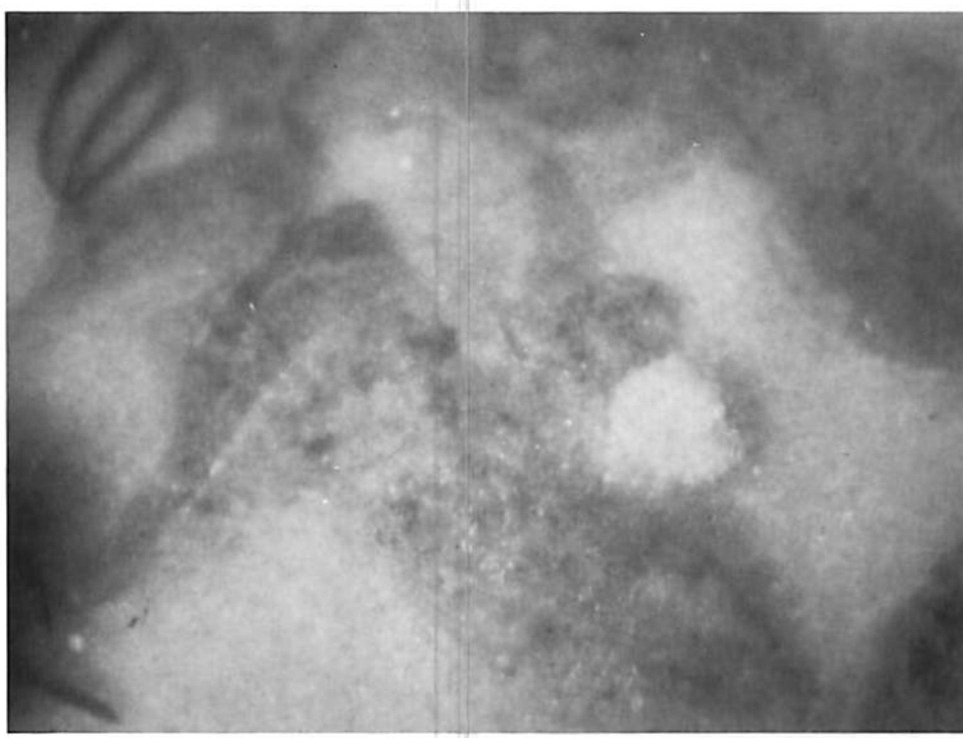
are fixed in the species. This is the procedure being used with the flounders. About one hundred specimens have been collected and marked. These fish are being fed, weighed, and measured regularly. From these individuals, those judged the best for propagation will be selected and an attempt made to rear their young. Successive generations will be handled similarly. The flounders will be kept in 10°C water during the cold months with the idea of speeding the process.

Triploid Flounders

To short-cut and supplement the selection program it is planned to culture special flounders from eggs. Eggs will be used for three purposes. First, normal flounders will be raised as control animals. Second, triploids would be raised as "meat" animals. No energy would go into the development of gonads so that all of their growth would increase the edible portions of their bodies. The third procedure under development concerns a technique involving radiation of the sperm and cold-shocking the eggs fertilized by the irradiated sperm. It is expected that combining these two treatments, and *then* raising flounders from these eggs will result in individuals with much less size variability.



Numbers resulting from cold-branding.



Flounders actively feeding on prepared food.

Biology and Ecology

Seaweeds (Attached Marine Algae): Morphology, Systematics, and Ecology

Principal Investigator:
Professor Arthur C. Mathieson

Graduate Students:
Mr. Clayton A. Penniman, Master of Science Program in Botany
Mrs. Eleanor Tveter, Master of Science Program in Botany

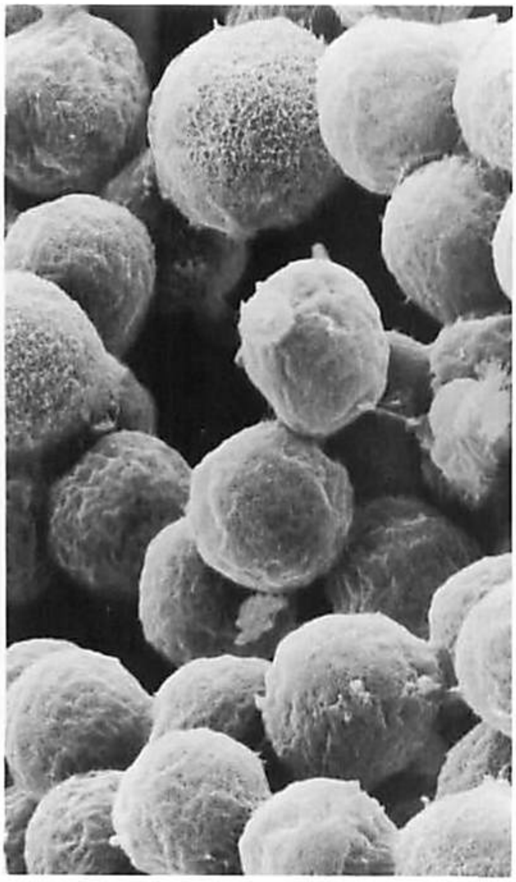
Research Technician:
Mrs. Eleanor Tveter

The objectives of this Sea Grant project are to obtain a better understanding of sporic reproduction of Irish Moss as well as to contribute to the enhanced methods of "seed stock" selection of *Chondrus.*

The rates of carpospore and tetraspore liberations are being determined seasonally, and under a variety of environmental parameters, e.g., temperature, salinity, and light conditions. Spore viability is also being determined seasonally, in order to determine the optimal periods of reproduction. This information is fundamental to the conservation and protection of this valuable resource.

The mariculture of *Chondrus* is being actively conducted in a variety of sites in Canada. Here, studies of "seed stock" selection are directed to a better understanding of differential properties, as well as a possible enhancement of properties (such as percent carrageenan) by environmental parameters, including nutrients and temperature.

Other studies of seaweeds involve six other graduate students supported by agencies other than Sea Grant. Included are: (1) ecological studies of the estuarine brown alga *Ascophyllum nodosum forma scorpioides,* (2) an ecological study of seaweed populations on a sandy beach in Seabrook, New Hampshire, (3) the seasonal ecology of a Mediterranean seagrass community, (4) autecological studies of the brown alga *Fucus spiralis,* (5) vertical stratification of subtidal red algae and, (6) the ecological significance of sporeling coalescence in *Chondrus crispus Stackhouse.*



Microphotograph of spores of Chondrus crispus.

Scuba diving offshore of Appledore Island, Isles of Shoals, for subtidal seaweeds.

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

Principal Investigator:
Professor Theodore C. Loder

Faculty Investigators:
Professor Fletcher A. Blanchard
Professor Wendell Brown

Graduate Students:
Mr. Daniel L. Cordell, Master of Science Program in Electrical Engineering
Miss Jane S. Fisher, Master of Science Program in Earth Sciences
Mr. Erich S. Gundlach, Master of Science Program in Earth Sciences
Mr. Jeffrey A. Thornton, Master of Science Program in Earth Sciences
Mr. Thomas C. Shevenell, Ph.D. Candidate, Columbia University

Undergraduate Students:
Mr. Martin F. Bowen, Zoology
Mr. Frank A. Byron, Zoology
Miss Suzanne Gammons, Botany
Mr. Vincent Kayser, Electrical Engineering
Mr. Byard W. Mosher, Chemistry
Mr. Alan B. Packard, Chemistry
Mr. John E. St. Andre, Chemistry

This project, aimed at improving the understanding of the overall implica-

Upper — Compacted solid waste bales and biological fouling plates on a rack prior to lowering into seven hundred feet of sea water by the deep submergence research vessel Nekton Gamma.

Lower — Bale H, a bale of solid waste materials, including food wastes, as it appears after submergence for more than two and a half years at a depth of fifty feet. A number of species of macroalgae have attached to the plastic mesh covering on the bale.

tions of placing compacted solid-waste in a marine environment was started in 1971. Observation of compacted bales placed off the Isles of Shoals in July, 1972 continues. At approximately bimonthly intervals, observations are made of the biological, physical, and chemical changes within and around the experimental bales. Physically the bales have changed little over the past year. Those bales which were wrapped in plastic mesh have attracted flora and fauna that are similar to those found on nearby rock outcrops. Most of the plastic-mesh wrapped bales are now covered with marine algae forms such as *Laminaria* and *Agarum* that utilize the mesh as attachment substrate. The bales which are without the plastic mesh wrappings show little or no attached algae.

One major new study this year involved placing experimental bales and fouling plates near Veatch Canyon at the edge of the continental shelf. These bales and plates were mounted on racks to be retrieved for observation and study twelve to eighteen months after emplacement. The racks were placed using the Deep Submersible Nekton-Gamma. Dr. Richard Cooper, National Marine Fisheries Service, Woods Hole, Dr. Ruth Turner, Harvard University, and Dr. John Culliney, Marine Biological Laboratory, Woods Hole, cooperated in this portion of the project. Unfortunately, one of the racks holding the test bales and plates was snagged by a trawl net and returned in pieces only a few weeks after it was emplaced. It could not be replaced because the depth requires the use of a deep submersible. Other aspects of the project nearing completion include: (1) Effect of hydrogen sulfide on crab behavior, being conducted as a master's thesis; (2) hydrogen sulfide equilibria in the anoxic bale system; (3) dissolved organic carbon in bale systems; (4) trace metal mobilization within a bale system; (5) a computer control for a chemical monitoring system; and (6) a descriptive model of a commercial marine dump.

Buoy Systems Studies

Wave Measuring Buoy and Coastal Zone Modeling

Co-Principal Investigators:
Professor Godfrey H. Savage
Professor Alden L. Winn

Associate Investigator:
Professor Kerwin C. Stotz

Graduate Students:
Mr. David J. Agerton, Ph.D. Program in Engineering
Mr. John Delano, Master of Science Program in Electrical Engineering
Mr. David O. Libby, Master of Science Program in Mechanical Engineering

Undergraduate Student:
Mr. David E. Dunfee, Mechanical Engineering

Staff and Support Personnel:
Mr. Paul E. Lavoie (Diving Safety Officer)
Professor D. Allan Waterfield (Volunteer Diver)

Chief Technician:
Mr. Robert A. Blake

This project was completed during the calendar year of 1974 with mixed results. The Coastal Zone Modeling of wave refraction in the Gulf of Maine reached the conclusion that it was simply not within the state of the art to reconstruct deep water wave spectra from data measured in shallow water (where wave lengths are greater than the water depth) and then projected out into deep water by subtracting the effects of wind as well as shoaling and refraction. (See (1), third paragraph below.) This reconstruction of waves had been an important goal of the project because it would have permitted wave data to be measured close to land (where it would be economical to run a shore cable both to supply power and to transmit the data to a shore receiving station); then to be translated into a deep water wave spectrum. The resulting deep water wave spectrum could then be used as input to the regular wave refraction model to determine maximum wave heights and energy distribution anywhere in the Gulf of Maine. On the other hand, these negative findings emphasize the lack of wave force prediction capability that exists in the Northeast United States and similar areas, and demonstrates the need for further research to gain such capability. Meanwhile a healthy conservatism should be maintained in the design of offshore structures until there is a better understanding of the working conditions.

A wave measuring buoy near the Isles of Shoals recorded wave data for several months in the fall of 1973 as reported last year. It was then recovered because several of the rubber tethers parted after being accidentally sliced by divers working on them. Efforts to reinstall the system in the spring of 1974 were terminated when it was discovered that the shore cable had, for the third time, been separated. This time the failure was due to wave action near the shore in about twenty feet of water. The cable had been reinforced and specially weighted over a 200 foot length to protect it from being fouled by lobster pot mooring lines which had caused the previous cable separation. However, the additional diameter and mass of the cable made it much more responsive to wave action so that it literally beat itself to death. Protecting the cable from the actions of the fishermen had made it more vulnerable to the forces of nature. It is now certain that an inexpensive bottom-mounted shore cable is an elusive goal which does not offer a ready solution to long term data-recording needs in the Gulf of Maine. Man-made hazards offer the greatest deterrent to sub-surface instrumentation in shallow water. Commercial fishermen in particular make few allowances for anything except their own survival.

These investigations have resulted in four reports or publications: 1) D. E. Thrall, "Development of a Computer Program to Simulate Wind Wave Generation, Refraction, and Shoaling in the Gulf of Maine," UNH-SG-106, EDAL Report No. 113, March, 1973. 2)

A. L. Winn, G. H. Savage and R. Hickman, "Design and Instrumentation of a Shore-Recording Wave Amplitude Measuring Buoy," Ocean 75 Conference, to be published in October, 1975. 3) K. E. Stotz, D. O. Libby and G. H. Savage, "Computer Model and Data Interpretation for a Rubber Cable Tethered Wave Amplitude Measuring Buoy," Ocean 75 Conference, San Diego, California, September 22-25, 1975. 4) D. O. Libby, "An Attempt at the Restoration of Deep Water Wave Conditions from Shallow-Water Data by Disjunction of Wind and Bottom Effects," Masters Degree Project, Mechanical Engineering Department, University of New Hampshire, May, 1975. These investigations also advanced the knowledge of rubber filaments as structural members for mooring-tethered bodies subjected to heavy wave action. Other "rubber band" buoy research at the University of New Hampshire related to this project during the past three years has been funded by the Office of Naval Research and the United States Coast Guard Research and Development Center. The findings have been shared with the University of Delaware, Oregon State University, the Woods Hole Oceanographic Institution, The EDO Corporation, and Normandeau Associates, Inc. Work on rubber band buoys for the United States Coast Guard continues through the Ocean Technology Exploration Company, a New Hampshire-based enterprise.

Some of the findings from this research have been personally discussed with faculty from the Institute of Ocean Engineering at Heriot-Watt University, Edinburgh, Scotland, the Civil Engineering Department of the University of Trondheim, Norway; and the Technical University of Denmark. These discussions have been one of the bases for a developing cooperation with these North Sea ocean engineering organizations which are focusing on problems similar to those in the Gulf of Maine. Faculty exchanges are being arranged with these institutions for 1975-76.

Man in the Sea

Saturation Diving Program

Principal Investigator (PRINUL):
Prof. D. Allan Waterfield

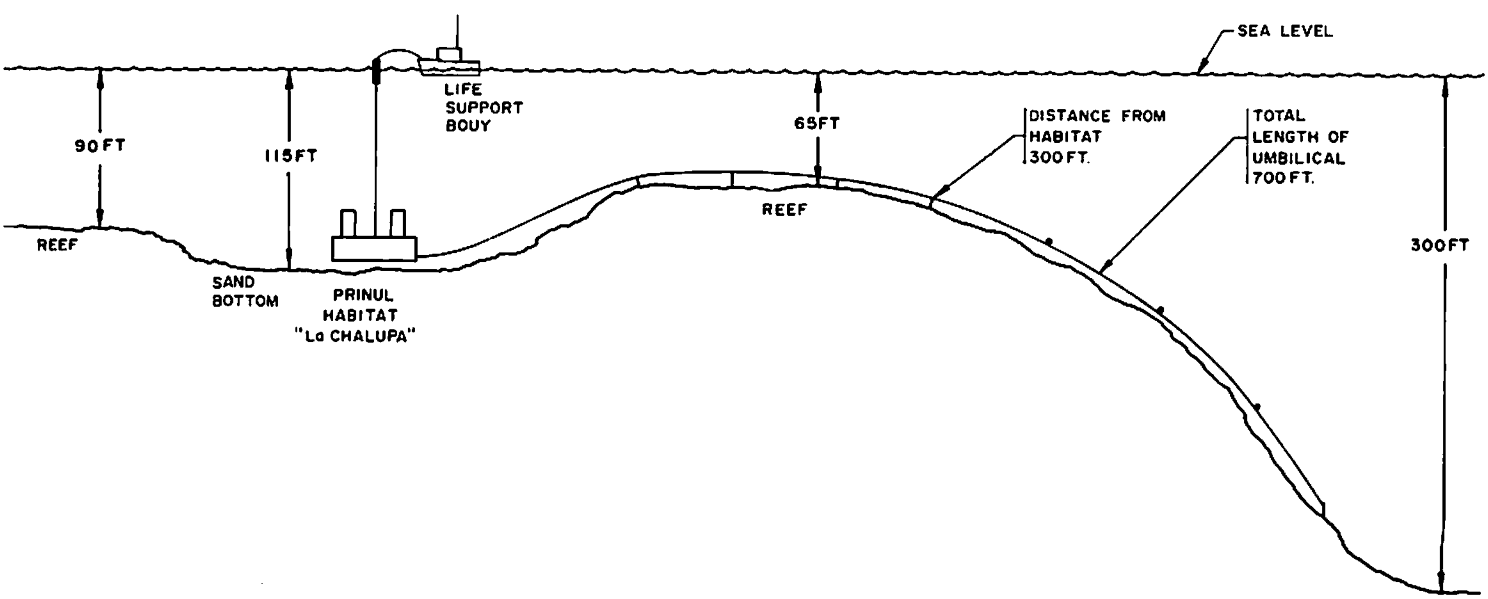
Other Principal Personnel (PRINUL):
Dr. James Miller, National Oceanic and Atmospheric Administration
Mr. Ian Koblick, Marine Resources Development Foundation, San Germain, Puerto Rico

Advisor (HYDROLAB Student Project):
Professor Godfrey H. Savage
(Names of other participants appear on page 22.)

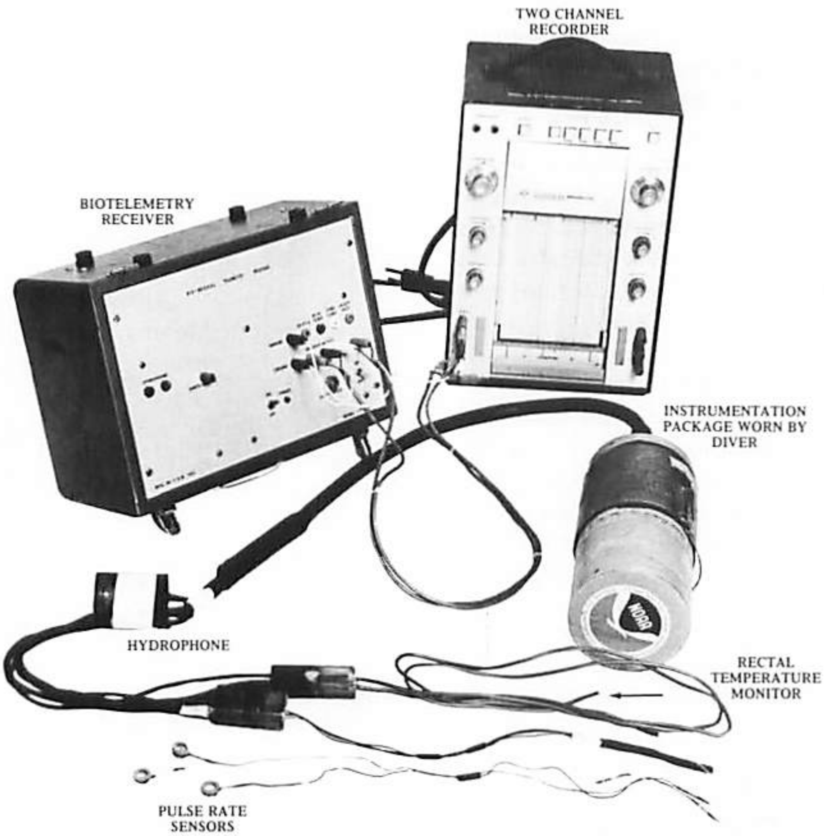
During the year 1974 the University scientists and engineers continued their studies of saturation diving and saturation systems. UNH personnel were involved in two missions each with international teams, one at the Puerto Rico International Undersea Laboratory (PRINUL), the second at HYDROLAB, Freeport, Grand Bahama.

PRINUL

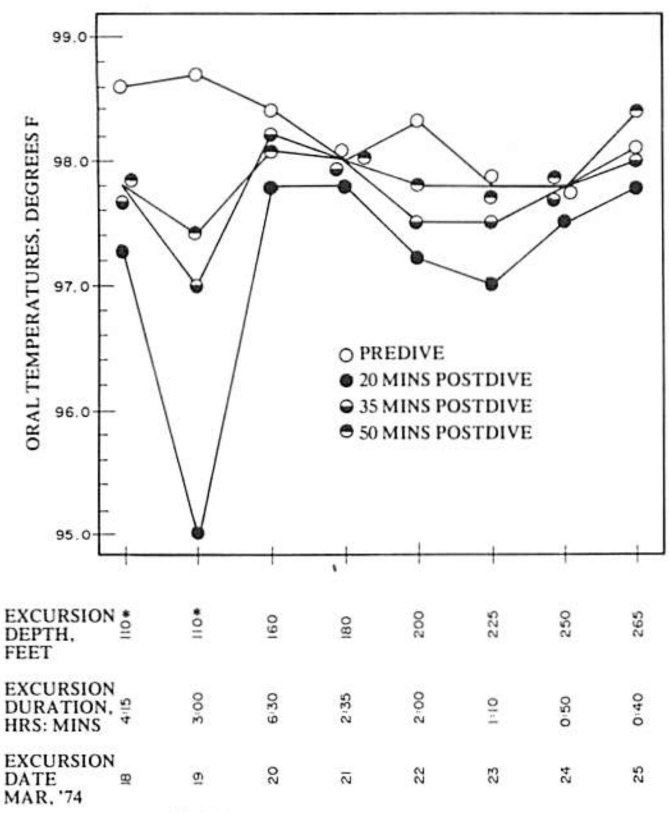
The Puerto Rican Underwater Laboratory, LA CHALUPA, is a unique barge-like system. Ita normoxic nitrox laboratory with the capability of raising and lowering itself in the water column by varying water ballast. The



PRINUL Project Site Profile.



Ultrasonic Biotelemetry System for Divers.



*JACKET AND HOOD ONLY

PRINUL Saturation Diving Project Predive and Postdive Oral Temperatures.

supporting surface boat is unmanned. It provides electrical power, fresh water, high and low pressure air, and communications for the submerged laboratory. The system was developed to be used at a working depth of 100 feet supporting a team of four aquanauts for fourteen days without resupply.

In March of 1974 UNH personnel joined an international team of divers in a two-week saturation expedition at a depth of 100 feet, this being the deepest normoxic nitrox saturation dive to date. The principal experiment for this mission was an open sea trial of the downward vertical excursions tables developed by the Environmental Physiology Laboratory of the Union Carbide Technical Center, Tarrytown, New York, for the Manned Undersea Science and Technology (MUS&T) Office of NOAA. These tests were the second part of the experiment reported in UNH Marine Program Annual Report 1973. The same personnel conducted both tests with the 1974 test establishing the deepest to date open water downward vertical excursion by saturated divers breathing air. Included within this experiment were tests for nitrogen narcosis and empirical testing of oxygen poisoning and decompression sickness. An important aspect of the overall mission was the collection of biomedical data from the aquanauts. These data were collected by use of the unique acoustic biotelemetry system developed at UNH as part of a Sea Grant research program. This equipment was described in EDAL Annual Reports for 1971 and 1972. Additional data of aquanaut's daily body temperature fluctuation were collected within the laboratory by using an electronic rectal temperature monitor.

The success of this mission has further opened the saturated divers "working window." It has demonstrated that a diver can work out of a normoxic nitrox saturated mode (95 percent nitrogen — 5 percent oxygen) at 110 feet depth to a depth of 265 feet using compressed surface air (80 percent nitrogen — 20 percent oxygen) during the excursion without fear of physiological damage.

The biomedical data gathered supported previously collected data and added new information in terms of daily body temperature variation. The data indicate that (1) dive exposure time is more important than depth in loss of body heat. (2) normoxic nitrox saturation appears to depress daily body temperature.

HYDROLAB

In March of 1974 staff and students from the University of New Hampshire provided the surface support team for the saturation mission of a team of German scientists in the HYDROLAB habitat, Freeport, Grand Bahama. The support was provided by the students working on the Sea Grant student project studying the engineering design of a device to measure the metabolism of benthic flora.

This unique opportunity was not only a service to the advancement of saturation diving, it provided the students an opportunity to test the equipment they developed, in situ, and to experience first-hand the field operations of scientists at work.

Marine Instrumentation

An Infrared Remote Sensing Technique for Improved Oil Slick Classification

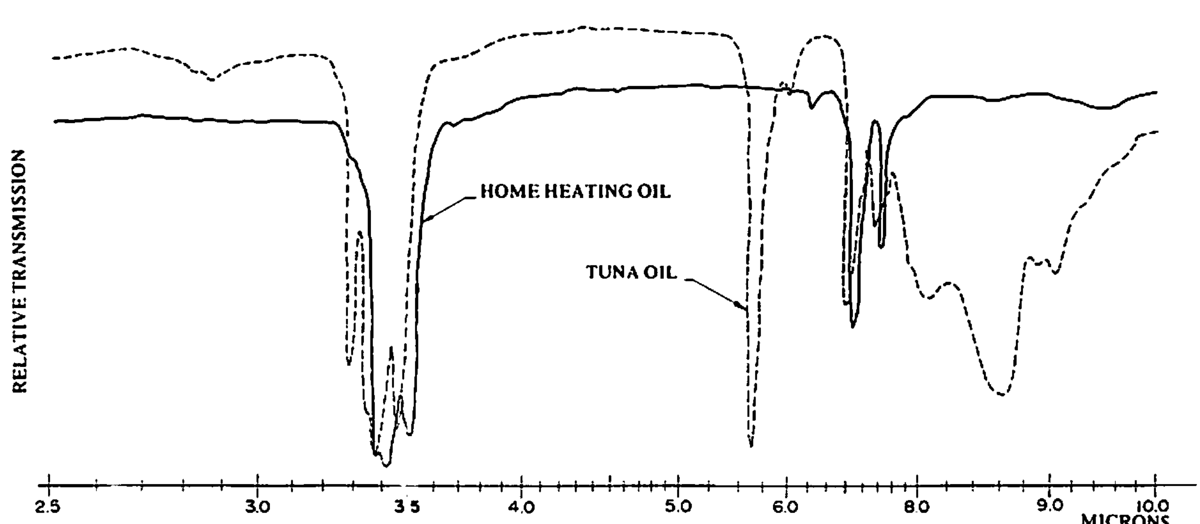
Principal Investigator:
Professor Glen C. Gerhard

Project Assistant:
Mr. Robert L. Bolus

This report is concerned with one specific application of remote sensing of ocean surface slicks — the use of the thermal infrared portion of the spectrum to provide quantitative and qualitative information on these slicks using an airborne infrared spectrometer package.

As an interim step, a comparison was made of sensing systems then under development for the Coast Guard and their potential cost effectiveness when compared with visual observation methods then employed. While a prototype multiple sensing package was being developed, interim sensing packages were purchased by the Coast Guard for patrol use. While a great improvement in slick detection and classification was anticipated, this investigator believed that spectral recognition techniques had not been adequately examined, especially from the standpoint of differentiating between various types of slick-causing substances. Spectral recognition techniques have been successfully utilized for applications such as soil and crop identification. It was the purpose of this project to investigate the feasibility of obtaining emitted infrared spectral signatures from the ocean surface to allow discrimination among various types of surface slicks: petroleum-based products, fish oils, and wind slicks.

This report describes the design, fabrication, and evaluation of a relatively inexpensive and simple system for obtaining emitted infrared spectral signatures from the ocean surface. Results obtained with this system showed that, while some laboratory spectra were obtained, the potential field utilization of the instrument was severely limited by the sensitivity of the detectors employed. While the use of available high detectivity (and relatively high cost) infrared sensors would have enabled the evaluation of this technique to be considerably more definitive, the cost considerations caused the project to be terminated at this point.



Standard Transmission Spectra of Home Heating Oil and Tuna Oil Compared.

The Marine Advisory Service

The Sea Grant Marine Advisory Service at the University of New Hampshire

Director:
Bruce A. Miller

The Marine Advisory Service at the University of New Hampshire continues to be a cooperative effort of the marine personnel of the University. Its function is to communicate the full scope of the University's marine activities to the various appropriate user groups within northern New England. The aim is to foster the practical application of relevant marine research in solving social, economic, and environmental problems of the state and the region. Communication is effected by publishing both technical and general reports on the results of marine related research and by issuing periodic news letters and press releases on the broad spectrum of northern New England marine activities. Individual requests for information are answered.

A series of specific advisory projects that should directly or indirectly affect the economy of the region has been developed. A primary effort in 1974 has been directed toward stimulating a diversified seafood program in New Hampshire and southern Maine. The University of New Hampshire's Advisory Service has joined with two Maine agencies and a Maine aquaculture company in a cooperative effort designed to establish a sustained blue mussel industry by 1978. University aquaculture personnel are working with the New Hampshire Fish and Game Department in its development of a Coho sports fishery and with Maine Salmon Farms to produce pan-sized salmon. A survey of the potential for a New Hampshire and southern Maine crab fishing industry has just been completed. The Advisory Service is working with companies based in New Hampshire and Maine toward the establishment of the commercial culture of lobster. Consultation services are provided to commercial seaweed companies on the development of new seaweed species for economic utilization. Aquaculture personnel provide tours of facilities and make numerous presentations to public and private organizations throughout the year.

Formalized ocean engineering service activities to industry in the region have existed at the University since the founding of the Engineering Design and Analysis Laboratory in 1965. The assistance given has been mainly in the form of responses to a broad range of specific technical questions and by engineering faculty membership on State boards, commissions, or panels. Examples are: the New Hampshire State Port Authority, the Maine-New Hampshire Bi-State Commission on Oceanography, and the New Hampshire Oceanographic Foundation. Recently, ocean engineering personnel contributed to the governor's study on the feasibility of locating a refinery and deep water terminal in the New Hampshire coastal zone. University ocean engineers have continued to provide technical consulting and testing services to a wide range of state and regional audiences. Continuing education courses were conducted in various communities for specific user groups in the region. Presentations on various aspects of the marine engineering program were provided to high school classes, adult professional groups, alumni, and other interested audiences.

The Advisory service worked with the Office of Comprehensive Planning and with the Southeastern Regional Planning Commission in the development of the Coastal Zone Management Plan for the New Hampshire seacoast. Assistance has been rendered to private companies and state agencies in environmental monitoring studies dealing with the Great Bay estuarine system and the Isles of Shoals. A survey for the New Hampshire Marine Dealers Association on the impact of the marina industry on the New Hampshire economy has just been completed.

The New Hampshire Marine Advisory Service has participated in the formation of the New England Marine Advisory Service (NEMAS), located at the New England Center for Continuing Education. This organization was funded by Sea Grant late in 1974, and its Board of Directors has progressed in its plans for a permanent organization. A full-time director will promote regional information exchange and coordinate talent sharing, as well as organize conferences and seminars on topics of regional importance.

Marine activity in New Hampshire increased significantly during 1974, spurred by population growth in the coastal areas combined with an influx of energy-related proposals for industry. Conflicts in our coastal area over land use, water allocation, and questions about the overall quality of life of seacoast residents have intensified. The realization that New Hampshire may have offshore supplies of petroleum makes advisory efforts to enhance public understanding of critical coastal zone issues imperative. A broader program is therefore being implemented, particularly in the critical area of coastal zone management, and initial development of an expanded advisory program that will fully meet New Hampshire's needs is progressing.

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
Mr. Kenneth A. Honey

University of Maine (Orono):
Mr. Richard A. Lutz
Mr. Bohdan M. Slabyj

University of New Hampshire:
Mr. Roy S. Alonzo
Mr. Bruce A. Miller

Consumer demand for seafood has grown steadily over the past few years, even though the supply of conventional seafood products is in a precipitous decline. The help meet this demand, attempts are being made to encourage the development of new fisheries based on currently underutilized species, among them the edible blue mussel, *Mytilus edulis.* This shellfish is one of the most abundant marine molluscs on both the European and American Coasts of the North Atlantic. In Northern Europe the natural stocks formed along the rocky shores are collected for local consumption, and intensive cultivation on ropes, poles, and rafts in shallow bays and inlets supplies regional and foreign markets with fresh, high-quality mussels. In spite of a substantial European harvest the demand increasingly exceeds the supply.

Natural beds of blue mussels, many containing high-quality mussels, are also found in abundance along the coast of North America from Cape Hatteras to Labrador. Until recently, these stocks have not been harvested for food. State agencies throughout New England have even paid to have mussels removed from clam flats.

Why are mussels currently underutilized in North America, while they are in such great demand in Europe? The formerly low price of other shellfish products meant that there was little to encourage promotion of a new seafood product. More importantly, the American public has never been adequately introduced to fresh or prepared mussels of high quality, and consequently is not aware that mussels are a good seafood product. Some people have eaten mussels collected from low quality natural beds, or those that have been poorly handled and prepared. The pearls and muddy flavor from some of these mussels have discouraged many potential users. Misconceptions about the quality of mussels, particularly in reference to mussel poisoning, have made some people afraid to try them, and at a time when outbreaks of paralytic shellfish poisoning in New England appear to be on the increase, this problem must obviously be dealt with very carefully to prevent further misinformation. Finally, even if a person does like mussels, the supply of quality ones from natural beds has been limited and unreliable, which makes it difficult to obtain them anywhere but in the most specialized markets and restaurants. For a combination of these main reasons, the blue mussel industry has been slow to materialize in the United States.

With the advent of the emerging food crisis, the situation has significantly changed over the past two years. We no longer ask *if* a fishery can be developed, but when. This Sea Grant sponsored Maine/New Hampshire joint mussel project has been 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.

At present this effort 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, Inc., of Damariscotta, Maine. Working communications are maintained with the blue mussel project at the University of Washington, with mussel activities 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 help those interested in establishing a commercial rafting venture.

Edible blue mussel and epicure.

The product development project, conducted by the Maine Department of Marine Resources, in association with the University of New Hampshire, has resulted in feature articles on the use of blue mussels in the *National Fishermen, Down East* magazine, the feature section of the *Boston Globe*, and in several New Hampshire newspapers. Demonstrations of mussel cookery by the Maine Department of Marine Resources at the State Houses in Maine and New Hampshire, combined with in-store demonstrations throughout New England have resulted in significant increases in demand, resulting in a dramatic rise in catch, not only in Maine, but also in other New England states. Demand in the stores for mussels, and requests for mussel cooking pamphlets published for home use in New Hampshire and Maine, seem to indicate that the consumer will continue to buy and use mussels when properly exposed to them.

Mussel use in restaurants is also on the increase. Food technologists at the Maine Department of Marine Resources have developed a breaded, quick-frozen product, and exposure of this product at the National Hotel, Motel and Restaurant Show resulted in an immediate increase in restaurant use of mussels throughout New England. In addition, studies at the Thompson School of the University of New Hampshire have resulted in new mussel recipes designed for large scale restaurant preparation which will be published shortly.

Mussel cultivation research has continued to expand at the University of Maine's Darling Center, where eighteen experimental rafts have been constructed and are currently in use to assess the aquacultural potential of numerous estuarine and coastal environments throughout Maine and New Hampshire. Research on pearl incidence had indicated that the harvesting of mussels from floating structures (i.e., commercial rafts) which have been in the water for less than five years should provide a method of obtaining a quality product even in areas where the presence of pearls has proved to be a deterrent to the commercial harvest of natural stocks. Results of raft cultivation efforts have been published in a Sea Grant bulletin entitled, "Raft Cultivation of Mussels in Maine Waters —Its Practicality, Feasibility, and Possible Advantages." Two techniques have been developed for estimating age and growth of individual mussels, and these techniques should provide more accurate methods to assess the aquacultural potential of various Gulf of Maine environments.

Problems of shelf life, handling, and taste are being resolved by the University of Maine at Orono, where

Mussels cacciatore and other tasty dishes were prepared and served on the New Hampshire State House lawn by members of the joint Maine — New Hampshire blue mussel team.

research has shown that quality of harvested mussels under storage in bushel quantities improved if the mussels were immersed in the ocean for several hours after harvesting, and stored in bushel sacks surrounded by ice. Shelf life can also be extended in the store if the repackaged product is held at or near 32°F. Other results show the importance for future storage of harvesting mussels from low bacteria beds, and of proper washing and repacking in clean containers.

Taste studies have demonstrated no detectable difference in flavor among frozen, fresh, and canned product, but a taste panel could detect a softer texture in canned mussels. To guarantee a quality product throughout the year, studies are currently under way to determine the cause of occasional poor taste in mussels during spawning. Paralytic shell fish poisoning is now monitored on a regular basis by the Maine Department of Marine Resources, as well as agencies in other states, to insure the safety of harvested mussels. All of these activities are contributing to a higher quality product.

A heavy set of mussels attached to ropes on an Abandoned Farm raft in the Damariscotta River. (Boston Globe, Ed. Fitzgerald photo.)

The first commercial mussel culture company in the United States, Abandoned Farm, Inc., was formed to produce and market, on an economic basis, commercial-sized mussels grown on rafts held in Maine's Damariscotta River. Abandoned Farm joined the Sea Grant blue mussel project in 1974 to determine the economic feasibility of commercial mussel culture in Maine. Current work by company personnel, assisted by research personnel from the Darling Center, is in progress to provide information needed to develop new procedures for commercial raft cultivation geared to Gulf of Maine waters. When combined with information already adapted from the commercial mussel industry in Europe, this information will establish the means to economic success for Abandoned Farm and other commercial mussel mariculture ventures in Northern New England.

Even though considerable time and capital will still be necessary over the next few years to establish a sustained blue mussel fishery, the development of this industry, both to utilize existing high-quality natural stocks and to develop a cultivated product will be a great boost to the local and regional fisheries economies of Northern New England. Because of the great potential for economic benefit to the region, the high probability for success, and the estimated low expenditures required to effect significant results, development of the blue mussel industry should continue to be a priority 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 during the 1965-66 academic year and has been repeated each year since. The program has been funded since 1968-69 by Sea Grant. Thus, we are currently in our tenth year, and in our seventh year of Sea Grant funding.

The projects course is designed to provide the undergraduate student with an educational experience that they would not normally receive in their academic program — specifically the experience of working as a member of an interdisciplinary team on a meaningful ocean-related problem under real-world constraints. Projects are of two basic types: those that lead ultimately to a piece of working hardware to solve a technological ocean problem; and those that are comprehensive studies of an ocean-oriented societal problem with recommendations for action. Examples of the former are development of a shallow water coring device and design of a recall system for scuba divers. Examples of the latter are a study of East Coast fisheries legislation and an examination of recreational uses of an estuary.

Under the guidance of a faculty advisor, each student team is asked to define a problem, prepare and submit a budget, engage in dialogue with experts in the ocean community, make progress reports, and write 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. Previous juries have included people from Woods Hole, Benthos, General Electric, E G & G, MIT, Simplex Wire and Cable, Office of Naval Research, New Hampshire State Agencies, Ocean Research Equipment, Klein Associates, and the SEA GRANT office of NOAA.

Each spring the director of the projects course asks ocean-oriented faculty to suggest projects for the following academic year. Juniors in the physical, biological, social sciences, and engineering are invited to attend a session where the project ideas are presented by the faculty. The students are asked to indicate their interest in the course and to list their first three choices for projects. From these preferences, the projects are chosen and the project teams are formed, every effort being made to insure that the teams as well as the projects span more than one University discipline. In September, each team is convened by its faculty advisor and the projects are begun. In October, budgets are prepared, submitted (and usually trimmed), and monthly meetings begin at which each group reports its progress. These reports are presented by the students, with the faculty advisors present merely as observers, to insure that each student demonstrates his or her ability to state precisely and concisely what the project team has accomplished to date.

In November, students begin contacting vendors and experts. They encounter such frustrations as prices that are too high, items that are out of stock, delivery times that are too long, and difficulty in scheduling interviews or securing appropriate documents. They develop the ability to improvise with less-than-optimum resources.

Toward spring the pressure of final design, testing and report preparation occurs. There are typing delays because secretaries are busy with other things. In late April the date of the jury session is announced. Students are given a list of the jurors and asked to prepare an abstract of their project report which is then sent to each juror prior to the jury session.

The jury session lasts a full afternoon, with each team having thirty to forty minutes to present its report. Following the jury session, a banquet is held for students, jurors and faculty advisors. This is a most enjoyable event and, with the pressure off, gives the students an opportunity to become acquainted with the visiting jurors.

There were seven projects in the 1973-74 projects course, involving 37 students from eight University disciplines: civil, electrical, and mechanical engineering; botany; business administration; environmental conservation; resource economics; and zoology. Five of these projects were hardware oriented and two were concerned with our nearby Great Bay estuary, specifically with pollution in the Bay and recreational uses of the Bay.

Faculty members who have been involved with the projects course over the years are convinced that this form of education is extremely valuable and quite unique for an undergraduate student, whether the student is in engineering, the sciences, or any other University discipline. We continue to be most appreciative for Sea Grant support.

An Accelerometer Buoy

Advisor:
Professor David E. Limbert

Students:
Mr. Frank F. Oliver, Mechanical Engineering, Project Leader
Mr. Adolphe P. Cyr, Mechanical Engineering
Mr. David E. Dipirro, Electrical Engineering
Mr. David R. French, Electrical Engineering
Mr. Raymond G. Gauthier, Mechanical Engineering
Mr. William J. Renault, Mechanical Engineering
Mr. Peter N. Wardwell, Mechanical Engineering

The feasibility of using an accelerometer buoy as a low-cost, reliable and inherently simple method of collecting wave profile data was investigated. Basically an accelerometer system consists of an accelerometer vertically mounted and supported by a floating object. The floating object should experience vertical accelerations identical to those of the sea surface being investigated. The output signal from such a device, when monitored and recorded, can be processed to obtain spectral power, displacement, and velocity data.

Simply stated, the project objective was to design, construct, and test, in model form, a system whereby it would be possible to obtain reliable, time dependent, formulations for the vertical movements of an ocean surface. Accomplishment of this project objective included settling upon the basic features of a design and subjecting the design to a mathematical proof. Following this the hardware components to construct a working model were selected or constructed. Upon assembly, the model was subjected to a wave tank test.

Design constraints imposed included: a) Adaptability — waves of interest were large ocean waves of one to fifty seconds period and two to twenty feet in height. b) Mobility — system should be relatively mobile for ease in changing recording sites, dictating low weight and small size of each of the major components.

The idea of servomechanism control to maintain the vertical attitude of the accelerometer was discarded because of the cost. Instead a "tuned" buoy was used. Tuning weights were installed within the spherical buoy and at the top and bottom of its vertical axis. For test purposes a range of weights was chosen as indicated by the mathematical analysis and lead weights cast. The purpose of the weights was to provide inertial resistance to the tipping of the buoy caused by both gravitational and viscous forces. During the test, weights were interchanged and the results noted until a tolerable degree of stability was attained. Best results were obtained when the buoy was loaded to approximately one third submergence and the top and bottom tuning weights were as nearly equal to one another as possible while still maintaining good self-righting quality.

During the tests, the translation of the buoy seemed to be directly proportional to the submergence depth of the individual test. This very important factor must be considered when designing the tethering system to the "mother" buoy. If translation is slow, the force generated on the tether will be reduced thus cutting down any additional tipping effect.

The electronics subgroup of the accelerometer buoy converts wave acceleration data to an analog electrical signal. It is then converted from the analog to digital form, and the data transmitted to shore where it can be recorded.

Basically a device inside the accelerometer package senses the position of the accelerometer servo. This signal is then fed to the input of a built-in amplifier which produces a correction signal to move the servo back to its neutral position by magnetizing a return coil to the servo itself. The measure of this reaction current gives a signal proportional to acceleration, both in magnitude and direction. The power supply for this unit is fifteen volts plus or minus, resulting in an output from zero, for no acceleration, to plus or minus seven and one-half volts for maximum accelerations.

A model of the accelerometer buoy being tested in a wave tank.

The Development of a Water Current Sensor and a Data Multiplexing System

Advisor:
Professor Glen C. Gerhard

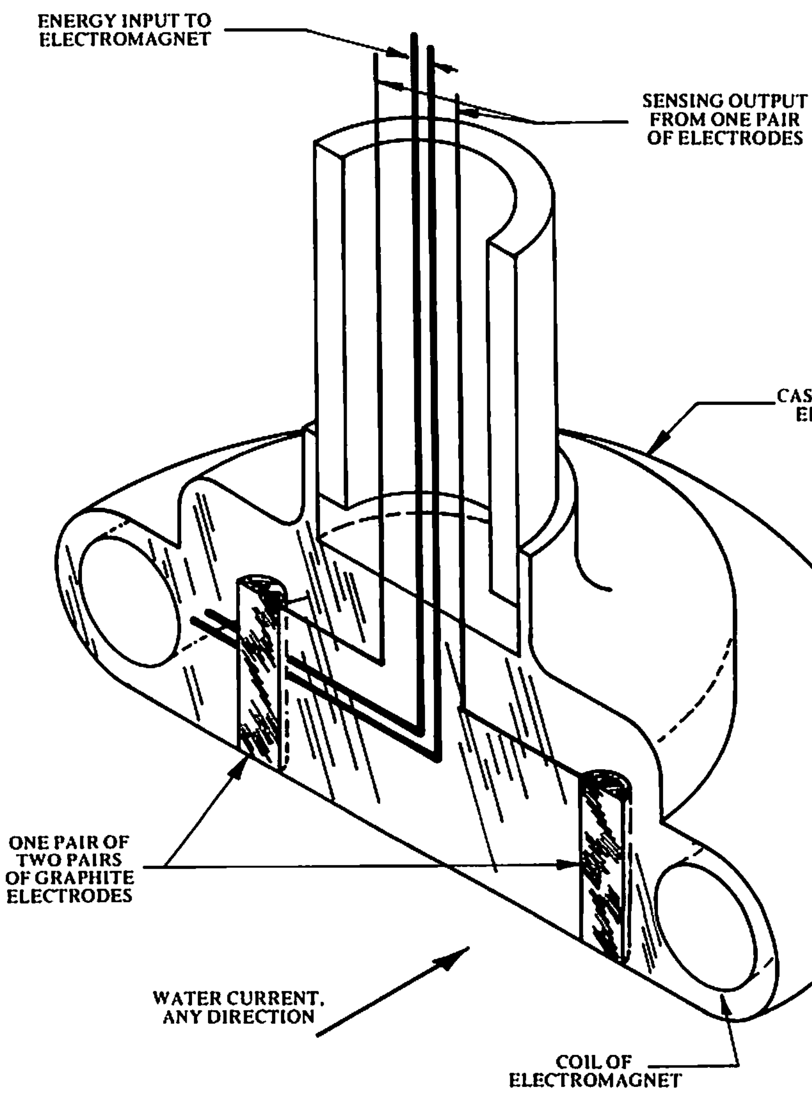
Students:
Mr. J. Herbert Hall, Electrical Engineering
Mr. Ronald J. McNeil, Electrical Engineering
Mr. Arthur H. Streeter, Electrical Engineering

Monitoring the current, temperature, salinity, and pressure-depth, in a bay or estuary is the final objective of the project of which this study is a part. In monitoring an estuary, several remote sensing units are placed so that the conditions in the various parts of the entire estuary will all be monitored at once. The scope of this study is restricted to current measurement and the transmission and collection of the data for the system as a whole. Such a basic system consists of up to eight remote sensing units, a central data acquisition module, and a shore station.

The specifications for the current metering device were: to measure currents of one to three hundred centimeters per second, compatibility with radio telemetry, an absence of moving parts to reduce maintenance caused by fouling, and a battery life of one month. The macroscopic approach, which was used in this project, centers around Faraday's Law of Induction: "A conductor moving in a magnetic field will have an electromotive force induced in it proportional to the magnetic field strength, the velocity of the conductor, and the length of the conductor." When Faraday's Law is applied to the measurement of water velocity, the water acts as the conductor.

A sensing head based upon Faraday's Law was designed. It consisted of 1500 turns of No. 28 AWG magnet wire, potted in epoxy, and a pair of electrodes. The coil has a d-c resistance of 140 ohms and an inductance of 0.4 henrys. Using this device with a 40 volt power supply to drive the coil, a measured field of 26 gauss was produced at the surface of the epoxy on the axis of the coil. The sensing head was later immersed in tap water contained in a metal tank. The resulting output consisted of a large d-c offset which varied erratically with the relative motion of the water. Changing to a wooden tank and subsequent addition of salt to the water to increase its conductivity failed to improve the results. Next the magnet was excited with an oscillator and driver circuit. It was anticipated the amplitude of the signal would change with the water velocity. The output here also proved to be erratic. Rearrangements and modifications were tried without improvement. A workable sensing device was consequently not produced during the course of this project.

The remote sensing unit is under command of the data acquisition module and the shore station. Until selected for interrogation by the shore station and the data acquisition module, the remote sensing unit remains dormant with no power consumption. The signal processing begins when a raw signal from the



Sensor head.

electrodes of the sensing unit is amplified by low noise amplifiers. Using sample and hold gating, transients are allowed to decay before the signal is processed further. The phase of the incoming signal is used to indicate the direction of the water flow. Finally the processed signal is transmitted to the data acquisition module where the frequency of the signal is counted.

The data acquisition module and the shore station work together to gather data from an array of up to eight remote sensing units. The units may be all water current sensors or other compatible sensors. The system was designed to be capable of accommodating additional sensors and performing additional functions. It has some error-correcting capabilities and, with some alteration, can interface with a radio telemetry system. In operation an eight-bit command word made up of four command bits and four address bits is sent to the data acquisition module from the shore station. After an error detecting process, the command is either retransmitted or executed and the system awaits a fresh command from the shore station. With the eight bit command word of four command bits and four address bits, sixteen sensors may be addressed and sixteen commands decoded.

The shore station electronics system is designed to allow manual operation of the entire system. It can be converted to computer control. A typical command sequence might be: the desired command and sensor are entered into the switch register and the proper (TLB) switch is pressed to transmit the command; a light indicates when valid data are present; data are recorded and the reset switch is pressed.

During the course of the project satisfactory prototype data-acquisition module and shore station circuits were designed, built, and tested.

A Device Facilitating Rescue of Disabled-Bottomed Submersibles

Advisor:
Professor E. Eugene Allmendinger

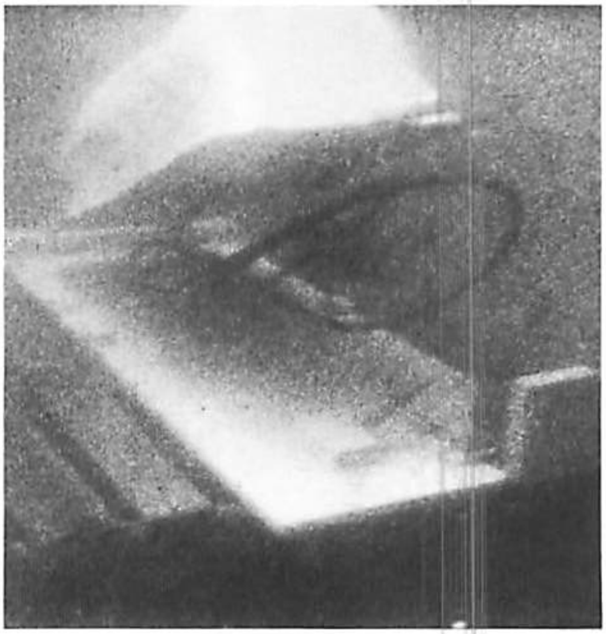
Students:
Mr. Thomas C. Schwandt, Civil Engineering
Mr. Norman R. Vachon, Mechanical Engineering

This project was conceived as a consequence of two tragic accidents which occurred during 1973 involving non-combatant submersibles — the JOHNSON SEA LINK and the PISCES III. From these accidents the concept of retrieval of the submersible itself rather than only the crew was given a new impetus and this project is a result.

When the project originated, there already existed two notable deep search and retrieval systems: ALCOA-SEA-PROBE and CURV (Cable-controlled Underwater Recovery Vehicle). Sophisticated as they are, they cannot effect a search and rescue operation and raise a disabled or bottomed submersible. The difficulty stems not only from the fact that there are so many different designs of submersibles, but also from the fact that means of attachment to the disabled submersible is lacking. This interface between the surface-connected search and rescue system and the submersible in distress is the focus of this project.

A survey of the pertinent literature followed by interviews with two deep-ocean-search experts resulted in the formulation of a list of points important to the operation of a rescue device: the device 1) must release automatically; 2) should be faired into the hull to avoid fouling; 3) should be of a type easily modified to suit existing submersibles; 4) should be as low in price as possible; 5) should be designed for easy engagement by surface rescue equipment.

The chosen design envisioned a bail or loop which, when released, would be buoyed fifteen or twenty feet above the submersible by a cable fastened to a lifting point on the vehicle. The bail or loop, rising approximately vertically above the submersible would serve as



Automatically-ejected cover has released buoy and cable.

Released buoy hauls communication and mooring cable to surface.

Underwater model test of a device for facilitating rescue of a disabled-bottomed submersible.

the attachment point for the surface-connected rescue system.

This concept was the result of not being able to envision a claw or clamshell or bucket-type device large enough to fit over the larger submersibles. A steel net device was rejected because of the near impossibility of being able to control its closure or its ability to hold onto the submersible.

The final design decision was that the attachment bail should be of two one-foot-in-diameter vertical steel circles welded at right angles to one another, buoyed by a syntactic foam float, and attached to the submersible by a "Phillystrand" cable. Normally this assembly is housed on the submersible until automatic release of the buoyed bail. A solenoid-operated mechanism releases the cover, buoy, and cable.

An open water test was performed on May 11, 1974, which demonstrated that the basic idea would work. The test also brought out a few faults in the device which need to be overcome.

Most significant was the fact that the cover kept the device entrapped until near the end of the ascent when the cover would finally slip away. One solution to this problem might be to anchor the cover at one end so that it would not rise with the device but would free the device quickly. Another solution might be to give the cover a positive buoyancy of its own so that it would float away from the device upon release.

A second problem encountered was that the solenoid operated rather slowly under actual underwater conditions. A more sophisticated solenoid available especially for deep submergence use should solve this problem satisfactorily.

Third, a more sophiticated release device should be designed.

The test demonstrated the general feasibility of this device which with further development could result in a significant and effective means of submersible rescue, at a cost of about one thousand dollars per unit.

Engineering a System to Measure the Metabolism, in Situ, of Sublittoral Marine Communities

Advisors:
Professor Godfrey H. Savage
Mr. David J. Agerton

Consultants:
Professor Theodore C. Loder
Professor Arthur C. Mathieson

Students:
Mr. Robert L. Parker, Student Project Leader, Electrical Engineering
Mr. Gerald L. Boisvert, Mechanical Engineering
Mr. David E. Dunfee, Mechanical Engineering
Mr. R. Brian Richardson, Mechanical Engineering

This student group designed and built an underwater respirometer capable of sensing and indicating, in situ, the photosynthesis and respiration rates of a sublittoral marine community of plants and animals. Developmental work and preliminary design testing were carried out at the UNH Jackson Estuarine Laboratory. Engineering field tests of the complete system were conducted off Freeport, Grand Bahamas, during the week of March 4, 1974, while the UNH team members were also acting as support divers for a German-American saturation diving mission operating from HYDROLAB.

The respirometer was designed to enclose a benthic community to enable measurement of metabolism over a forty-eight hour period. The system included instrumentation to measure and record dissolved oxygen, ambient light energy, and water temperature. Other components of the system were designed to maintain conditions within the chamber equivalent to those in the natural environment.

A clear, acrylic, semi-cylindrical chamber of fifteen-inch radius and thirty-six inches long, permitted ninety-five percent of the ambient light to reach the marine community. This chamber was sealed to a frame embedded into the sand bottom to create a closed system which would still permit the selected benthic community

Student project team emplaces base and acrylic dome of chamber for holding a community of marine algae. The power supply cylinder is in the center foreground. The instrument case is to the right. Freeport, Bahamas, March, 1974.

to continue its normal life processes. Two student-designed submersible pumps circulated water inside the chamber at a rate equivalent to the ambient current. Power was supplied by underwater power packs containing two twelve volt batteries. These batteries, with gas relief valves replacing the caps, were immersed in a container filled with a non-conducting oil and provided with a flexible, pressure-compensating membrane.

The forty-eight hour, in situ, tests of the apparatus in the Bahamas demonstrated the engineering feasibility of this approach to biological benthic survey.

A great Bay Pollution Study

Advisor:
Professor Larry G. Harris

Students — Part I and Part II:
Miss Elaine M. Calderone, Zoology
Miss Donna M. Desautels, Zoology
Mr. Jeffrey H. Glaser, Zoology
Miss Karen E. Hartop, Zoology

Students — Part III:
Mr. Richard D. Greer, Zoology
Mr. Russell E. Shea, Zoology
Mr. Kevin T. Tacy, Zoology

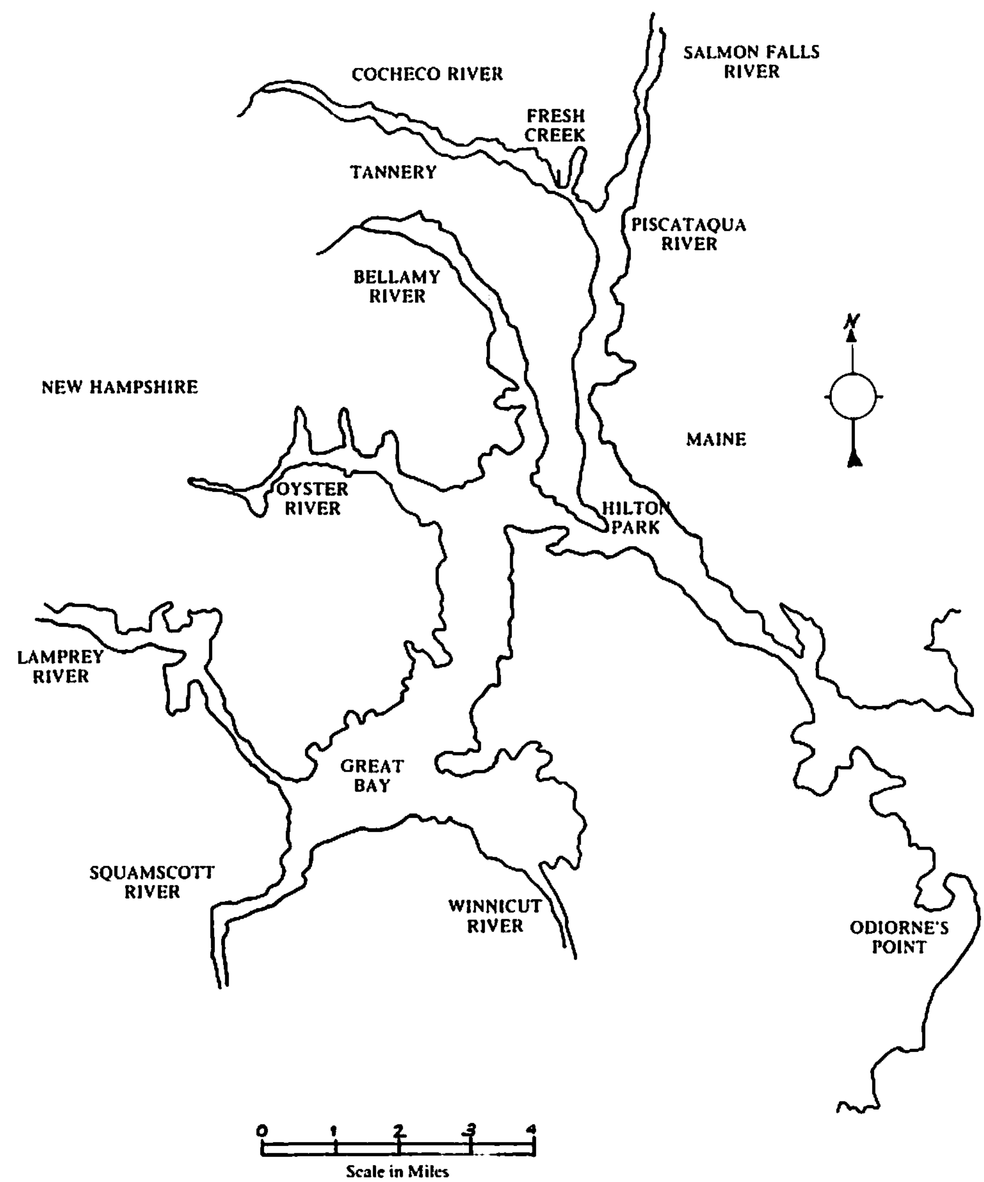
Student — Part IV:
Mr. Robert J. Moore, Zoology

Knowledge of the nature of the local pollutants and their effects on marine organisms is vital to the success of a mariculture project. The purpose of this project was to study the pollutants and their effects on certain marine life in the nearby Great Bay estuary.

A leather processing plant in Dover, New Hampshire, has utilized a chrome tanning process since 1940. Dichromate salts are dissolved in the waste water from this leather plant, find their way through the primary sewage treatment plant, and are discharged directly into the Cocheco River and subsequently into the Bay. The chromium becomes associated in part with flocculent material which, suspended in the river water, finds its way throughout the estuary.

Part I: The Effects of Chromium on the Growth Rate of Mytilus edulis, *the Blue Mussel*

Size and type of the suspended particles suspended in the water are consistent with particles filtered by the blue mussel. To study the effect of chromium on the growth rate of the common blue mussel, two hundred mussels, two to four centimeters long, from the Hilton Park area were collected and measured. These mussels were divided between two buckets, one having a prepared bed of Fresh Creek (high chromium) sediment mixed with an equal amount of clean gravel and a similar bucket containing Hilton Park area sediment (low chromium). The



Map of Great Bay, New Hampshire, showing the Great Bay area proper and its seven freshwater rivers.

buckets, with netting closures, were placed in a natural environment at Odiorne's Point. After four weeks the mussels were again measured. The initial chromium concentration of the high chromium bed was five times as high as that in the low chromium bed. Both of the samples lost about fifty percent of their chromium content during the four weeks at Odiorne's Point, but the chromium content of the high chromium bed was still significantly high at the end of the period. No significant difference in the growth rate between the mussels exposed to the different levels of chromium sediment during the four-week period was noted.

Part II. The Effects of Chromium on the Smooth Flounder Liopsetta putnami.

The smooth flounder *Liopsetta putnami*, which reaches a length of one foot and a weight of one and one half pounds, inhabits the Great Bay estuary throughout the year, feeding on mollusks and annelids. Because of the preference of the smooth flounder for muddy substrate, and its habit of ingesting water as part of the osmoregulatory process, this fish is being continually exposed to the chromium content in the substrate.

Seventy-eight fish were exposed to three different levels of chromated sediment for a period of six weeks. In one tank chromium sediment was artificially concentrated. A second tank contained an intermediate level of chromium, while a third tank, used as a control, contained a natural level of chromium in the sediment.

Evidence in the form of histological sections and records of the lengths and weights of these flounder did not demonstrate any gross morphological or physiological changes.

Part III: The Effects of Chromium Pollution on Amhipod and Polychaete Populations

A project was undertaken to study the effects of chromium pollution on amphipod and polychaete communities in the Piscataqua and Cocheco Rivers. The relative abundance of the organism in these communities has been suggested as an indicator of environmental deterioration.

Water samples were taken to determine salinities at various points in the rivers. From these data, five sites for bottom sampling were chosen. At each site, four replicates were taken. Amphipods and polychaetes taken with the samples were sorted into families. The substrate was analyzed for particle size (silt, clay, gravel) and chromium content.

To analyze the data, stepwise regression was used for four variables: chromium content of the substrate, percent amphipods, percent polychaetes, and salinity. It was found that amphipod distribution varied inversely with polychaete distribution with respect to chromium content. It was also shown that the overall population size of amphipods was smaller at higher concentrations of chromium while polychaetes were the prevalent organism. The relationship was reversed at lower chromium concentration.

It was determined that salinity had less effect on the distribution of amphipods and polychaetes than did chromium content and that the amphipod distribution was less at lower salinities.

Part IV: A General Survey of PO_4 and NO_3 in the Great Bay and Surrounding Water

A general survey of PO_4 and NO_3 concentrations at various sites in Great Bay and surrounding waters was made. Six sites along the estuary were sampled in March, 1974. Samples were obtained from six additional sites on the major tributaries in April, 1974.

The samples were taken during a particularly good time because phytoplankton concentrations usually peak during spring run-off. Since nutrients are being fixed at a high rate, nutrient concentrations usually decrease over a period of time. The results show that over a two week span PO_4 concentration *decreased* while NO_3 concentration *increased*.

The total influx of PO_4 into the estuary on April 27, 1974, expressed as P, was found to be 49.70 μg/liter and of NO_3 expressed as N was 63.85 μg/liter from rivers alone. These nutrients are dispersed throughout the estuary according to the morphology of the estuary.

A Great Bay Recreational Study

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Students:
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Mr. Paul W. Getchell, Resource Economics
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Mr. Kent D. Stevenson, Environmental Conservation

This study was instigated because of the present need for New Hampshire to inventory its coastal resources. The fact that Great Bay is one of the few relatively undisturbed estuaries left in the East warrants its study and protection. Because UNH's Jackson Estuarine Laboratory is located on the shire of Great Bay, much is known about the flora and fauna of the Bay but little research has been done on its recreational use.

"The Great Bay area, with its forty miles of shore line and 8,000 acres of warm salt water, is the greatest undeveloped recreational resource in all of New England," according to a statement in a 1945 report to the New Hampshire Legislature by the State Planning and Development Commission. The report also mentions as assets the nearby educational, trading, and marketing facilities. Although there have been changes since 1945, the Great Bay area still remains a relatively undeveloped but an important natural resource for New Hampshire. Recent conflicts between industrial developers and those who would retain the Bay area's natural state were decided in favor of the latter. The decision was made, however, without benefit of the comprehensive studies which should be made to insure proper development and conservation and to serve the interests of future generations.

Throughout this report the term 'Great Bay area' should be understood to include both Great and Little Bays as well as that part of the estuarine system south of the Scammel and Sullivan bridges. In addition, the Hilton State Park on Dover Point is included. Shoreline boundaries were set at 1000 feet back from the high tide mark. The study area lies partly in Rockingham and partly in Strafford counties with shores in the towns of Durham, Newmarket, Newfields, Stratham, Greenland, and Newington, and the city of Dover. The nine square miles of tidal water are contained within shorelines ranging from gentle slopes to bluff. There are numerous small islands. Access to the Bay area is facilitated by US Route 4 connecting Portsmouth and Concord and by State Route 101 which connects Manchester and the New Hampshire ocean beaches. Pease Air Force Base lies on the eastern shore of Great Bay and denies public access to some six miles of shoreline. Present commercial establishments on the shores of the Bay include a restaurant, two major marinas, and a campground. Predominant recreational activities include water sports, fishing, hunting, oystering, clamming, and picnicking.

New Hampshire shares in the development of the nation's coastal areas. Some of the reasons for increased demand put upon New Hampshire shorelines are: (1) the net in-migration experienced by this state; (2) improved access provided by new highway systems; (3) increased leisure time; and (4) the growth of the eastern Massachusetts urban complex. Predictions anticipate a tripling of marine outdoor recreation by the year 2000.

Luckily very little uncontrolled growth has taken place in the Great Bay area. All of the towns surrounding the Bay have zoning and subdivision regulations tending to promote orderly development. However, these regulations are neither interrelated nor correlated. New Hampshire is currently trying to show the present recreational uses of Great Bay and to show its importance and potential as a natural resource.

The recreational use of Great Bay is not overwhelming. Of the forty-odd miles of shoreline, only a few thousand feet are available to the public. There is only one area, Hilton Park at Dover Point, that is well marked as a public access to the Bay. Other access areas are difficult to find. At one public access point in Durham entry by the public is contested by one of the abutters who objects to public use of "his" road.

At present there are twenty access points to Great Bay. Thirteen have boat launching facilities. Of these seven are state or municipally owned. All have car parking facilities. A fee is charged at about one-third of the boat launching sites. While the number of sites might seem adequate, there is much room for improvement. For instance, some of the sites are remotely located and many entrance roads are unpaved.

In the Great Bay area, year-round homes substantially outnumber the seasonal homes. Many of the owners control large tracts of land which have been in their families for years. These "true natives" of the Bay area have a very special feeling about its beauty and have no desire for change. The relatively few vacation homes in the Bay area do have some impact, but not to the degree of creating jobs or generating a significant money flow.

Boating on Great Bay has not shown the same increase as has boating for the rest of the nation. Increases have been held down by the unavailability of public access and the high proportion of privately owned land around the Bay. Unless the launching ramp is very long, launching at low tide becomes difficult in a tidal estuary. This tends to inhibit boating. However, an aerial survey of the area disclosed that there were 72 private boat piers or docks. One surprising fact uncovered was that although slips and moorings were filled during the summer, approximately half the boats never left their moorings, families and individuals finding recreational pleasure simply in being afloat.

There is much enthusiasm about fishing in Great Bay. Some forty species of fin fish are found in the Bay, many of them migratory. Many sources have expressed the feeling that the Bay has just about the best bass fishing on the east coast. The excellent bass fishing has resulted in the organization in 1970 of the Great Bay Striper Club. Smelt fishing attracts many fishermen. During the 1970's as many as a thousand smelt houses have been seen on Great Bay ice at the same time. Alewives are caught in weirs and used for bait. Two bridges open the Bay to fishermen who do not use boats.

Waterfowl hunters harvest black duck, Canada geese, and mallards principally. Pease Air Force Base has a wildlife conservation habitat containing 1600 acres and an important hunting area along Cedar Point has been established as a preserve. People nevertheless hunt in the area.

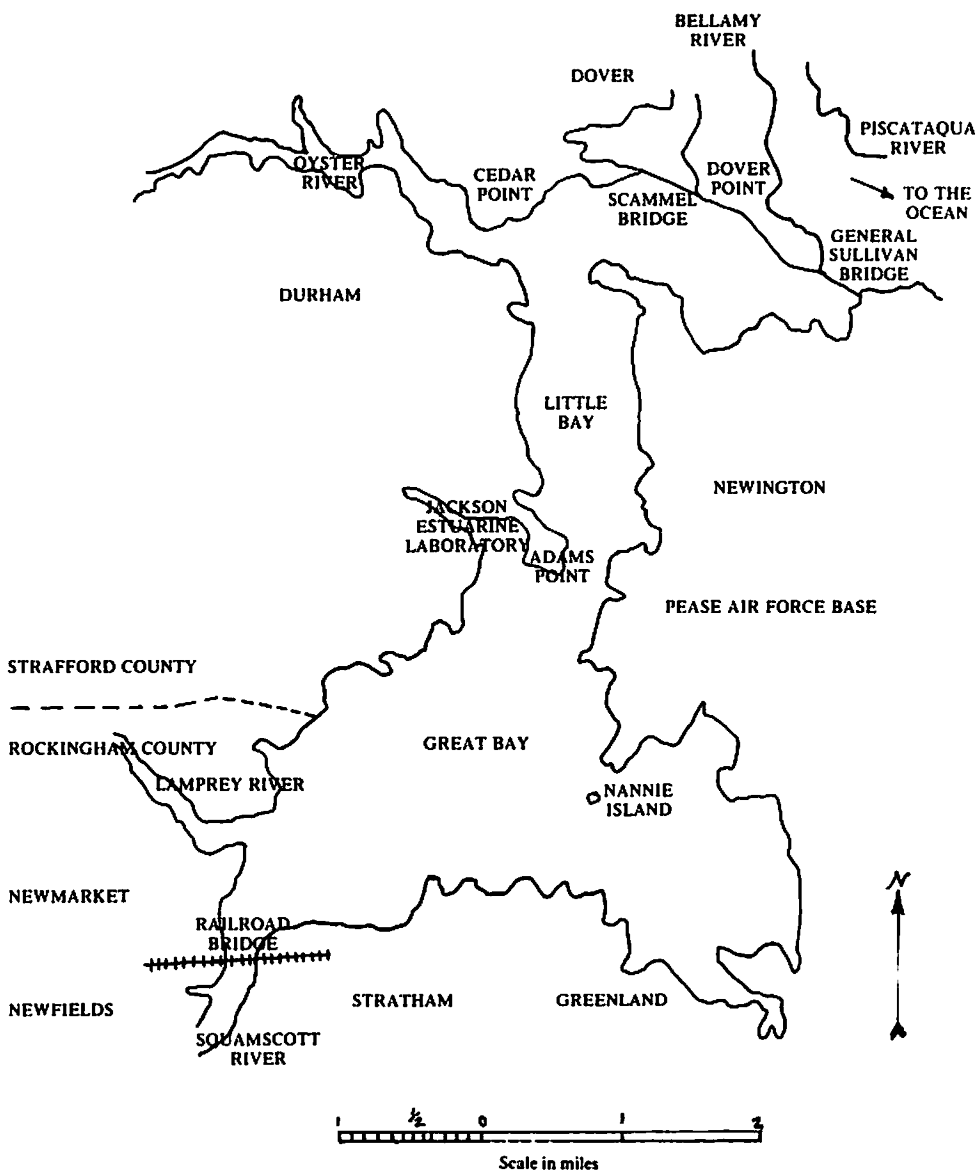
Lobstering, with approximately 300 traps, is done principally in Little Bay. Clamming is open to licensed state residents only and is somewhat inhibited by the fact that the clam flats are extremely rocky. Oystering is open only to licensed residents. The best fishing is off Adams Point, Nannie Island, the railroad bridge, and the Bellamy and Swampscott Rivers.

The single campground on the Bay includes 1700 feet of waterfront with 33 acres of property for tenting and trailer sites. Addition of a marina in the near future is likely. The two summer cottage groups in Greenland have some 45 cottages. Facilities include rowboats, a private launch, and a man-made beach.

The State of New Hampshire is fortunate in that the Great Bay estuary has not been over-developed up to the present time. It is very apparent that there is a substantial need to initiate a sound seacoast management program to protect the natural resources that are still undeveloped. Such a management program should include provisions that will not only bring about economic advantages but protect the environment as well.

Further study of the Bay area for recreational purposes should include: (1) a water quality perception study; (2) selection of significant areas for development along the shoreline; (3) a study to increase the number of public access points and improve facilities at existing access points; (4) determination of legislation affecting recreation in the Great Bay area; (5) setting up a commission of the towns surrounding the Bay to initiate a management council that will work with state and federal regional agencies for land-water use management.

Action is essential today. Coastal zone boundaries should be established with public participation, giving full consideration to regional, environmental, and economic needs. Boundaries should be defined early to "smoke out" the issues. Early planning is necessary if "crisis" legislation is to be avoided.



The Great Bay Area.

The Shallow Water Buoy

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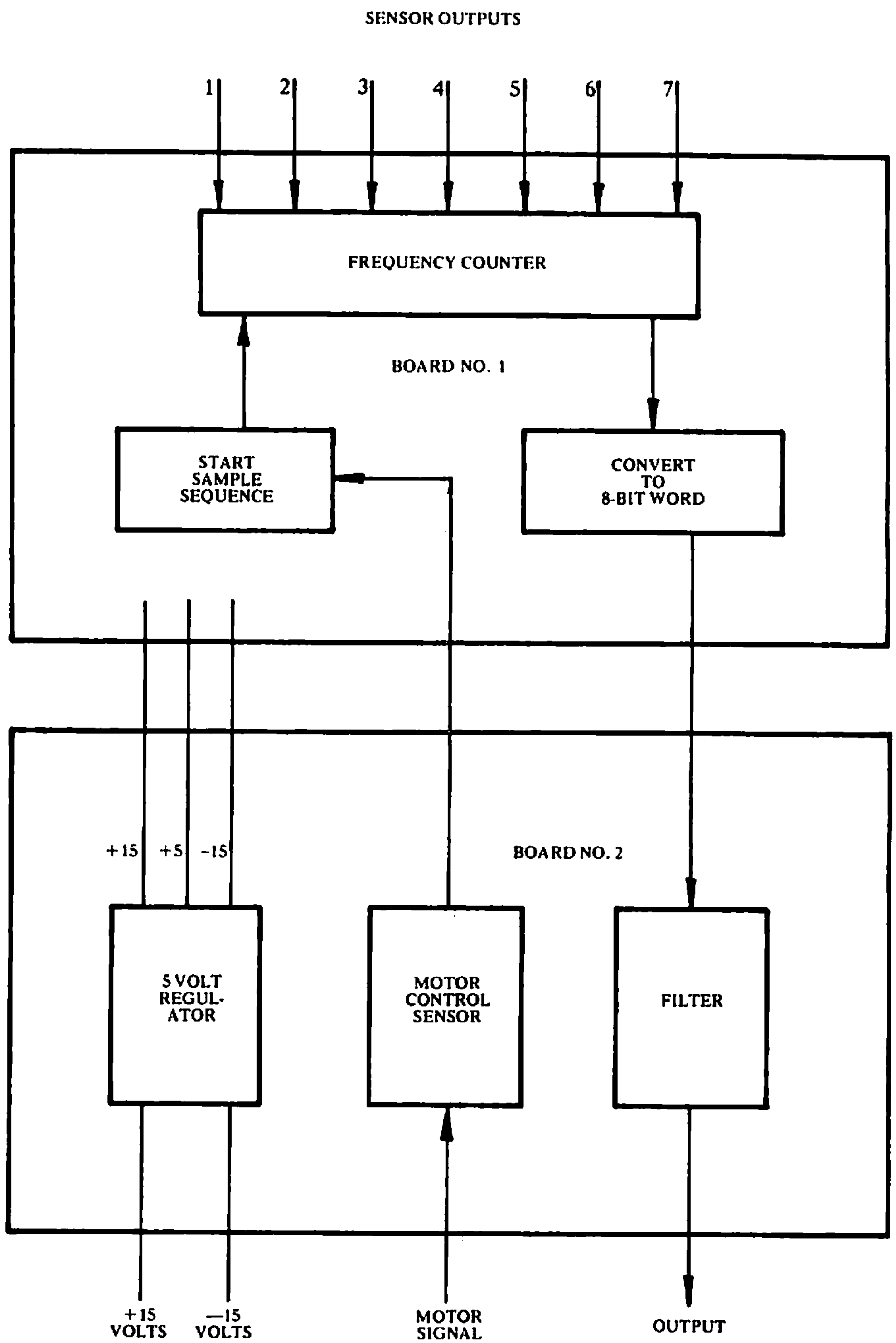
This year's shallow water buoy project is a continuation of last year's project. The purpose remains the same, to design, build, test, and install a buoy system capable of independent, long-term monitoring of estuary water parameters.

The modified system, completed and installed this year, includes a positively buoyant, triangular frame which carries the instrument package. This frame is tethered to the bottom by three cables 120 degrees apart anchored to the estuary floor. Two of the cables are of fixed length while the third, provided with a winch, controls the instrument package depth. The winch is driven by a 115 volt d-c motor powered from shore. The buoy is controlled on a repeating cycle. After a dormant period on the floor of the estuary the buoy rises toward the surface, stopping at intervals to sample. As it approaches the surface a sensor reverses the direction of the travel causing the buoy to move back toward the bottom. The shore located controller includes a timer, safety monitors which include a continuous depth (pressure) input and a redundant "buoy bottomed" sensor, and operator controls for "dormant



Multiplexer Block Diagram.

interval," "transit interval," "sampling interval," and "minimum depth."

Two separate power supply packages attached to the winch housing are supplied with 120 volt a-c current from shore. Each is capable of supplying 4 amps d-c, one at 27 volts positive, later reduced to 15 amps 13 volts, the other at 27 volts negative, later reduced to 15 volts.

The main buoy package contains all the vital electronics for receiving and processing raw data from various sensor elements. The temperature, pressure, and salinity sensors are physically attached to the main buoy package, while the flow meter is separately mounted. The main buoy package receives its power from the winch base station as ±25 volts d-c. This is converted to +15, +13, +5, and -12 volts d-c as needed to supply the various sensor cards and the multiplexes. A steel jacketed #20 AWG seven conductor cable and a nylon jacketed #16 AWG four conductor cable provide for power and data transfer between the shore station and the winch base station.

The pressure sensor is a Bourns variable resistor. The resistance and the derived voltage of this transducer are directly proportional to the pressure and hence to the depth. Two operational amplifiers are used, one controlling the gain of the circuits and thus the range of the converter frequency sweep, the other adjusting the voltage level and thus the frequency of the pulses from the converter. A consideration in pressure measurement is the fluctuation of pressure near the surface caused by waves. An "equal-to-or-less-than" depth-comparing circuit insures an instantaneous value for use in winch motor control.

A thermistor is used as a temperature sensor; using an operational amplifier and a voltage-to-frequency converter, a frequency is produced which is unique to a particular temperature.

The salinometer used is an inductively coupled device. The sensing head employs two toroidal coils with seawater forming a common linking loop. The conductivity of the sea water is a function of its salt content. When the water is used to conduct the signal from the driver coil to the sensing coil a signal which is a linear function of the conductivity results. The signal from this sensing coil is fed to an amplifier, which permits adjustment of the amount of signal voltage change for a certain change in conductivity and of the range of the voltage sent to a frequency converter. The amplified sensing coil signal is then rectified, and the resulting voltage is adjusted to properly operate the voltage to the frequency converter. The ultimate output is proportional to the water conductivity which can be related to the salinity.

The flowmeter utilizes the Doppler effect: the shift in frequency of the sonic signal by a moving body. The frequency shift is here directly proportional to the current velocity and is detected using a phase lock loop which generates a d-voltage that drives a voltage controlled oscillator. This voltage controlled oscillator output is compatible with the central multiplexer that serially sends the data to the shore station. With the use of suitable tables for correction of speed of sound in water, velocity measurements with an error of less than 1 percent can be achieved.

A multiplexer is a unit which simultaneously transmits two or more signals over a common wave carrier. The multiplexer scheme used for transmitting data from buoy to shore, transmits the data outputs from seven sensors. The output of each sensor, which is in frequency form ranging from 8 Hz to 2000 Hz, is applied to one of the multiplexer inputs. The analog frequency is then converted to an 8 bit binary coded numeral. This number is then transmitted one character at a time through an operational amplifier modified to function as an inactive band pass filter. The output of the filter is then transmitted to the shore via an underwater transmission line where it is stored on tape for later use.

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Julie M. Husman

January 1, 1974 — January 1, 1975
UNH Coherent Area Sea Grant Program

PROGRAM BUDGET BY CATEGORY (NOAA)

	NOAA Grant Funds	*University Matching Funds*
PROGRAM MANAGEMENT		
Program Management & Development	$ 40,500	$ 15,500
EDUCATION		
Marine Education & Training	$ 16,000	$ 26,600
RESEARCH		
Marine Resources* Development	$118,500	$ 67,100
Marine Technology Research & Development	$ 41,100	$ 30,300
Marine Environmental Research	$ 50,400	$ 26,100
ADVISORY SERVICES		
Marine Advisory Program	$ 20,700	$ — —
TOTAL	$287,200	$165,600
ADJUSTED TOTAL, May 3, 1974 (adjusted for UNH overhead charge)	$340,300	$193,400

*Includes joint University of Maine, Maine Department of Marine Resources, University of New Hampshire Blue Mussel Mariculture Program, and special Maine Salmon Farms, Incorporated, Aquaculture Project