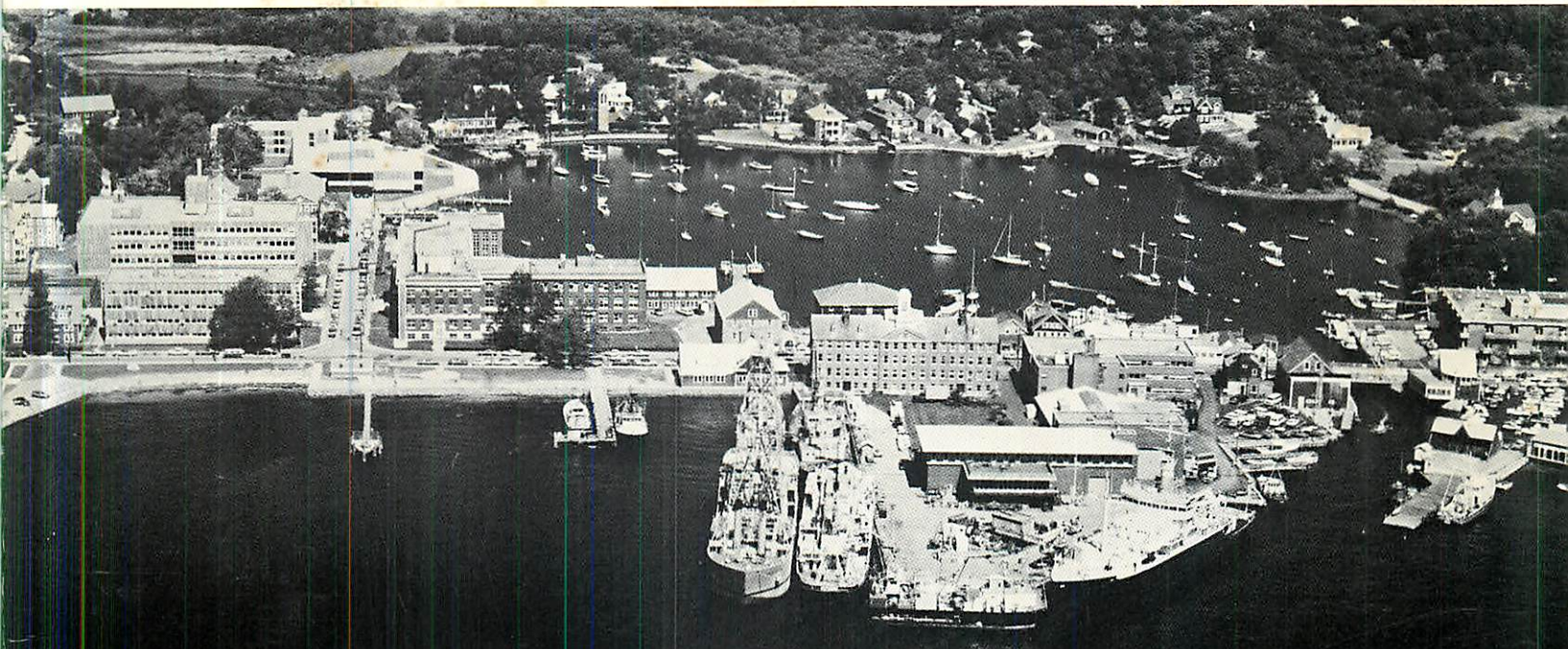
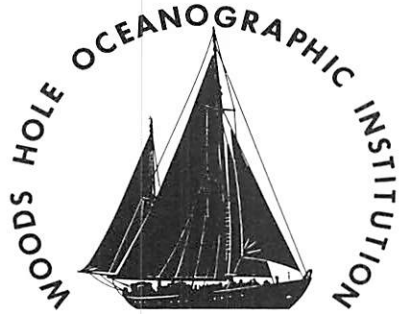
MARINE RESOURCES DEVELOPMENT and MANAGEMENT



1976-77 ANNUAL REPORT

Woods Hole
Oceanographic Institution
Sea Grant Program
NOAA Sea Grant
04-6-158-44106

MARINE RESOURCES DEVELOPMENT and MANAGEMENT



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Cover Photo:
The entire research fleet of the Woods Hole Oceanographic Institution was in home port over Labor Day weekend, 1977, for the first time in nearly five years. ALCOA SEAPROBE can be seen at left with her derrick. OCEANUS is tied up astern of SEAPROBE and beside the retired CHAIN, and ATLANTIS II is inboard of SEAPROBE. LULU with ALVIN aboard is at the end of the pier bow to bow with KNORR. Comparatively tiny ASTERIAS is in view just beyond the drawbridge to Eel Pond.

MARINE RESOURCES DEVELOPMENT and MANAGEMENT

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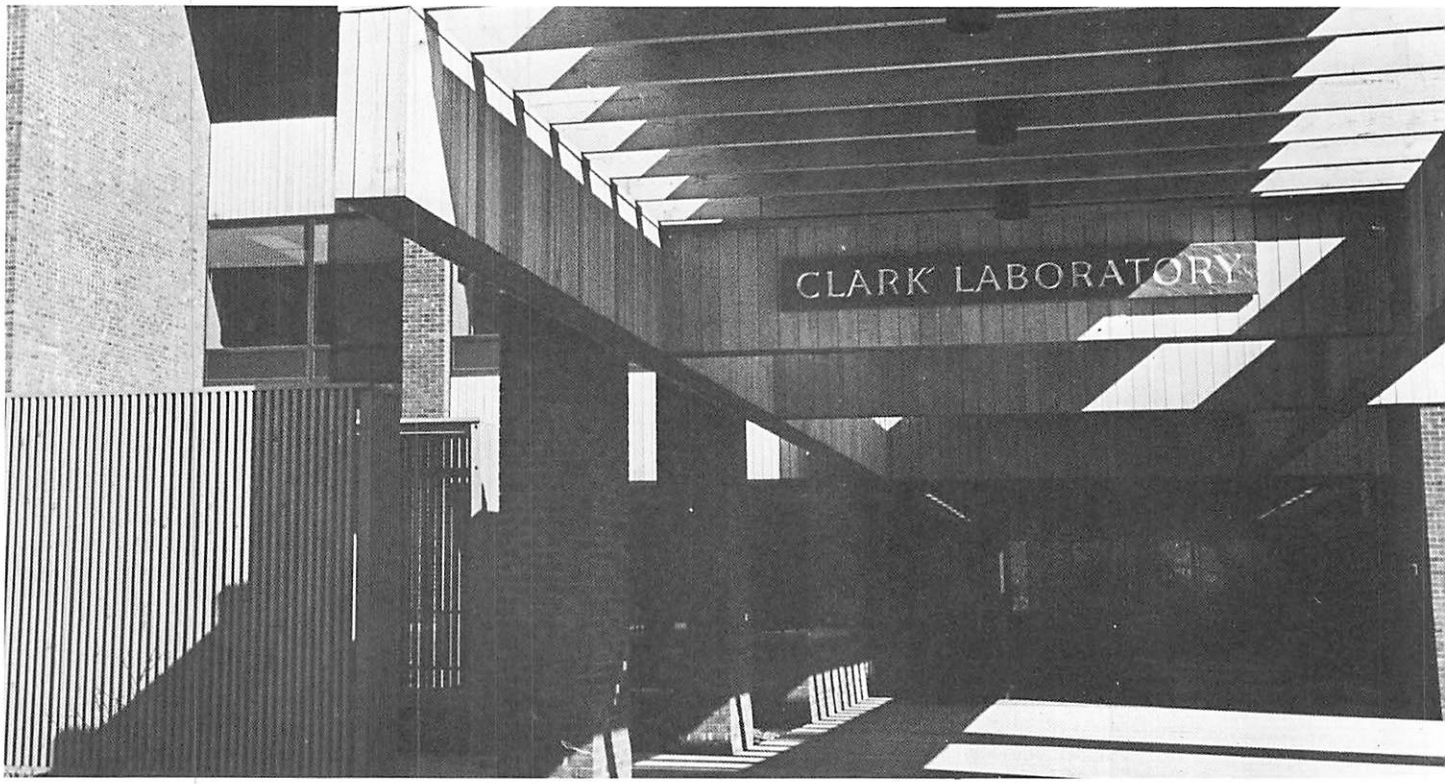
INTRODUCTION



Clark Laboratory
our new facility at our
Quissett Campus.

The Woods Hole Oceanographic Institution, since its founding in 1930 as a private, non-profit research institution, has been devoted to broad research and educational programs in marine science. Our five departments: Biology, Chemistry, Geology and Geophysics, Physical Oceanography, and Ocean Engineering and the Marine Policy and Ocean Management Program are conducting research in all parts of the world's oceans as well as considering problems concerning the results and use of such research. Although the Sea Grant program at our Institution is a modest part of our total budget (about 2%), it supports several very important projects. Of equal importance, Sea Grant is a source of funds that can be used to initiate new studies and rapid response to opportunities; examples include pollution problems within our coastal zone and effects of expanded jurisdiction of our offshore waters. We have been pleased to note a growth and broadening in the Sea Grant research projects at our Institution over the past few years.

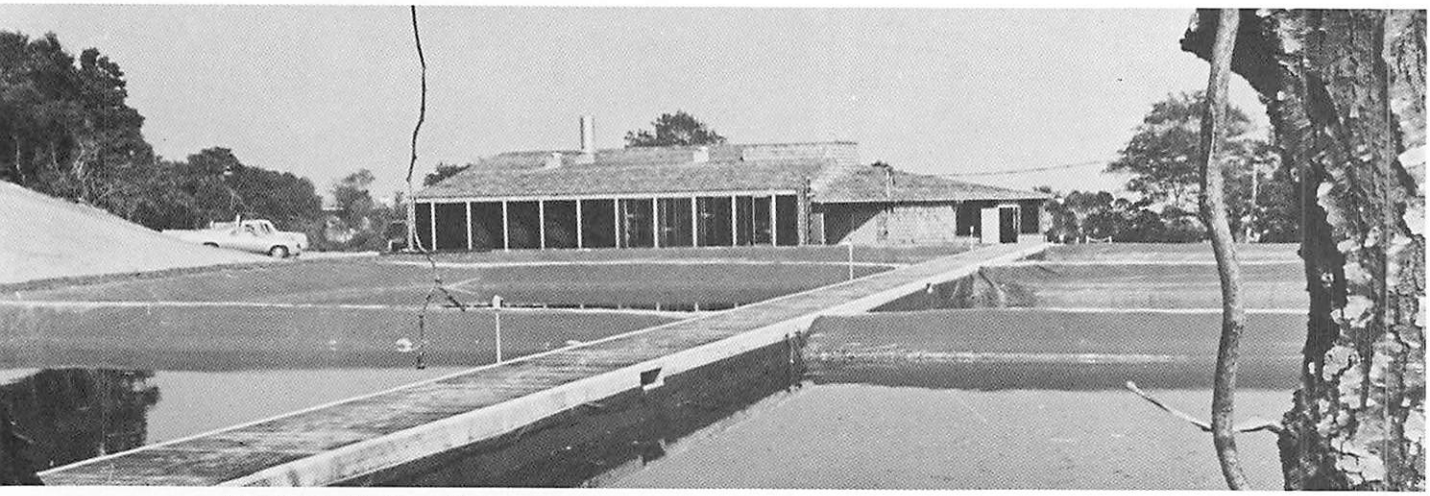
During the past year we had projects in Aquaculture, Living Resources, Socio-Political Studies, Ocean Engineering, Ecosystems Research, Pollution, Environmental Models and Marine Education and Training.

The main objective of our program has been Marine Resources Development and Management. We have also involved ourselves with local problems and have cooperated with town and state officials as well as with other laboratories. The scientific and technical staff of the Woods Hole Oceanographic Institution have shown increased interest in the problems of our nearshore regions and we anticipate even further growth and coherence in our Sea Grant efforts in the coming years.

In June of 1977, Mr. Dean Bumpus retired after a distinguished career at this Institution, including three years as Sea Grant Coordinator. During this time he helped to develop the projects described in this report.

David A. Ross
Sea Grant Coordinator
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
November, 1977

AQUACULTURE



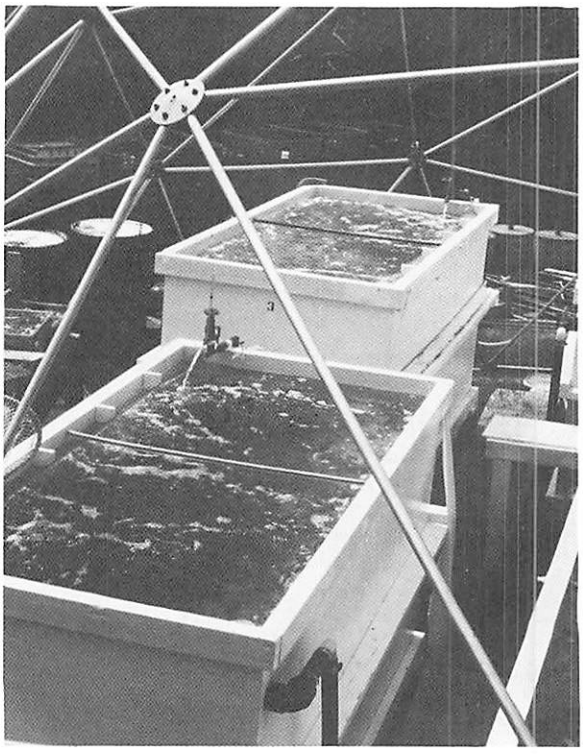
Aquaculture facility
(Environmental Systems Laboratory)
at our Quissett Campus.

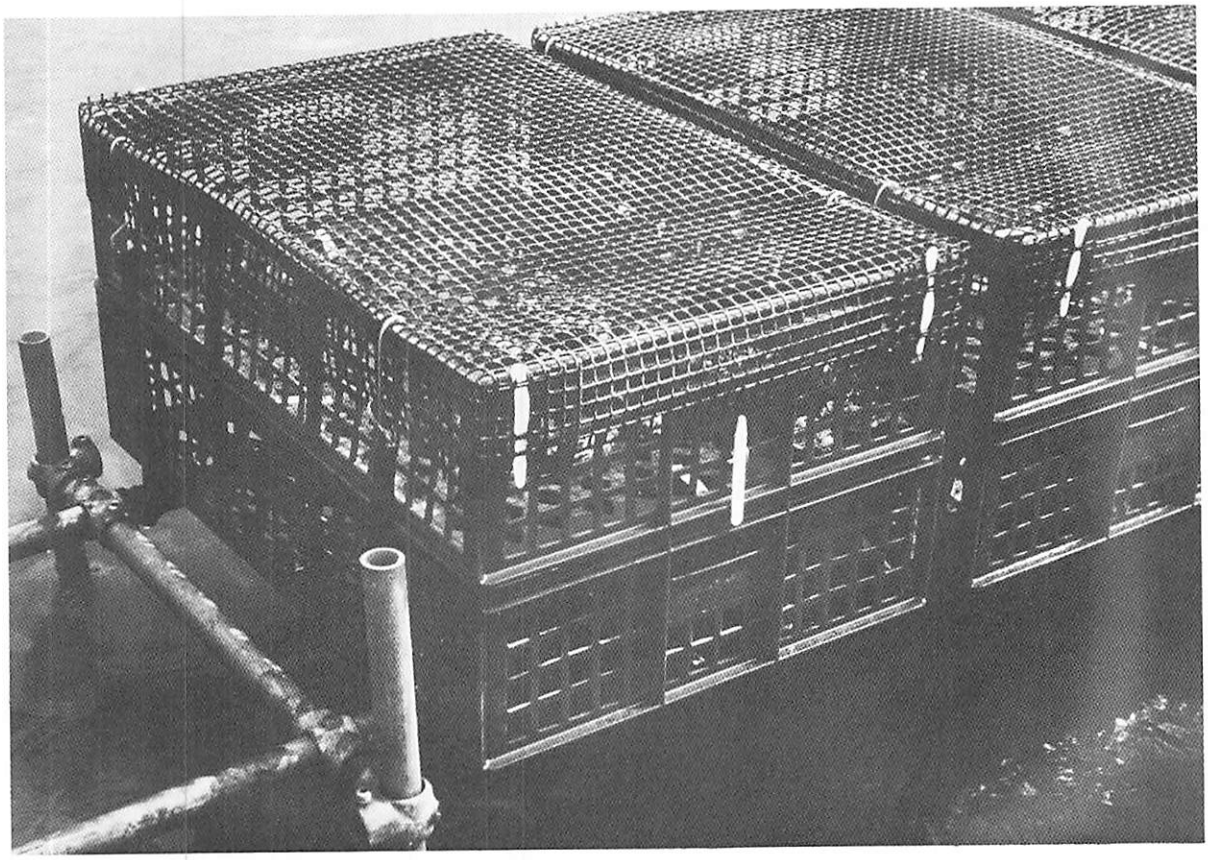
Marine Polyculture Based On Natural Food Chains And Recycled Wastes

— John H. Ryther and Roger Mann

During this fiscal year research has continued on the development of a waste recycling aquaculture system at our Quissett facility. Work has been performed in both laboratory and pilot-scale operations during the fourth year of this project. In the present system mixtures of secondary-treated sewage effluent and seawater are used to mass culture marine phytoplankton on a continous basis in large outdoor ponds. These phytoplankton are then fed to filter-feeding bivalve molluscs (oysters, clams, mussels). The effluent from the mollusc culture tanks is passed through cultures of microscopic red algae to effect final removal of excess and excreted nutrients from the earlier stages of the controlled food chain. During this year work has been centered on the effects of physical parameters on optimizing shellfish growth. In addition, monitoring of phytoplankton species predominance in mass algal cultures has continued in an attempt to gain further understanding of this important phenomenon.

Previously, Goldman and Ryther have reported that species competition in mass outdoor, marine phytoplankton cultures is strongly influenced by temperature. This has been confirmed in our recent studies; however, the importance of the nature of nutrient enrichment has also become evident in this context. In algal cultures enriched with secondary treated sewage effluent a change in predominant species from *Phaeodactylum tricornutum* to *Skeletonema costatum* was evident in November 1976 concurrent with a water temperature of approximately 6°C. The latter species remained dominant until March-April 1977 when, again concurrent with a temperature range of 6-10°C, it was again displaced by *P. tricornutum*. In contrast, cultures enriched with a simple inorganic chemical media (ammonium chloride and sodium monophosphate) exhibited no change in speciation during this period, *P. tricornutum* remaining dominant throughout.





A comprehensive study has been made of the growth, physiological and gametogenic response of two species of oyster to sustained temperatures of 12, 15, 18 and 21°C. These were the Japanese oyster, *Crassostrea gigas,* and the European oyster *Ostrea edulis*, which had previously been shown to grow well in the Woods Hole system. *C. gigas* increased from an initial live weight of 5.2g to values of 23.5, 28.2, 34.6 and 38.7g at 12, 15, 18 and 21°C respectively over a 19-week period. Dry meat increment, however, was inversely related to temperature with an initial value of 88.7 mg, and terminal values of 1736.0, 1253.0, 1322.0 and 1219.0 mg being recorded at 12, 15, 18 and 21°C respectively. Conversely *O. edulis* exhibited an increase in both live and dry meat weight proportional to experimental temperature. Initial values of 4.08 g live weight and 95.0 mg dry meat weight compare with terminal values of 22.33 g live and 756.0 mg dry meat weight at 21°C. These results have been examined in terms of changes in biochemical composition of the experimental animals, variations in ammonia excretion rate concurrent with changes in predominant respiratory substrate, and histological evidence of gonadal development.

Pilot scale studies on the growth of *C. gigas, O. edulis* and three other bivalve species, namely the Manila clam *Tapes japonica*, the Bay scallop *Argopecten irradians*, and the Blue mussel *Mytilus edulis* have shown good growth with all species, although high mortalities were recorded with *A. irradians*. A relationship of these mortalities to a high incidence of shell deformities seems possible. Three small-scale experiments were carried out to examine the effect of provision of substrate on the growth of *T. japonica*. In general no enhancement of growth over control populations devoid of substrate was observed.

The Genetic Component of Growth and Survival in Raft-Cultured and Natural Populations of Quahogs *(Mercenaria mercenaria).*

— Judith P. Grassle

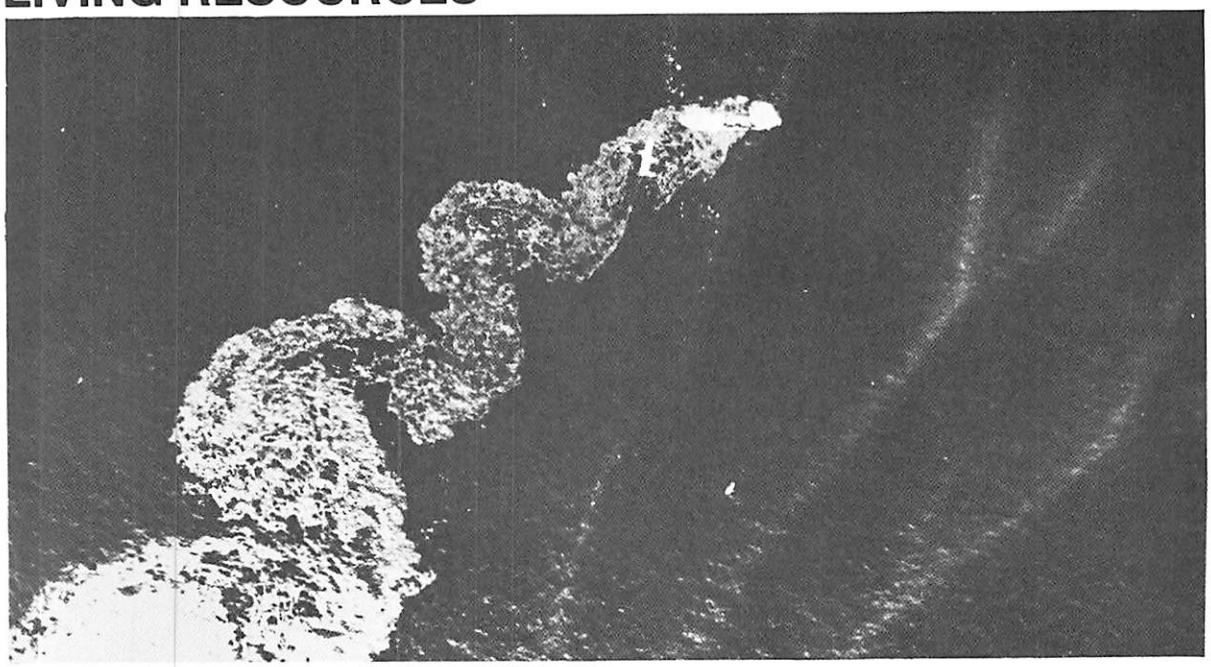
The object of this research is to correlate the frequency of certain genetic markers in natural and hatchery-reared populations of *Mercenaria mercenaria*, with the heritability of rapid growth rate, survival and early maturity in the Cape Cod environment.

Part of this work is done in collaboration with Mr. George Souza, Shellfish Warden for the Town of Falmouth, who is growing seed clams in raft culture. Such clams reach an average length of 1″ in one growing season, and thus have an improved chance of escaping heavy predation from crabs when they are transferred to the natural environment. Five seed stocks (two grown in the rafts in 1976, and three grown in the rafts in 1977) have been characterized at 8 polymorphic, electrophoretically-detected gene loci, and for other individual attributes of shell color and shape. Growth rates were determined over one growing season for individually numbered clams. The data is being analyzed to determine the correlations between different genetic markers and continuously variable characters, such as fast or slow growth rate, under the same environmental conditions. As the number of genetic markers can be expanded the better the correlations will become. This provides a more rational basis for selection of seed stock for culture in the local environment.

For this reason, we are also characterizing the genetic variability existing in local natural populations. It is possible to age adult *M. mercenaria* from the growth rings in the shell, and by examining populations in different environments, and looking at age-specific differences in allele frequencies in each of these populations (that is at the effects of selection), we will be able to genetically characterize those individuals which grow rapidly and survive in particular local environments.

George Souza, Falmouth Shellfish Warden, setting out experimental quahogs in a cultural raft.

LIVING RESOURCES



A view of the ARGO MERCHANT (from 5,500 feet) which went aground on Georges Bank in December, 1977. Photo taken by the National Aeronautics and Space Administration.

Effects of Mixed Petroleum Hydrocarbons in Marine Fishes

— J. J. Stegeman
D. Sabo

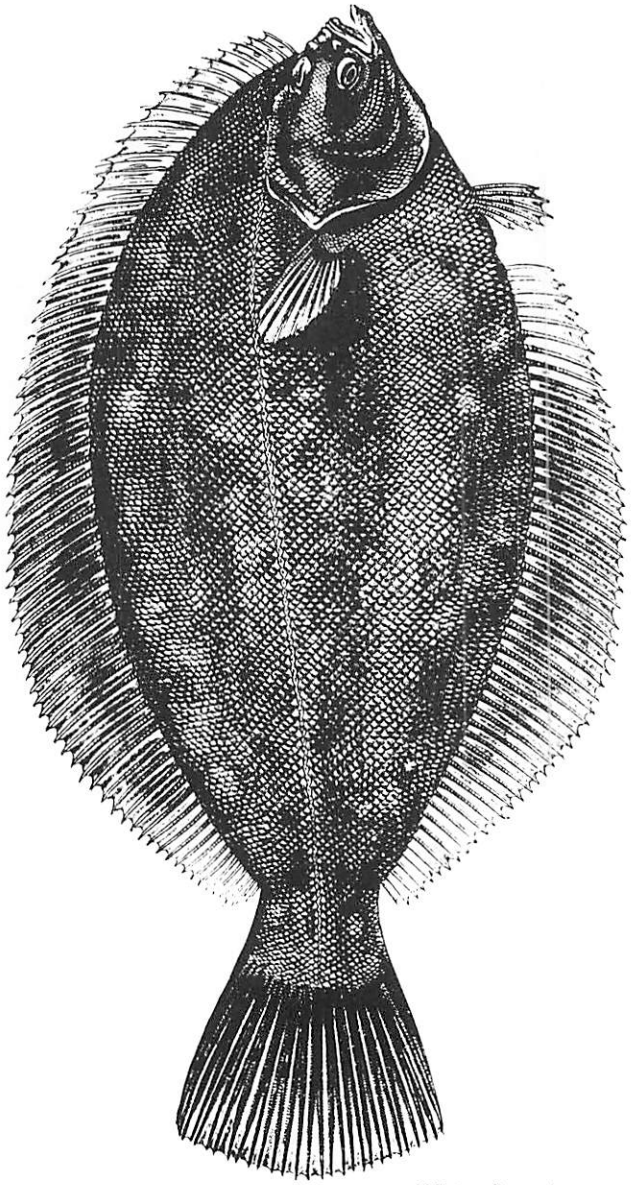
Our research to identify metabolic effects of chronic and low level hydrocarbon contamination in fishes has continued, with the objectives of assessing the importance of such effects in individuals and in populations, and developing appropriate diagnostic tools. The research continued to focus on aspects of several different areas: 1) characterization of the mixed-function oxygenase system in fish, and its involvement in metabolism and effects of hydrocarbons; 2) the extent to which hydrocarbons can disrupt normal intermediary metabolism; and 3) the use of histology and blood chemistry as tools for identifying effects. This year a cooperative study was also conducted on the effects on reproductive success of fishes.

The cytochrome P-450 dependent mixed-function oxygenase system, the enzyme system which is responsible for initiating the metabolism or biotransformation of hydrocarbons, was studied in a variety of fish species, including winter flounder (*Pseudopleuronectes americanus*), scup (*Stenotomus versicolor*), the marsh minnow (*Fundulus heteroclitus*), and two trout species, brook trout (*Salvelinus fontinalis*) and rainbow trout (*Salmo gairdneri*). In four of these species clear sex differences were identified in optical properties and catalytic function of cytochrome P-450, the protein containing the site where hydrocarbon biotransformation is initiated. These differences are probably related to the role of cytochrome P-450 in steroid metabolism, as they were most pronounced in spawning fish. It is not known how foreign compounds might interfere with this process in fish, or whether males and females may differ in their ability to metabolize hydrocarbons.

Some hydrocarbon compounds that are contaminants in marine waters, such as benzo[a]pyrene, are potent mutagens and carcinogens. Using the enzyme from scup liver, we determined that although fish mixed-function oxygenases are capable of metabolizing these compounds, the metabolic products resulting include compounds which are more toxic and mutagenic than the parent compound, now known to be relatively inert. Thus the biotransformation of some hydrocarbon compounds by fish results in an increase in toxic potential rather than a decrease.

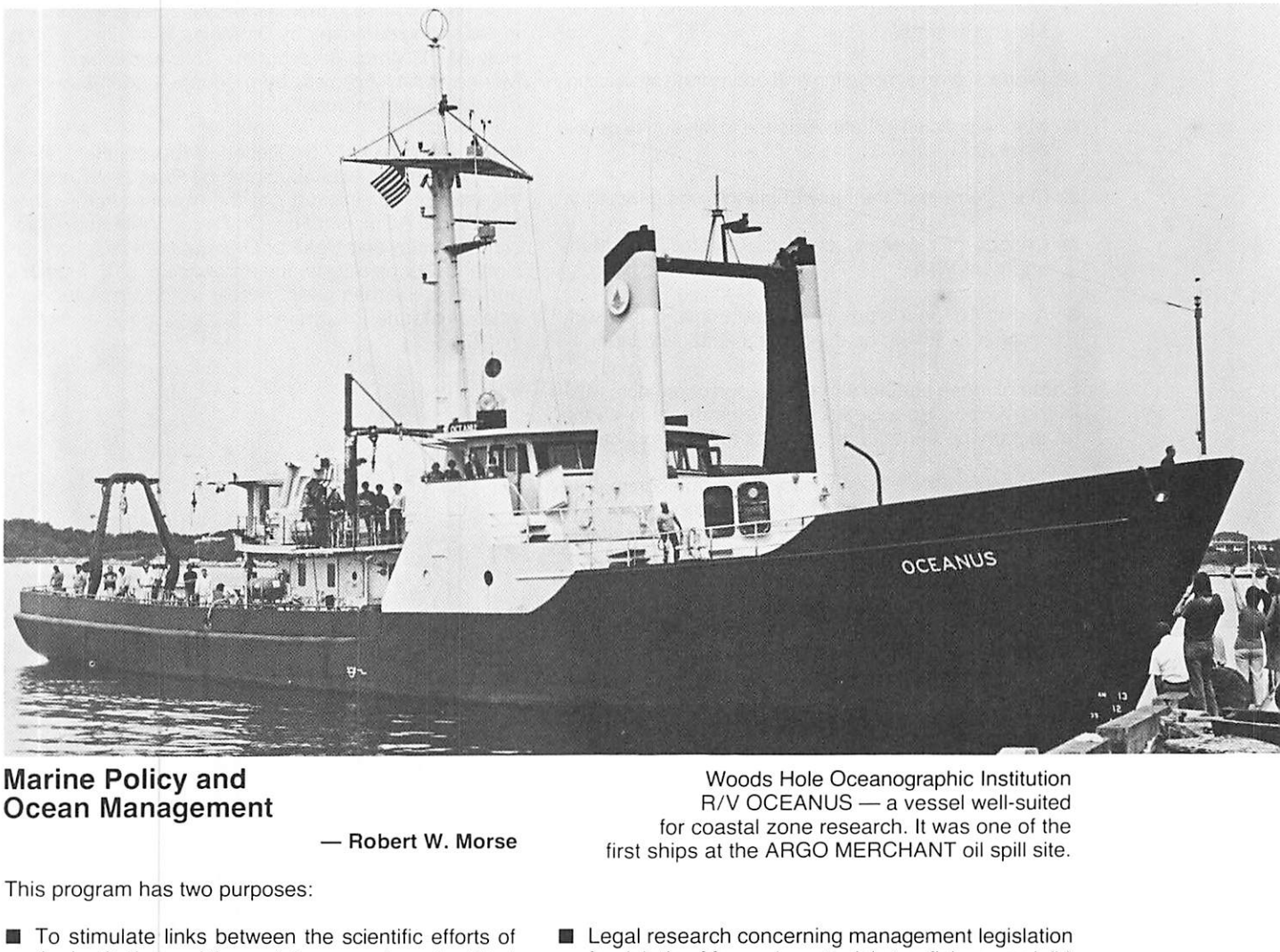
Brook trout and rainbow trout, obtained with the cooperation of the Massachusetts Division of Fisheries and Game, provided information which further supports the idea that higher levels of mixed-function oxygenase activities, specifically benzo[a]pyrene hydroxylase, may be related to the presence of environmental contaminants. Progress was also made in the purification of components of the mixed-function oxygenase system from scup, unusual because it exhibits consistently high levels of benzo[a]pyrene hydroxylase activity.

A cooperative study was carried out on winter flounder to determine whether the various metabolic and histological effects which had been identified in other species might appear in this species. Fish were exposed to 10 and 100 ppb #2 fuel oil for up to nine weeks, encompassing the period of gonad maturation. We found no differences in the activity of hepatic mixed-function oxygenases, and no apparent effects on lipid metabolism in the liver of the exposed fish. Similarly there were no effects which could be identified either histologically in the liver, or on any of a wide range of hematological parameters. There was a significant effect, however, on the survival of larval fishes resulting from eggs spawned by the exposed females and fertilized in the laboratory. These studies indicate that effects on reproductive success of fishes may result from petroleum contamination even though there may be no effect observed in any of a range of other parameters in the adult. This research was performed in a cooperative effort with the National Marine Fisheries Service, the Environmental Protection Agency, the University of Rhode Island, and the Falmouth Hospital.



Winter flounder
(Pseudopleuronectes americanus)
from **Fishes of the Gulf of Maine**
by Schroeder & Bigelow.

SOCIO-ECONOMIC AND LEGAL STUDIES



Woods Hole Oceanographic Institution
R/V OCEANUS — a vessel well-suited for coastal zone research. It was one of the first ships at the ARGO MERCHANT oil spill site.

Marine Policy and Ocean Management

— Robert W. Morse

This program has two purposes:

- To stimulate links between the scientific efforts of the Institution and the social, economic and political problems of the oceans, and
- To offer postdoctoral research opportunities for professionals in policy-related fields in which they are involved with marine problems emphasizing the relation of science, technology and policy.

The Program in 1976-77 included three Research Associates and nine postdoctoral Fellows. These individuals pursued independent projects and, in addition, participated in cooperative projects with members of the Scientific Staff. In 1976-77 these projects included:

- A study of the international legal problems involved with the geologic disposal of high-level radioactive wastes under the seabed.
- A study of the initial effects of the ARGO MERCHANT oil spill. The program helped coordinate the initial scientific response. Later it examined aspects of public reaction to the accident.
- Legal research concerning management legislation for (a) the Massachusetts lobster fishery and (b) nuclear power development.
- Writing of model legislation for the Massachusetts Lobster Fishery.
- The behavior of scientists as expert witnesses in litigations.
- Anthropomorphism as an element effecting public policy toward marine mammals.
- The application of mathematical systems and decision theory to several marine problems, e.g., the fertilization of salt marshes.
- Research of legal aspects of stimulated biological production in semi-enclosed habitats.
- A comparison of the legal and institutional constraints on aquacultures in developing countries.
- A review of this history of aquaculture in Japan.

- Salt marshes and their adjoining land prices in Massachusetts.
- World systems modeling and ocean food production.
- Marine policies in Latin America in relation to development.
- Management of the New England Fishing Industry.
- Critique of the Massachusetts Coastal Zone Management Plan.
- A distributional study of a New England port with respect to fishing boat income, capital and labor.

Some of these studies were in support of projects within the Woods Hole Sea Grant Program, such as the project on the enhancement of salt marsh productivity.

In late March the Marine Policy Program sponsored a preliminary workshop on the factors affecting the success of aquaculture projects in developing countries. The purpose was to review the present knowledge of the social, economic and legal problems influencing the establishment of new aquaculture activities around the world. While recognizing that aquaculture by itself could not meet the food deficit of the world, there was a strong feeling that aquaculture products could make significant differences in specific areas and that their full potential was not being reached. The workshop also concluded that most of the problems limiting the potential of aquaculture were not technical (i.e., biological) but cultural.

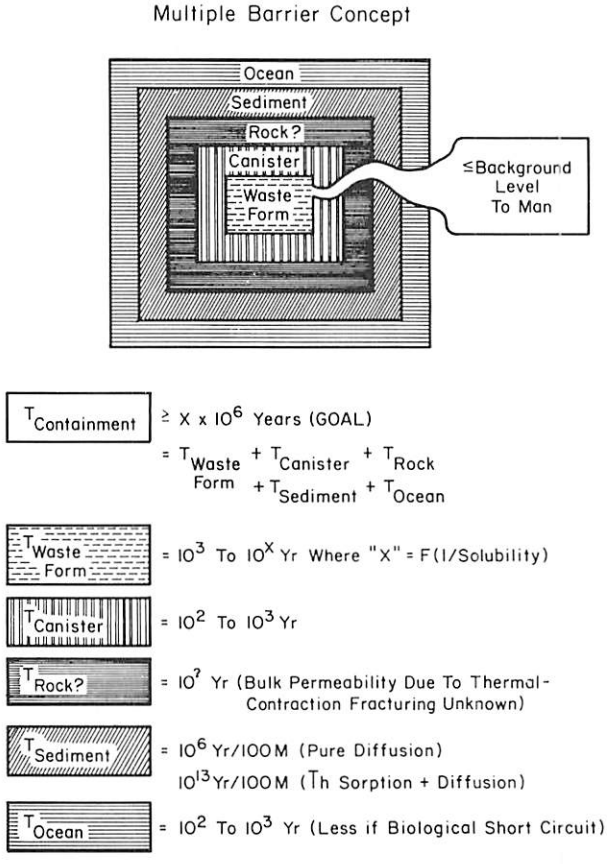
Plans are being made for a project to determine by a field study of actual aquaculture projects (primarily in South America and Africa) what the controlling factors are in the success or failure of such projects. This study will be conducted under sponsorship of the International Federation of Institutes for Advanced Study, of which the Woods Hole Oceanographic Institution is a member. This Institution will take the lead in laying out the research design for such a study and developing the required funds.

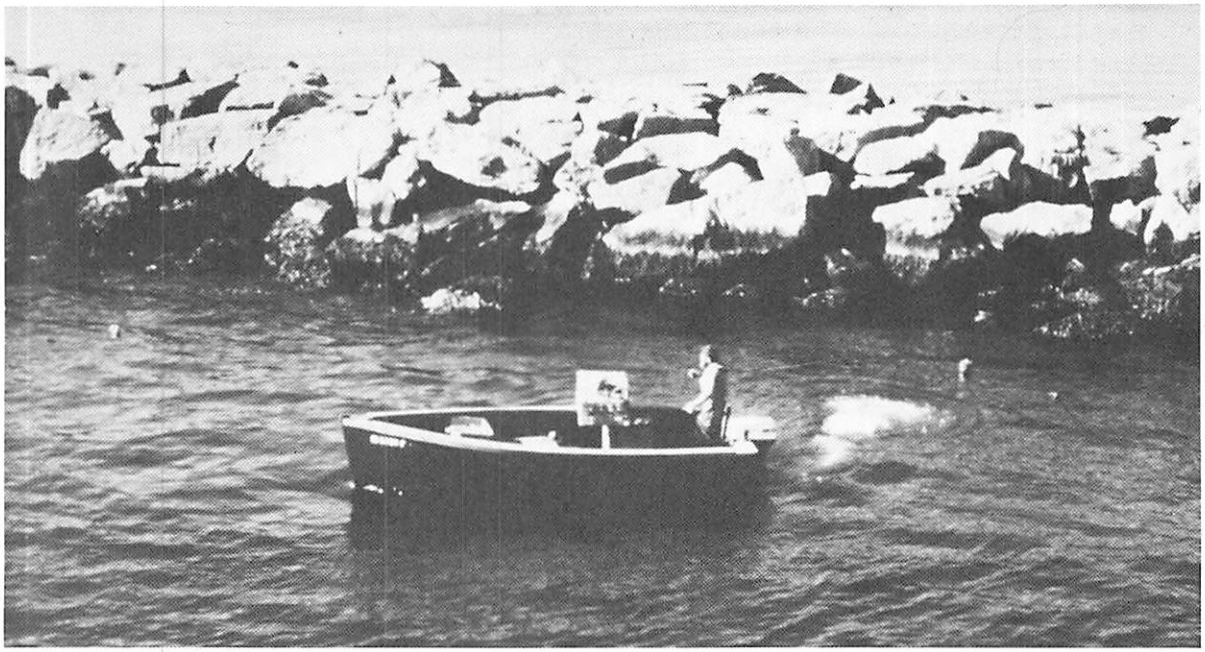
A continuing objective of our overall program is to identify future public problems affecting the ocean where scientific research and policy study need to proceed coherently together. With this in mind, the program sponsored a "working seminar" on the *benthic boundary layer*. This is the region near bottom of the deep ocean where chemical, physical and biological activities determine the interchange between the sea and the bottom. Since man's future activities such as dumping, mining or disposal of nuclear wastes — see figure — will undoubtably have major impacts on the bottom of the deep ocean, it is important to know now how well scientists will be able to answer the questions that may arise.

A seminar course in marine policy problems was taught in the spring semester by Dr. Morse in the joint Woods Hole-M.I.T. graduate program. This was attended by Marine Policy Fellows, by graduate students and by Institution staff members.

In the spring of 1977 Dr. Robert A. Frosch, the director of this Program, was appointed by President Carter to the post of Administrator of the National Aeronautics and Space Administration. Dr. Robert W. Morse, Associate Director and Dean of Graduate Studies, was assigned responsibility for the Program upon Dr. Frosch's departure. He has been closely associated with activities in Marine Policy since he came to the Institution in 1971.

Diagram of a containment model for disposing of nuclear wastes in the sediments of the sea floor.





Draft Legislation For The Massachusetts Lobster Fishery

— Susan Peterson and James Friedman

The objectives of this project were: 1) to provide information on types of limited entry programs which have been used elsewhere in order to provide background for development of limited effort legislation for the Massachusetts lobster fishery, and 2) to assist the Massachusetts Division of Marine Fisheries and the Massachusetts Lobsterman's Association in drafting legislation to conserve the Massachusetts lobster fishery.

Our report — The Massachusetts Lobster Fishery: Model Legislation and Management Plans — was published in early 1977. In it there is a detailed discussion of four possible management plans as they might be applied to the lobster fishery; benefits to the industry and the costs to society are also discussed. Revisions of the present laws governing lobstering to conform to the management plans are provided to illustrate some of the difficulties involved in wording legislation to limit fishing effort. Finally, we discuss the present lobster fishery based upon interviews with lobstermen and responses to interview forms. Since publication of the report, Massachusetts has chosen to continue the moratorium on issuing lobster licenses for yet another year rather than proposing new legislation. Thus there have been no attempts to apply any of the suggestions to the Massachusetts lobster fishery.

OCEAN ENGINEERING

William von Arx discussing the operation of his brine pond solar heat collector with the Sea Grant Site Visit Team, April 1977.

Seasonal Performance of a Brine Pond Solar Heat Collector in New England

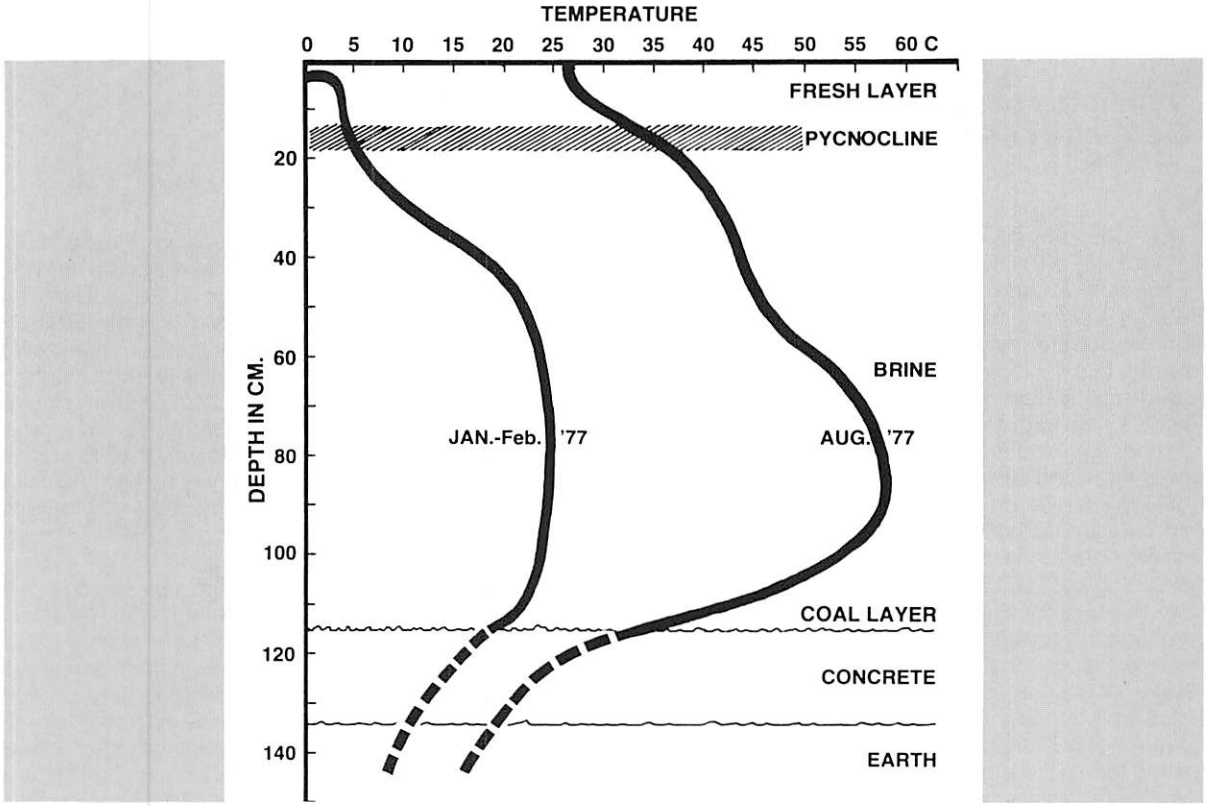
— William S. von Arx

The modified 20 metric ton, 20 m^2 area Bloch-Tabor brine pond built on the premises of the New Alchemy Institute, Hatchville, Massachusetts, under Woods Hole Oceanographic Institution Sea Grant auspices has been in operation since early October 1976 through one of the coldest winters in recent New England history. Despite a "cold" start in October 1976 the core temperature declined only to 24°C in January-February 1977, reached a summer peak of 58°C in August 1977 and is now showing seasonal decline. Generally speaking, the pond has maintained a temperature about 20°C above ambient; showing only very sluggish responses to weather changes and a smooth response to seasonal changes of insolation and average wind speed (see figure).

The pond, though small, has been operated in an unsheltered mode to see whether very large ponds (too large to be covered) could perform usefully in New England. As a result the open pond not only suffered evaporative losses and wind-mixing of the fresh water cap overlying the brine, but, when iced over, collected snow. Exposure to the elements also permitted accumulation of leaves, pollen, and dust on the surface which cast shadows. Almost daily cleaning was necessary but easily done with a drop of dishwashing detergent on the surface and a scoop net. The pond operated at an average efficiency of 24% (total daily output/daylight input x 100%).

The pond differs from the Bloch-Tabor design in utilizing coal as a black body absorber and brine concentrations of Calcium Chloride Hexahydrate near 45% to raise the refractive index to 1.42 and thus enhance the "fish-eye" or whole-sky radiation-trap effect. As a result the pond could acquire and trap radiation on cloudy as well as clear days to such good effect that it is difficult to distinguish between clear and overcast days in the recording thermograph records. Rainfall has a cooling effect from which recovery is rapid, and also "tops up" and freshens the sweet water cap over the brine. Precipitation has just about balanced evaporative losses from the surface since excesses overflow and P - E is generally positive in New England.

The experiment has been generally successful from the physical point of view (radiant heating of homes, for example), but its biological performance is marginal in mid-winter. Tropical species of plankton feeders, such as *Talapia*, grow best in water temperatures near 27°C which the pond at 24°C cannot supply in the coldest months. Anaerobic digesters for bioconversion of organic wastes into high grade fuels and fertilizers operate best at 35°C which, again, are not within the capabilities of the pond in mid-winter. Water plants, algae and nitrogen-fixing bacteria associated with *Azolla* (water ferns) survive and reproduce at 24°C and can thus be held over in winter, but 30°C or so would improve their vitality. Obviously, some form of increased heat storage capacity, with very long time constants, is required.



As a result of these findings and experiences an altogether different approach to solar heat collection and storage has been developed in which the heat excesses of summer are collected and stored below ground for use in winter: *the annual-cycle, groundwater heat storage system*. Preparations are being made to drive wells to and into the phreatic zone so as to pump several hundred-thousand gallons of cold groundwater to the surface for solar heating to about 45°C in summer, and return the heated water to the groundwater table for storage as a warm, buoyant lens for heat recovery in winter. The practicality of such a plan has been given careful study with much help from the geologists, hydrologists, and environmentalists of the U.S. Geological Survey, Environmental Protection Agency, and the National Water Well Association. Computer models of the "thermal onion" developed around heat storage well and heat recovery expectations have been made at the ETH, Zurich, Switzerland which suggest that a pilot experiment would provide valuable proof of the principle and indicate the scope of its applications.

A much more serious constraint on brine pond usage is environmental. The concrete tank holding the pond survived the pressure of foot-thick ice without damage, but subsequent bulldozer operations near the tank undermined its footings. This provoked the thought that a serious leak in a large hypersaline pond could discharge brine into the vadose zone and eventually contaminate groundwater to such an extent that the water quality of wells in the vicinity would suffer for years. For this reason the present experiment has been terminated. Clearly, brine ponds should be built only in places where they do not impose an environmental threat, as in connection with *marine* aquaculture tank or polder heating where inadvertent salt leakage would be of no consequence.

Theoretical and experimental study of the physics of brine pond efficiency indicates that the 20 m^2, 20-ton experiment represents the lower limit of practical size. Theory suggests that a more nearly optimum pond would be about 10,000 m^2 (one hectare) in area and 3 m deep with a much more gentle pycnocline developed in the upper 1 m. The pond should be fresh in the upper 20 cm and reach higher salt concentrations below the 1 m level. Since the coal layer tends to be neutrally buoyant at 40% brine concentrations, it thus becomes involved in convection and shades the bottom layers. A lower salt concentration would prove advantageous in terms of heat collection and heat storage capabilities. Wave and wind-stirring action on a large pond would have to be suppressed, possibly by floating a grid of wooden booms on the surface. Large solar ponds are being studied at the Dead Sea Works in Israel. It would be very instructive to conduct similar experiments in the less favorable climate of New England.

Dynamics of the Inclining Spar Current Sensor

— J. W. Mavor and
G. Rodenbusch

The static properties of an inclining spar current sensor make it an attractive aid to navigation in shallow seas. Estimation of the dynamic properties of this spar in waves and currents is of interest because of the effects on the current measurement. These would include apparent current due to finite wave height and non-linear drag rectification as well as "noise" due to motion in waves. The high natural frequency of the spar, ($\sim$.1Hz) a consequence of the excess buoyancy needed to counteract the currents being measured, is in the region of significant surface wave energy thereby making the spar susceptible to wave action. The presence of significant non-linear terms, V^2 hydrodynamic drag, in the damping and forcing functions of the spar, make classical linear random vibration techniques inadequate for treating the spar. Offshore oil production platforms presently being constructed in deep water (300m) also have natural frequencies within the surface wave band and are subject to V^2 form drag. The question of spar dynamics is therefore of some general interest. The existing techniques for analyzing such nonlinear systems are inefficient or unreliable. It is the objective of this study to investigate the performance of these techniques in estimating motions of a system dynamically similar to the current measuring spar.

The system which is being studied is a cylindrical spar, 0.1m in diameter, and 1.2m long in a uniform current and 2-D waves. This environment can be easily created in the MIT ship model towing tank and therefore allows experimental verification of the approximate solution methods. The small geometry is also an advantage in that hydrodynamic coefficients for cylinders in harmonic flows are available for the Reynolds number and Kuelengan Carpenter number ranges to be studied. Although a gross simplification of any realistic environment, understanding of this problem will provide important insights into the more complex complete problem.

Analysis of the spar system including estimation of wave damping and the existence of possible instabilities leading to the formulation of an approximate governing equation has been completed. Programs have been written and debugged to carry out a Fast Fourier Transform simulation of spar motions, and to make an equivalent linearization estimate of the spar response. Analysis has begun on designing a hybrid linearization-polynomial functional technique to improve the estimates of the linearization technique. Construction of a model spar instrumented with two rate gyros and three accelerometers is underway.

Another program, CYCLOPS (Cycling Oceanographic Profiling System), is a data collection system designed to take vertical profiles of a column of water of less than 60 meters depth. It is a versatile platform capable of use by numerous instruments to measure parameters such as current, temperature, salinity, dissolved oxygen content, water clarity, etc. CYCLOPS will operate unattended for a period of up to two weeks with profiles being run at any set interval. It is designed to process data *in situ* and has the capability of detailed examination of perturbations in the data by physically returning to the site of the anomaly.

The idea for CYCLOPS came from a paper of a similar concept, the Cyclesonde, developed by the University of Miami. However, CYCLOPS has four features which distinguish it from the Cyclesonde. First, it can stop or make small excursions at any depth for any length of time to examine a region of interest more closely. Second, it is controlled by a computer capable of examining the acquired data to detect emerging trends or changing quantities. Third, it is intended for shallow water. Fourth, it is much less expensive than Cyclesonde.

At this point, most of the parts needed for CYCLOPS have been purchased, however, there is still some work to be done, including some machining for parts of the frame. Waterproof connectors must be bought or built, and the computer must be fully tested and the programs debugged. Measuring instruments must be attached and interfaced. Finally, all components must be assembled and lab-tested before open water testing.

ECOSYSTEMS RESEARCH

Interactions of Fluviatile Salmnoid Species

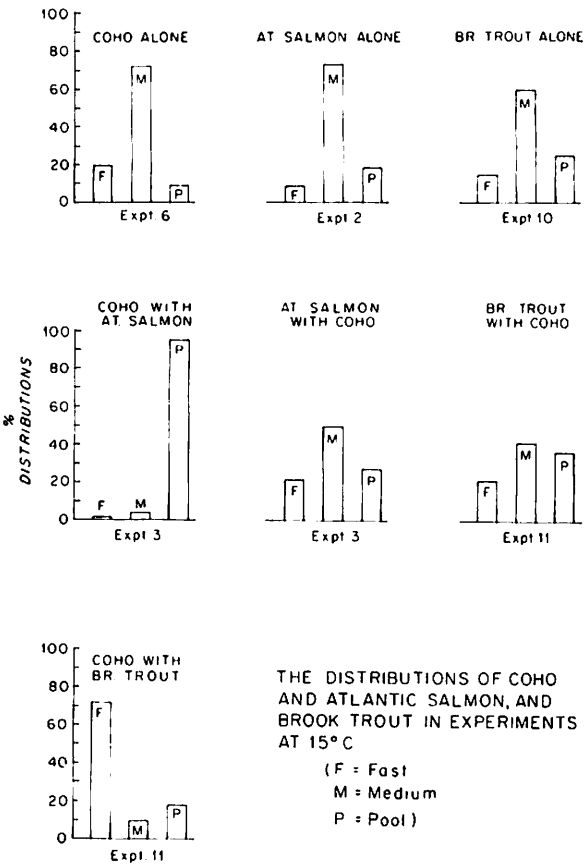
— R. J. Gibson

The objective of this project is to study the behavioral interactions between juvenile coho salmon (*Oncorhynchus kisutch*), juvenile Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*).

The coho salmon has, in recent years, been introduced to the Great Lakes and to the east coast of North America. Its life history and habitat requirements are very similar to those of Atlantic salmon, especially at the fluviatile stages and there is much concern that populations of the indigenous salmonids might be adversely affected. Consequently, behavioral interactions between juvenile coho salmon and brook trout, and between coho and Atlantic salmon were studied in a stream tank. The stream tank has an observation area of 13.2m^2, and provides choices of fast water, at 14-17 cm/sec, medium flow, of 6-8 cm/sec, and a pool, with slower flow of 3.8-6 cm/sec. Experiments were conducted at 15°C and 20°C and one at 7°C. Results of experiments at 15°C are shown in the histograms below. At 20°C activity and aggression on all three species were higher. In a 7°C experiment with coho and Atlantic salmon, activity and aggression were very low, and both species were more common in the pool environment.

As shown in the histograms the medium flow was generally the preferred habitat for each of the three species when a species was tested alone. The coho distribution was very much more affected by another species than either the Atlantic salmon or the brook trout. With Atlantic salmon, coho occurred more frequently in the pool than when alone. They occurred less in the pool when present with brook trout, probably because they were attacked considerably more by the brook trout than by the Atlantic salmon. The Atlantic salmon were more territorial than either of the other two species, and coho and Atlantic salmon tended to be more spatially segregated than the trout and coho, so that interspecific attacks between Atlantic salmon and coho were fewer. Intraspecific attacks amongst the coho were higher when trout were present, probably because they were kept more active by the trout.

The buoyancy of the three species was measured. The mean specific gravity of Atlantic salmon was 1.046 (range 1.020-1.060), for coho 1.023 (1.010-1.040), and brook trout 1.015 (1.010-1.020). Atlantic salmon were significantly less buoyant than either of the other two species. This would indicate that young Atlantic salmon are better adapted for faster water than either coho or brook trout.



THE DISTRIBUTIONS OF COHO AND ATLANTIC SALMON, AND BROOK TROUT IN EXPERIMENTS AT 15°C

(F = Fast
M = Medium
P = Pool)

Atlantic salmon are ecologically compatible with brook trout, and judging from these experiments probably would also be with coho. More severe competition might be expected between coho and brook trout, but the latter appear the more aggressive of the two, and would probably not be displaced by coho. Some experiments are planned using all three species together to complete this part of the study.

On the west coast young steelhead trout (*Salmo gairdneri*) co-exist with coho, with the trout occupying the riffles and coho the pools. The steelhead trout, therefore, appear to occupy a similar niche to that of Atlantic salmon, so displacement of one of these species by the other would be expected. Steelhead trout have also been introduced to the east coast. These two species will be observed in the next series of experiments.

POLLUTION RESEARCH

Sediment and Heavy Metal Distribution in New Bedford Harbor, Massachusetts

— Colin P. Summerhayes and
Jeffrey P. Ellis

Work done by a number of investigators has shown that the estuaries of the northeast U.S. coast are being filled by a net landward transport of fine-grained sediments from the continental shelf. Because of their large surface area, these sediments play an important role in the transportation of chemical pollutants that are often injected into the estuarine environment. Undissolved materials contained in effluent discharges are usually fine-grained particles that tend to be transported and deposited with naturally occurring fine-grained sediments. Estuaries, therefore, are thought to act as sinks for most materials dumped into them.

A study of New Bedford harbor was undertaken to test this hypothesis; the area was chosen because of its proximity to Woods Hole, its long history of pollution and because of the small river discharge into the harbor. The conclusions of the study are based on 112 bottom samples and some 70 suspended matter stations, which were repeatedly occupied during the two year course of the study. Data from a number of State and Federal agencies was also incorporated into the study.

The major findings are:

1. The hurricane barrier built in 1966 has caused a significant increase in the sedimentation rate within the harbor;

2. Harbor sediments are highly enriched in locally derived heavy metals;

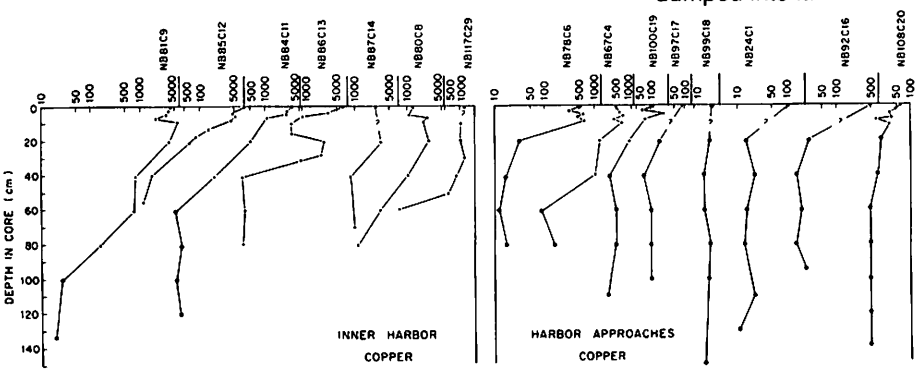
3. New Bedford harbor acts as an imperfect trap for materials dumped into it, and there is some transfer of industrial contamination to Buzzards Bay.

The hurricane barrier built across the mouth of New Bedford harbor restricts the exchange of the inner harbor with Buzzards Bay to a 150 foot wide, 30 foot deep navigation channel and two double barrel, gated conduits. Tidal currents are generally weak. Suspended matter data indicate that the flood tide is more effective in transporting sediments than the ebb tide.

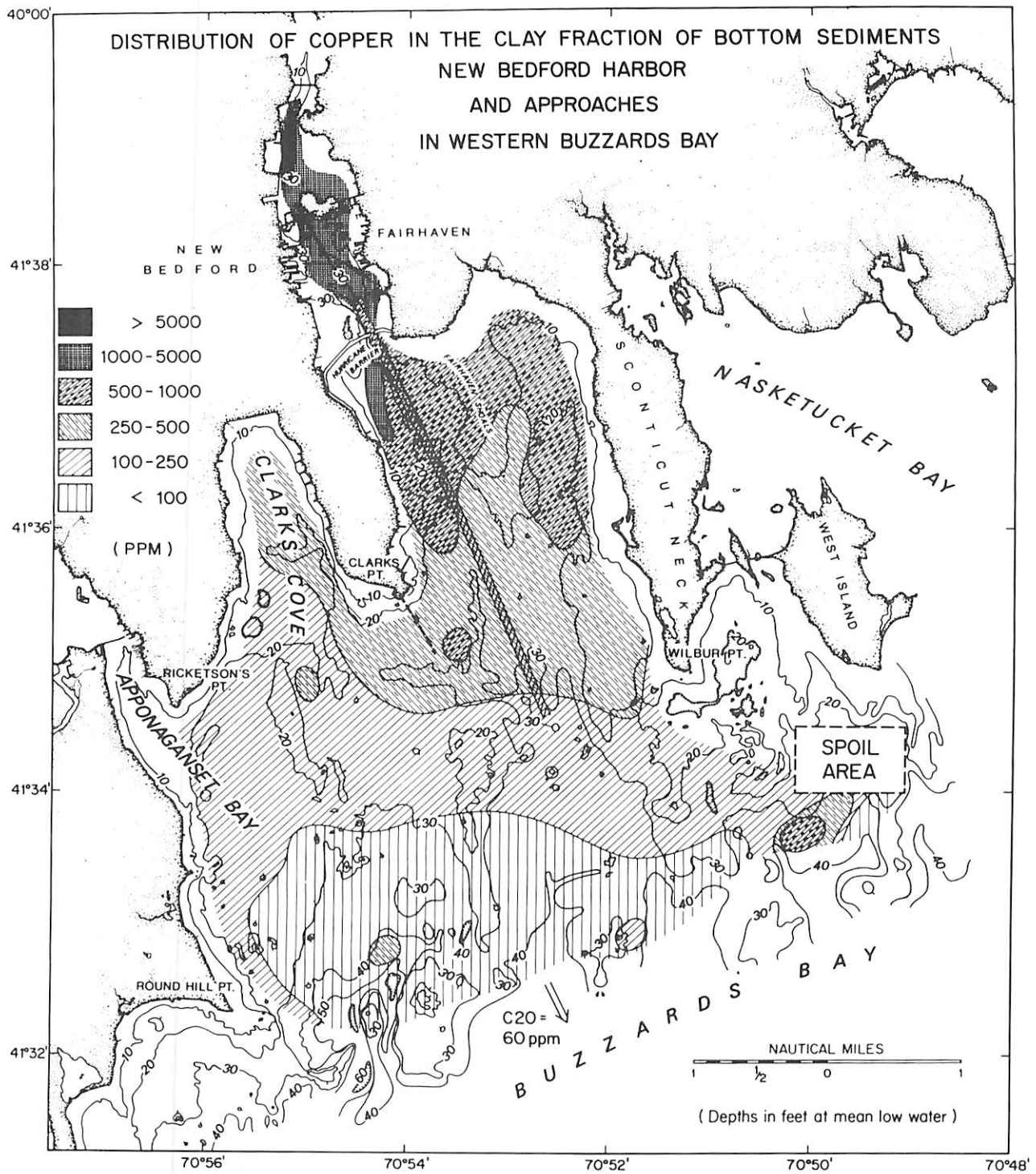
Radiometeric methods were used to date cores from two harbor sites. These data indicate that prior to the construction of the hurricane barrier, average sedimentation rates within the harbor were on the order of 2 to 3 mm/yr, and that after completion of the barrier these rates increased to 2 to 4 cm/yr.

Large quantities of Cu, Cr, Pb and Zn have been discharged into New Bedford harbor and its approaches. Lesser amounts of As, Ag, Cd and Hg can also be found in the bottom sediments of the region. Of these heavy metals, copper is by far the most abundant, and concentrations in the clay fraction reach levels as high as 8050 ppm, background levels are on the order of 25 ppm. A large portion (39%) of the copper found in the bottom sediments of New Bedford harbor occurs as an insoluble mineral phase, that may represent particulate metal. The variable vertical distribution of copper in the sediments indicates that the processes which have led to its concentration, i.e., industrial input and the local rate of sedimentation, have not operated at a constant rate.

Copper and other metals rapidly become part of the bottom sediment, therefore tending to be retained inside the hurricane barrier. Trapping of these metals, however, is not complete. The evidence suggests that 24% of the metals discharged into the harbor eventually find their way into Buzzards Bay. This transport is probably the result of harbor dredging and near bottom turbulence associated with tidal transport. New Bedford harbor is, therefore, an imperfect sink for the materials dumped into it.



Distribution of copper in ppm in the bottom sediments of New Bedford harbor and surrounding regions.


DISTRIBUTION OF COPPER IN THE CLAY FRACTION OF BOTTOM SEDIMENTS
NEW BEDFORD HARBOR
AND APPROACHES
IN WESTERN BUZZARDS BAY
40°00'
41°38'
41°36'
41°34'
41°32'
70°56'
70°54'
70°52'
70°50'
70°48'
NEW BEDFORD
FAIRHAVEN
> 5000
1000-5000
500-1000
250-500
100-250
< 100
(PPM)
HURRICANE BARRIER
CLARKS COVE
CLARKS PT.
RICKETSON'S PT.
APPONAGANSETT BAY
ROUND HILL PT.
SCONTICUT NECK
NASKETUCKET BAY
WEST ISLAND
WILBUR PT.
SPOIL AREA
BUZZARDS BAY
C20 = 60 ppm
NAUTICAL MILES
1 ½ 0 1
(Depths in feet at mean low water)

ENVIRONMENTAL MODELS

A Study of the Physical Properties of Bourne's Pond, Falmouth

— Michael Fitzgerald
Jeffrey P. Ellis

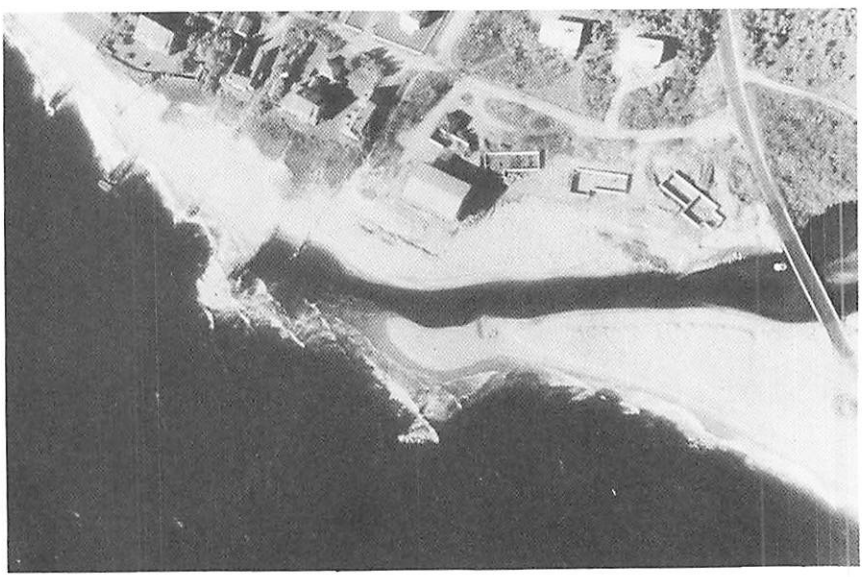
Bourne's Pond is a 152 acre, elongated, brackish pond located in the eastern part of Falmouth, Massachusetts. Its major source of freshwater is a small stream which, before it enters the pond's northern end, flows through a series of cranberry bogs. Freshwater also enters Bourne's Pond as a result of local storm runoff, septic tank seepage and ground water discharge. The pond empties into Nantucket Sound through a shallow, shifting channel, which has been periodically closed, in recent years.

Closure of the Bourne's Pond channel has prevented normal tidal flushing, which has caused a build-up of organic matter and a depletion of oxygen levels in the pond. This deteriorating condition has led to the failure of a once extensive shell-fishery. The conditions which now exist within Bourne's Pond were first examined in late 1965 by a team from the Massachusetts Division of Marine Fisheries. Much of the work done on the problems of Bourne's Pond has been accomplished by or done for George Souza, the Falmouth Shellfish Warden.

Our investigation of Bourne's Pond commenced in late fall, 1976; our aim is to learn more about the configuration of the pond's floor and of the sediments which cover it, to monitor seasonal changes in a number of environmental parameters, particularly dissolved oxygen, and to determine what extent tidal flushing of the pond is effected by its physiography. The information being generated by this study will help local government agencies plan recovery programs for Bourne's Pond.

We have made periodic observations of water temperature, conductivity, dissolved oxygen, pH, and Eh, and collected water samples for suspended matter analyses. Several cores and grab samples have been collected; the cores are being dated by Pb^{210} to establish the rate of sedimentation within the pond. Other analyses will determine organic matter and some trace metal content.

To date our investigations have revealed a number of important environmental factors. We have found that most of the suspended material is organic in nature. The pond, itself, is divided into a number of basins that are separated from each other by spits and bars. Within these basins, the bottom water tends to be warm, saline and have low values of dissolved oxygen. These bottom waters probably remain there until surface water temperatures become cold enough for overturn. These individual basins will probably continue to have environmental problems, even if steps are taken to increase tidal flushing, since it is doubtful that their bottom waters will be significantly effected unless additional steps are taken to reduce the amount of organic matter in suspension in the pond.



Infrared photograph of the Bourne's Pond Inlet area taken at 2,000 feet, November 11, 1975.

Stability of a Small Coastal Inlet — (Bourne's Pond)

— J. A. Moody

A study of the stability of Bourne's Pond Inlet and its affect on circulation has been a project of oceanography classes at Falmouth High School. During the past year several topographic charts have been prepared and sediment transport has been inferred. The sediment transport process appears to be cyclic in nature and connected to the occurrence of intense SE storms which shift the inlet back to its far westward position. These storms occur about every 2-3 years between December and March and initiate a new cycle of inlet movement.

Three different stability criteria were applied to the inlet. All approaches indicate that the inlet is very unstable with a tendency to fill and close rapidly, a conclusion that is supported by observations over a 6 year period.

The area of the inlet is usually between 4 and 15 m^2 which is less than the theoretical critical area of 18 m^2 needed for stability. This indicates that the inlet may never be stable in part due to low inlet current velocities because of the restricted surface area of the pond.

The maximum inlet ebb tidal velocities are 40-70 cm/sec which is less than 50% of the flood velocities for the same hydraulic head. This has resulted in an average pond elevation of 16 cm above the mean level of the ocean outside. The low inlet velocities are reflected in an apparent sluggish and stratified circulation of the pond itself. A high saline (26-30 ‰) bottom layer has been found to exist at all seasons and for nearly the entire length of the pond. Initial measurements have shown that this bottom layer is tidally dominated with typical speeds of 0.5-2.5 cm/sec. The upper layer is wind driven with typical speeds of 3-10 cm/sec.

The results of this year's investigations indicate:

1. that the stability of this small inlet can be modeled using methods applied to large-scale inlets.

2. the dynamics of the tidal flow in the inlet is non-linear. Consequently, it cannot be represented by a simple function in closed form that has been used for solving large inlet problems. The large number of harmonic terms which are required to describe the flow seem artificial in that they don't represent real physical processes.

3. the circulation of the pond is primarily in two layers. The surface layer (0-100 cm) is dominated by the wind and the high saline bottom water is driven by the tides but it is thought that no significant amount of the bottom water is transported out of the pond.

4. the results from these studies were used by Tibbetts Engineering Corp in preparing a preliminary report on waterflow improvements at Bourne's Pond and submitted to Division of Waterways.

MARINE EDUCATION AND TRAINING

Marine Science Libraries Cooperative Network

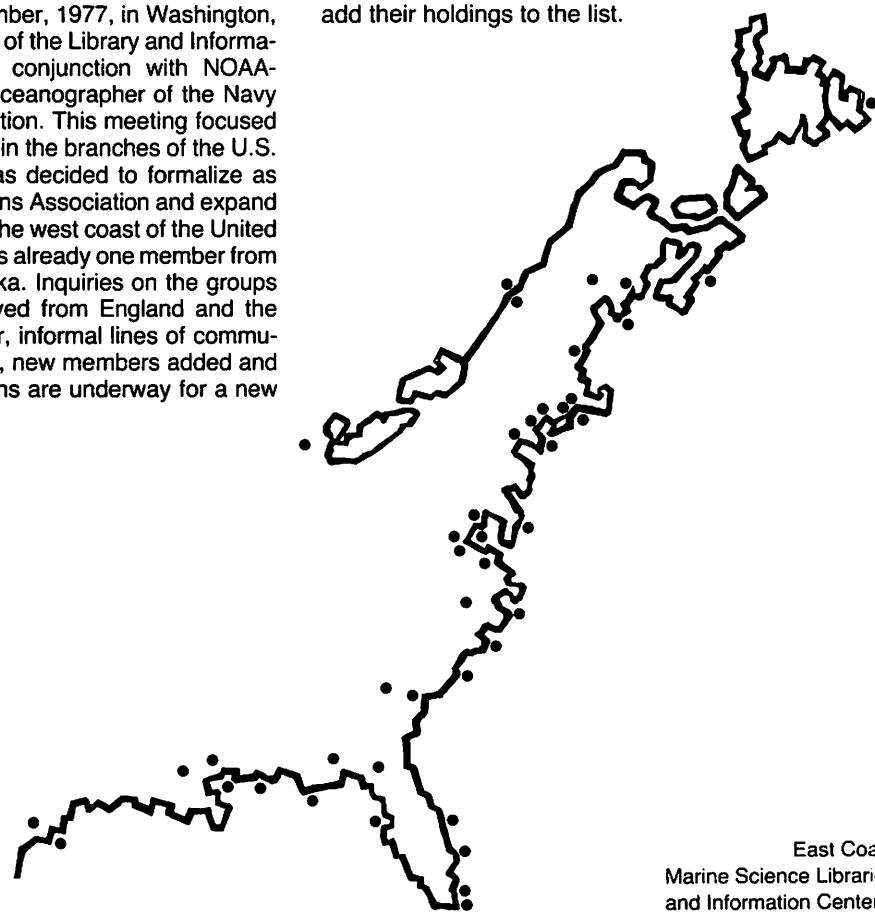
— Carolyn P. Winn

The objective of this project was to improve communication and cooperation among the marine science libraries and information centers located on the east coast of the United States and Canada and the Gulf Coast of the U.S. The specific goals were to hold a second workshop-meeting of marine science librarians, to identify problems, design new projects, to compile a directory of libraries and information centers which serve the scientific community involved in marine research, and to compile a union list of oceanographic atlases.

In September 1976, 72 librarians representing 46 institutions or government agencies met in Woods Hole, Massachusetts. A directory listing 74 libraries and information centers was distributed to the members. The meeting covered computer retrieval systems, acquisition of government publications, and the proposed regional coastal zone information centers. The third meeting was held in September, 1977, in Washington, D.C. under the sponsorship of the Library and Information Division of NOAA in conjunction with NOAA-NODC, the Office of the Oceanographer of the Navy and the Smithsonian Institution. This meeting focused on information sources within the branches of the U.S. Government. The group has decided to formalize as the Marine Science Librarians Association and expand the membership to include the west coast of the United States and Canada. There is already one member from Oregon and one from Alaska. Inquiries on the groups activities have been received from England and the Fiji Islands. During the year, informal lines of communication were strengthened, new members added and cooperation increased. Plans are underway for a new edition of the directory.

The most significant contribution the group has made is the establishment of cooperation among the academic libraries, state and federal government libraries and information centers, research institution and corporation libraries. This type of cooperation cutting across size and organization lines provides the basis for future networking activities which will give an individual scientist or policy maker access to marine information regardless of the location of that information.

Work on the Union List of Oceanographic Atlases is progressing and a rough draft of the list recording the holdings of 22 libraries will be forwarded to NOAA Library and Information Services Division in December, 1977. Bibliographic descriptions of 300 atlases have been standardized, with preference given to Library of Congress cataloging information. The rapidly increasing membership has delayed the publication of the list until the new libraries have the opportunity to add their holdings to the list.



East Coast
Marine Science Libraries
and Information Centers.

REPORTS AND PUBLICATIONS

Aquaculture

DeBoer, J. A., and J. H. Ryther, 1977, PRELIMINARY STUDIES ON A COMBINED SEAWEED MARICULTURE — TERTIARY WORK TREATMENT SYSTEM. World Mariculture Symposium, 9-12 Jan. 1977, San Jose, Costa Rica, 13 pages.

D'Elia, Christopher, P. A. Steudler, and N. Corwin, 1977. DETERMINATION OF TOTAL NITROGEN IN AQUEOUS SAMPLES USING PERSULFATE DIGESTION. *Limnology and Oceanography*, Vol. 22, No. 4, pp. 760-764.

Goldman, J. C., 1977. BIOMASS PRODUCTION IN MASS CULTURES OF MARINE PHYTOPLANKTON AT VARYING TEMPERATURES. *Journal of Experimental Marine Biology and Ecology*, 1977, Vol. 27, pp. 161-169.

Mann, R., 1977. A NOTE ON THE EFFECT OF TEMPERATURE AND ENRICHMENT ON SPECIES COMPETITION IN MASS CULTURES OF MARINE PHYTOPLANKTON. W.H.O.I. Tech. Rpt. 77-59. *

Mann, R., 1977, SOME BIOCHEMICAL AND PHYSIOLOGICAL ASPECTS OF GROWTH AND GAMETOGENESIS IN *Crassostrea gigas* (Thunberg) and *Ostrea edulis L.* GROWN AT SUSTAINED ELEVATED TEMPERATURES. W.H.O.I. Tech. Rpt. 77-59. *

Mann, R., 1977. GROWTH OF *Mytilus edulis L.* IN A WASTE RECYCLING AQUACULTURE SYSTEM. W.H.O.I. Tech. Rpt. 77-59. *

Mann, R. and R. E. Taylor, 1977. GROWTH OF THE BAY SCALLOP, *Argopecten Irradians*, IN A WASTE RECYCLING AQUACULTURE SYSTEM. W.H.O.I. Tech. Rpt. 77-59. *

Mann, R. and R. E. Taylor, 1977. LONG TERM STUDIES OF THE GROWTH OF THE JAPANESE OYSTER, EUROPEAN OYSTER AND MANILA CLAM IN A WASTE RECYCLING AQUACULTURE SYSTEM. W.H.O.I. Tech. Rpt. 77-59. *

Mann, R., 1977. THE EFFECT OF SUBSTRATE PARTICLE SIZE ON GROWTH OF THE MANILA CLAM, *Tapes Japonica*. W.H.O.I. Tech. Rpt. 77-59. *

Ryther, J. H., 1977. PRELIMINARY RESULTS WITH A PILOT-PLANT WASTE RECYCLING-MARINE AQUACULTURE SYSTEM. Chapter 4 in *Wastewater Renovation and Reuse*. F. M. d'Itri, Ed., Marcel Dekker, Inc., N.Y., p. 89-132.

Ryther, J. H., 1976. MARINE POLYCULTURE BASED ON NATURAL FOOD CHAINS AND RECYCLED WASTES. W.H.O.I. Tech. Rpt. 76-92: 18 pages.

* Printed collectively as a WHOI manuscript report in Marine Polyculture.

Living Resources

Chevion, M., J. J. Stegeman, J. Peisach and W. E. Blumberg, 1977. ELECTRON PARAMAGNETIC RESONANCE STUDIES ON HEPATIC MICROSOMAL CYTOCHROME P-450 FROM A MARINE TELEOST FISH. *Life Sciences* 20: 895-900.

Gagosian, R. B., 1977. THE CYCLING OF LABILE ORGANIC COMPOUNDS: STEROLS IN THE NORTH ATLANTIC OCEAN. *Oceanic Sound Scattering Prediction,* Ed. by Neil R. Andersen and Bernard J. Zahuranec, Plenum Press.

Sabo, D. J., Heineke and J. J. Stegeman, 1977. ENVIRONMENTAL STRESS AND BLOOD CHEMISTRY IN MARINE FISH. *Federation Proceedings* 36: (3): p. 1146.

Stegeman, J. J., 1977. SEX DIFFERENCES IN HEPATIC MICROSOMAL CYTOCHROME P-450 IN SPAWNING TROUT. *Federation Proceedings* 36: p. 941.

Stegeman, J. J. and D. J. Sabo, 1976. ASPECTS OF THE EFFECTS OF PETROLEUM HYDROCARBONS ON INTERMEDIARY METABOLISM AND XENOBIOTIC METABOLISM IN MARINE FISH. In *Sources, Effects and Sinks of Hydrocarbons in the Aquatic Environment*. American Institute of Biological Science, pp. 423-436.

Socio-Economic and Legal Studies

Friedman, J. M., 1976. SALT MARSHES AND THE CONSTITUTION: AN INTRODUCTION TO CONSTITUTIONAL ISSUES IN ENVIRONMENTAL PROTECTION. *The Cape Naturalist*, 5 (3): 44-49.

Graham, N.W., 1976. THE EXTENT TO WHICH MARINE TRANSPORTATION WITHIN THE ECONOMIC ZONE WILL BE AFFECTED BY ENFORCEMENT OF THE PROPOSED POLLUTION CONTROLS. W.H.O.I. Tech. Rpt. 76-95: 12 pages.

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REPORTS AND PUBLICATIONS continued.

Graham, N. W., 1976. FISHERIES LAW: UNILATERAL OR MULTILATERAL FORMULATION. W.H.O.I. Tech. Rpt. 76-113: 85 pages.

Peterson, S. B., 1976. REPORT OF THE WORKSHOP ON EXTENDED JURISDICTION, May 10-11, 1976. W.H.O.I. Tech. Rpt. 76-73: 53 pages.

Peterson, S. B. and James Friedman, 1977. THE MASSACHUSETTS LOBSTER FISHERY: MODEL LEGISLATION AND MANAGEMENT PLANS. W.H.O.I. Tech. Rpt. 77-5: 81 pages.

Sarr, M. L., 1976. MARINE TECHNOLOGY TRANSFER AS FOREIGN AID TO LESS DEVELOPED NATIONS FROM OCEANOGRAPHIC INSTITUTIONS IN INDUSTRIALIZED COUNTRIES: A SEARCH FOR AN EFFECTIVE MECHANISM IN THE EDUCATIONAL SECTOR. W.H.O.I. Tech. Rpt. 76-84: 52 pages.

Smith, L. J. & S. B. Peterson, 1977. THE NEW ENGLAND FISHING INDUSTRY: A BASIS FOR MANAGEMENT. W.H.O.I. Tech. Rpt. 77-57: 130 pages.

Wenk, E., Jr., 1976. ASSESSING IMPACTS OF NEW OCEAN LAW. W.H.O.I. Tech. Rpt. 76-104: 37 pages.

Winner, R., 1976. MAINE SCIENTIFIC RESEARCH AND THE LAW OF THE SEA CONFERENCE: SOME PROPOSED AMENDMENTS TO THE REVISED TEXT. W.H.O.I. Tech. Rpt. 76-80: 54 pages.

Marine Environmental Research

Connor, M. S. and R. W. Howarth, 1977. POTENTIAL EFFECTS OF OIL PRODUCTION ON GEORGES BANK COMMUNITIES. A REVIEW OF THE DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR OUTER CONTINENTAL SHELF OIL AND GAS LEASE SALE NO. 42. W.H.O.I. Tech. Rpt. 77-1: 44 pages.

Grassle, J. F. and W. Smith, 1976. A SIMILARITY MEASURE SENSITIVE TO THE CONTRIBUTION OF RARE SPECIES AND ITS USE IN INVESTIGATION OF VARIATION IN MARINE BENTHIC COMMUNITIES. *Oecologia* 25, 13-22.

Stewart, R. S. and J. O. Willums, 1975. OFFSHORE APPLICATIONS OF MODELING TECHNIQUES, II: MODELS OF OIL SPILL DRIFTING. *Northern Offshore* 4 (10): 43-48.

Stoffers, Peter, Colin P. Summerhayes, Ulrich Forstern, and Sambasiva R. Patchineelam, 1977. COPPER AND OTHER HEAVY METAL CONTAMINATION IN SEDIMENTS FROM NEW BEDFORD HARBOR, MASSACHUSETTS: A PRELIMINARY NOTE. *Environmental Science & Technology*, Vol. II, pp. 819-821.

Summerhayes, Colin P., Jeffrey P. Ellis, Peter Stoffers, Scott R. Briggs and Michael G. Fitzgerald, 1977. FINE-GRAINED SEDIMENT AND INDUSTRIAL WASTE DISTRIBUTION AND DISPERSAL IN NEW BEDFORD HARBOR AND WESTERN BUZZARDS BAY, MASSACHUSETTS. W.H.O.I. Tech. Rpt. 76-115: 112 pages.

MARINE EDUCATION

Winn C. P. and C. Hurter, 1976. DIRECTORY OF MARINE SCIENCE LIBRARIES ON THE EAST COAST OF THE UNITED STATES AND CANADA. Woods Hole Oceanographic Institution: Woods Hole, Mass., 40 pages.

PROGRAM

Bumpus, D. F., 1976. MARINE RESOURCES DEVELOPMENT AND MANAGEMENT: A REPORT OF THE WOODS HOLE OCEANOGRAPHIC INSTITUTION SEA GRANT PROGRAM FOR JULY 1975 - JUNE 1976. W.H.O.I. Tech. Rpt. 76-111: 44 pages.

PROGRAM SUMMARY

Program Area	Project Support '71-'72	'72-'73	Coherent Program '73-'74	'74-'75	'75-'76	'76-'77
Marine Resources Development						
Aquaculture						
Bivalve mollusc culture in a waste recylcing aquaculture system — Ryther (new title)		N	C	C	C	T
Finfish Research at Matamek, Quebec - Gibson			N	*	*	*
Culture of Midges - McLarney			N	F		
The Genetic Component of Variable Growth and Survival in Seed Quahogs - Grassle					N	C
Living Resources						
Populations and Migrations of Certain Large Pelagic Fish - Mather	N	C	*	*	*	*
Behavior of Lobsters in a Semi-Natural Environment at Ambient Temperatures and under Thermal Stress - Atema		N	C	T		
The Sources of Important Biochemicals in Marine Crustacean - Gagosian		N	C	F		
Effects of Petroleum Hydrocarbons In Marine Fishes - Stegeman, Sabo				N	C	F
Population Density and Distribution of *Limulus polyphemas* in Cape Cod Waters - Smith					NF	
Initial Investigations of Red Tide Problems on Cape Cod - Wall					NT	
Socio-Economic and Legal Studies						
Marine Economics						
Limited Effort Programs in the New England Fishery - Smith, Peterson				N	C	F
Ocean Law - Coastal						
Regulation of Harbors and Ponds of Martha's Vineyard - Friedman					NF	
Draft Legislation for the Massachusetts Lobster Fishery - Peterson, Friedman					N	F
Socio-Political Studies						
Marine Policy and Ocean Management - Frosch/Morse		N	C	C	C	C
Marine Technology Transfer as Foreign Aid to Less Developed Countries - Sarr					N	F

Continued on next page

PROGRAM SUMMARY continued.

Program Area	Project Support '71-'72	'72-'73	'73-'74	Coherent Program '74-'75	'75-'76	'76-'77
Marine Technology Research and Development						
Ocean Engineering						
High Resolution Sub-bottom Profiling - Vine				N	T	
An Acoustic Probe for Ocean Bottom Surveys - Dow				NF		
Solar Energy Conversion - von Arx				NT		
Handbook of Oceanographic Engineering Materials - Dexter					N	F
An Optical Trap for the Use of Diffuse Solar Radiation in Hyper-thermal Aquaculture - von Arx						N
Dynamics of the inclining spar current sensor - Mavor						NT
Studies for the Development of An Improved Zooplankton Sampling Pump System - Haury						N
Marine Environmental Research						
Research and Studies in Direct Support of Coastal Management Designs						
The Design of Environmental Surveys over Time - Smith					N	
Grain-Size in Laminae of Beach Sand - Emery						N
Effects of No. 2 Fuel Oil on a Salt Marsh: A Quantitative Three Year Study of Recruitment and Growth - Hampson						N
The Interactions Between Chemical Species and Phyto-plankton Growth in Natural Water Systems - Goldman/Brewer						N
A Study of the Physical Characteristics of Bourne's Pond, Falmouth - Summerhayes/ Ellis						NF
Ecosystems Research						
Interactions of Fluviatile Salmonid Species - Gibson					N	C
Distribution of Potential Food Resources for Shellfish in Bourne's Pond - Brand					N	F
Pollution Studies						
Sediment Dispersal in New Bedford Harbor and Western Buzzards Bay - Summerhayes					N	F

PROGRAM SUMMARY continued.

Program Area	Project Support '71-'72	'72-'73	'73-'74	Coherent Program '74-'75	'75-'76	'76-'77
Environmental Models						
Stability of a Small Coastal Inlet - Moody					N	F
Marine Education and Training						
Course Development						
Ocean Engineering - Mavor	N	C	F			
Coastal Zone Management - Black					N	F
Other Education						
Marine Science Libraries Cooperative Network - Winn						NF
Program Management and Development						
Program Management and Development - Bumpus/Ross			N	C	C	C

During FY '77 the Woods Hole Oceanographic Institution Sea Grant Program consisted of:

16 Research Projects (plus four new initiatives at the end of the year)
1 Education Project
1 Program Management

Personnel associated with the Sea Grant Program were:

Scientific Staff	20	Post-Doctoral Investigators	10
Technical Staff	7	Graduate Students	4
Departmental Assistants	23	Undergraduate Students	2

N - New Project; **C** - Continued Project; **F** - Completed Project; **T** - Terminated Project; * - Continued with funds from sources other than Sea Grant.

BUDGET SUMMARY
1976-1977

	Sea Grant	Matching	Total
Bivalve mollusc culture in a waste recycling aquaculture system	87,900	50,000	137,900
The genetic component of variable growth and survival in seed quahogs	38,000	7,225	45,225
Effects of mixed petroleum hydrocarbons in marine fishes	71,500	1,380	72,880
Marine Policy and Ocean Management	10,000	303,400	313,400
An optical trap for the use of diffuse solar radiation in hyperthermal aquaculture	15,400	53,644	69,044
Dynamics of the inclining spar current sensor	35,000	56,139	91,139
Interactions of fluviatile salmnoid species	10,400	13,476	23,876
Sediment dispersal in New Bedford Harbor and western Buzzards Bay	51,500	6,072	57,572
Stability of a small coastal inlet	5,600	3,250	8,850
Program Management and Development	94,700	17,250	111,950
TOTAL	**420,000**	**511,836**	**931,836**

SOURCES OF MATCHING FUNDS

Scaife Foundation
Pew Foundation
Jessie Hayes Foundation
Town of Falmouth
Woods Hole Oceanographic Institution

POSTSCRIPT

The preceding pages have described our program during the 1976-77 period. To better understand the direction of our present efforts, we have included a brief description of our 1977-1978 projects.

Our aquaculture project is now under the direction of Roger Mann. Its primary goal is to ascertain if oysters fed algae that have been grown in seawater enriched with secondary sewage effluent will concentrate human enteric viruses, heavy metals or organic trace contaminants. If so, are these concentrations such to make them unsuitable for human food and would simple additional treatment of the sewage effluent prevent such concentrations. Likewise, could the oysters be depurated by keeping them in clean seawater for a period of time and feeding them algae not grown in a sewage effluent.

Judith M. Capuzzo has started a new project on the effects of diet on the growth energetics of post larval lobsters (*Homarus americanus*). The ratio of protein to carbonate in a shrimp meal diet will be determined to assess the relative importance of proteins and carbohydrates as energy sources in addition to assimilation and growth efficiencies. Such information will be of value to assess metabolic utilization and energy partitioning of artificial diets by post larval lobsters. The results, of course, will be applicable to lobster aquaculture projects both in our own lab as well as those of other institutions.

Judith P. Grassle of the Marine Biological Laboratory is continuing her project on the genetic component of growth and survival in raft cultured and natural populations of quahogs (*Mercenaria mercenaria*). She will repeat her raft culture experiment using seed stocks produced from local quahogs and will perform a selection-response experiment using groups of local quahogs, fast-growers and slow-growers in a mass selection experiment.

Richard L. Haedrich will be starting a new project concerning the population of eels in Cape Cod waters. He will determine the abundance, biomass, population structure, growth rate and movements of the American eel (*Anguilla rostrata*) within a typical drainage system on Cape Cod. This will include bays, salt ponds, marshes, freshwater creeks or ponds. He will also estimate the annual elver recruitment to and throughout the drainage system and attempt to predict, through comparison of catch as a function of habitat, the extent to which the eel population is being exploited. Observations will be based on field collections and abundant data from the Massachusetts Department of Natural Resources.

John J. Stegeman and Richard Wolke from the University of Rhode Island are initiating a new effort by looking at the histopathology of marine fishes that have been exposed to organic contaminants. They plan to use anatomic pathological methods of light and electron microscopy to assess the health of fish stocks environmentally and experimentally contaminated by organic pollutants and provide data relative to specific lesions and/or disease prevalence in fish from contaminated populations. These studies should provide valuable information concerning overall health of fish which can then be correlated with information concerning physiological effects of low level organic pollutants.

Our marine policy and ocean management program, now under the direction of Dean Robert Morse, will continue its past efforts in sponsoring interdisciplinary studies for social scientists and other professionals who are working on problems related to man's increasing use of the sea.

William von Arx is continuing his project of using an optical trap to catch diffuse solar radiation. The energy is caught through a combination of absorption on a blackened pond floor and total reflection at the free surface and artificially enhanced pyxnocline. He is also exploring the possibility of using new techniques to store heat within ground water.

Woollcott Smith has a new project on environmental survey design that has two principal objectives. The first is to provide effective statistical consulting to the other projects in our Sea Grant Program and second to use time series methods to investigate the design of environmental surveys. In this project, he will develop quantitative guidelines for design of surveys to estimate the effect of a planned environmental intervention and will illustrate the general methods with a set of examples from coastal environmental surveys.

The source and fate of estuarine sediments in Boston Harbor is a new project under the direction of John D. Millman. Among its major objectives are ascertaining the distribution, composition and transport of sediments within Boston Harbor both from natural and anthropogenic sources and defining sediment matter regime within the harbor with emphasis on temporal and spatial variations. More long range goals include establishing the late Holocene history of the harbor and investigating the extent of incorporation and migration of heavy metals and organic material within Boston Harbor sediments.

John Gibson is continuing his study of interactions of fluviatile salmonid species. He is comparing the habitat preferences and agnostic behavior of exotic salmonids with indigenous species. He is doing this work in an experiment tank in which water velocity, depth and temperature can be adjusted.

John M. Teal and his colleagues from Boston University have started a new project on stimulated marine bioproduction. A principal objective is to evaluate the increased production of fish and shellfish that may result

from greater plant production caused by the addition of fertilizers within a tidal saltwater marsh. After one year of preliminary measurements of plant and animal production in certain marshes, they will stimulate production with commercially available fertilizers. Before and after measurements of nutrient budgets will also be made so that they can calculate ecological as well as economic efficiency of the treatment. Ultimately, they hope to use sewage effluent as a source of plant nutrients.

During the year we have started four projects with new initiative funding. One by K.O. Emery is to determine the grain-size distribution in coarse-grained versus fine-grained laminae of beach sands and see if both differ from the grain-size distributions of normal "handful" samples that are commonly obtained for typical studies of beach processes. Another new project under the direction of Loren R. Haury, is for the development of an improved zooplankton sampling pump system. Such a device will be useful for the salt marsh work described above. The third project under the direction of George R. Hampson is to study the effects of #2 fuel oil on a salt marsh. In particular, he will evaluate a quantitative three year study of recruitment and growth of different plants within a polluted salt marsh and compare it to an unpolluted area. Finally, a project has been started, which will continue into the next year, by Joel Goldman and Peter Brewer to study the interactions between chemical species and phytoplankton growth in natural water systems.

In June of 1977 David A. Ross took over the job of Sea Grant Coordinator from the retiring Dean Bumpus and Mrs. Ellen Gately joined the Sea Grant Program as Staff Assistant in September of the same year.

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