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Institution



MARINE RESOURCES DEVELOPMENT AND MANAGEMENT
A REPORT ON THE WOODS HOLE
OCEANOGRAPHIC INSTITUTION SEA GRANT PROGRAM
JULY 1975 - JUNE 1976

By

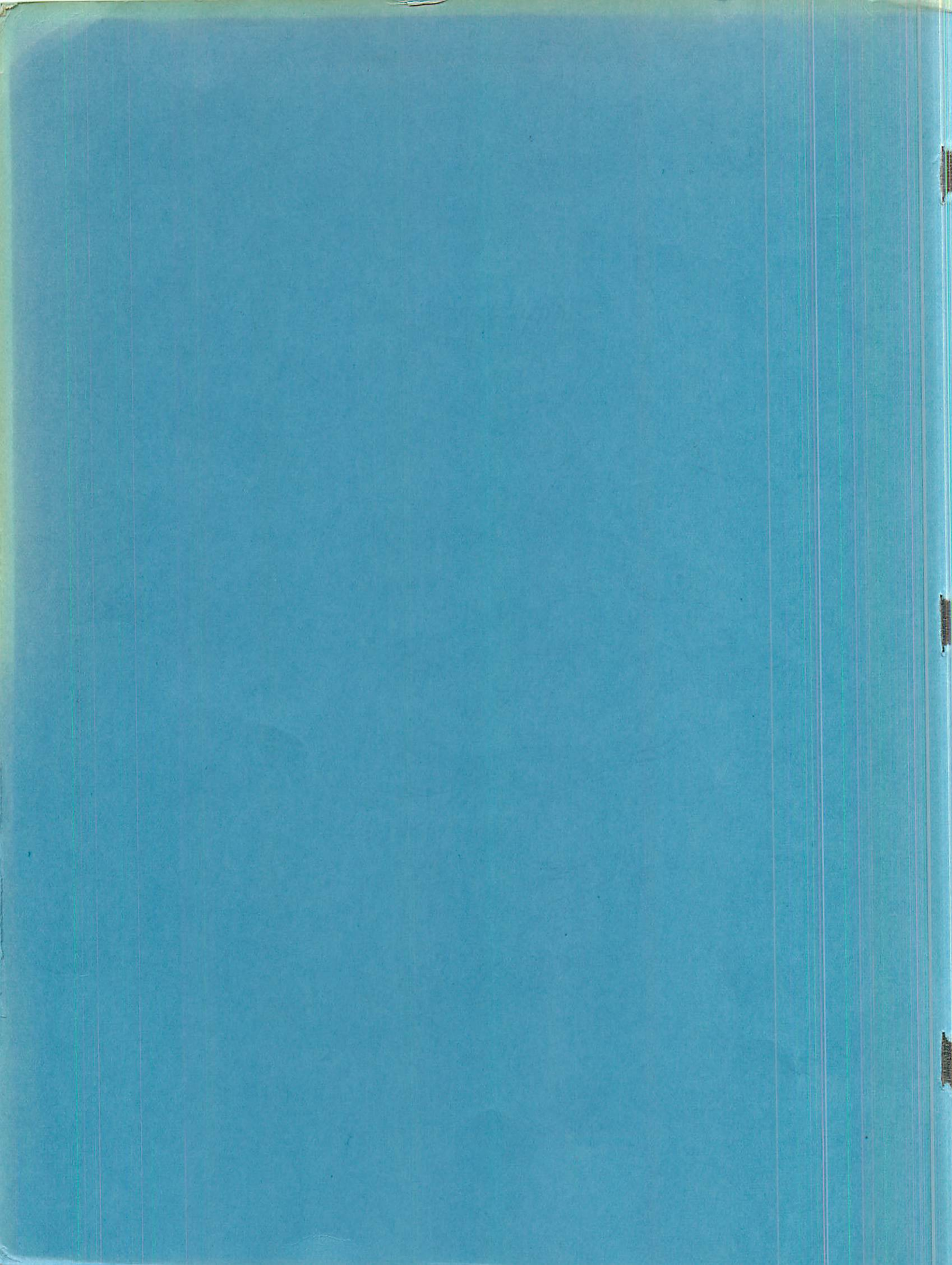
Dean F. Bumpus

December 1976

TECHNICAL REPORT

*Prepared for the Office of Sea Grant under
Grant 04-6-158-44016.*

WOODS HOLE, MASSACHUSETTS 02543



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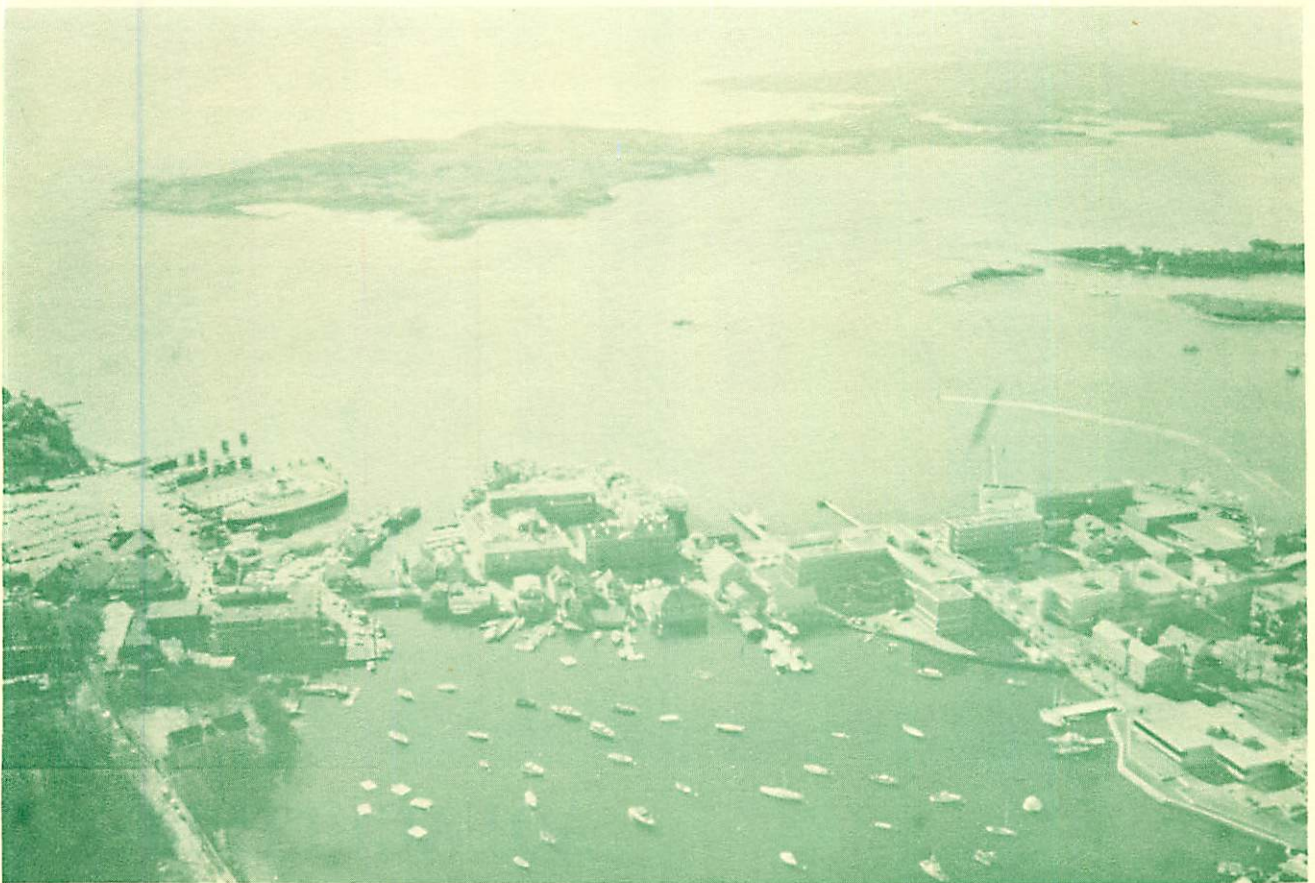
Ferris Webster
Associate Director for Research

MARINE RESOURCES DEVELOPMENT AND MANAGEMENT

1975-1976 ANNUAL SEA GRANT REPORT

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Introduction

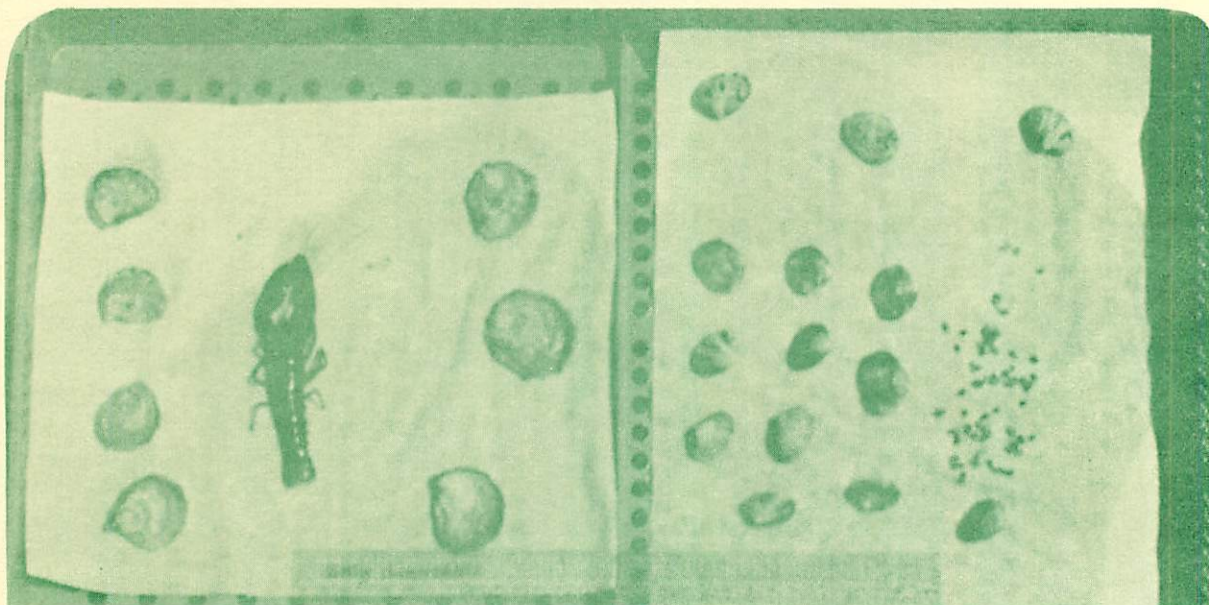
The Woods Hole Oceanographic Institution through its five departments, Biology, Chemistry, Geology and Geophysics, Physical Oceanography, and Ocean Engineering, and its Marine Policy and Ocean Management Program, is conducting research in all phases of Marine Science, Ocean Engineering, and Marine Policy and Management. Our Sea Grant Program budget represents about 3.5% of the Institution's total budget. This program has broadened somewhat during the past year to include research in Aquaculture, Living Resources, Marine Economics, Ocean Law-Coastal, Socio-Political Studies, Ocean Engineering, and Marine Environmental Research and the development of one course in Coastal Zone Management at the Massachusetts Maritime Academy.

The thrust of our program is aimed at Marine Resources Development and Management on a broad scale, but some of our researches have begun to focus on local problems in cooperation with the Falmouth Shellfish Warden and Waterways Committee and the Martha's Vineyard Commission. We are encouraging members of our Staff to be responsive to the needs of individuals or groups in the Coastal Zone and elsewhere who exhibit practical problems which we can help solve. We look forward to further developing relationships in this area.

December 1976

Dean F. Bumpus

Dean F. Bumpus
Sea Grant Coordinator
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AQUACULTURE

MARINE POLYCULTURE BASED
UPON NATURAL FOOD CHAINS
AND RECYCLED WASTES

- John H. Ryther

Research has continued on the development, testing, and evaluation of a combined waste recycling-marine polyculture system, with emphasis on phytoplankton, bivalve-mollusc, and seaweed culture. Healthy cultures of phytoplankton have been maintained in the ponds for sustained periods of time, at high densities and yields and with good nutrient removal performance. However, it has not been possible to control the species of phytoplankton that appeared, became dominant, and persisted in the cultures. Both the mass culture and laboratory studies have shown that temperature is the single most important controlling factor that determines species in the mass cultures. However, that control is limited to a seasonal selection of one of a very small

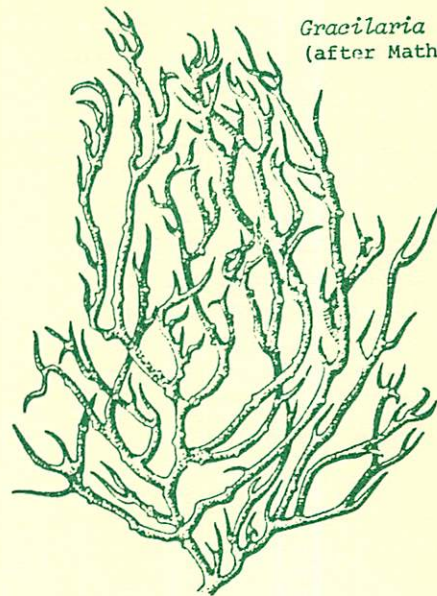
number of "weed" species that apparently are able to develop, dominate, and persist in the highly eutrophic mass culture environment. Of these, the small pennate diatom *Phaeodactylum tri-cornutum* is the most common and persistent, dominating completely the mass cultures during most of the year. In mid-winter when temperatures range from 0° to about 8° C, *Phaeodactylum* may be replaced by *Skeletonema costatum*, one of the more desirable centric diatoms. In mid-summer, when pond temperatures exceed about 25° C, *Phaeodactylum* is succeeded first by other pennate diatoms such as *Nitzschia closterium* or *Amphora* sp. and, at still higher temperatures, by green flagellates or green coccoid algae such as *Nannochloris* sp. or *Stichococcus* sp.

The yields of phytoplankton and the concurrent nutrient removal capacities of the mass algal cultures that have been achieved during the past year agree substantially with those projected from results of the first year's observations (i.e., mean ash-free dry weight yields ranging from about 3 g/m²/day in winter to 9 g/m²/day in summer). The earlier conclusion was also confirmed that yields are temperature independent and controlled primarily by solar radiation.

More and better information was obtained during the past year concerning the measured mass flow and balance of nitrogen through the phytoplankton pond system. Development of a new technique for measuring dissolved organic nitrogen in seawater has permitted our filling that gap in the mass balance determination. It was found that no significant net production of dissolved organic nitrogen occurs in the algal ponds.

For the first time, measurements were made of the rate of settling of phytoplankton from the algal ponds. Despite very weak circulation of the cultures, a very small fraction (less than 5%) of the algal production is apparently lost to the system by sedimentation.

During the first year of operation the shellfish raceways were stocked with seed American oysters (*Crassostrea virginica*) and hard clams (*Mercenaria mercenaria*). These animals failed to grow significantly during the following 18 months. Since



Gracilaria
(after Mathieson, 1975)

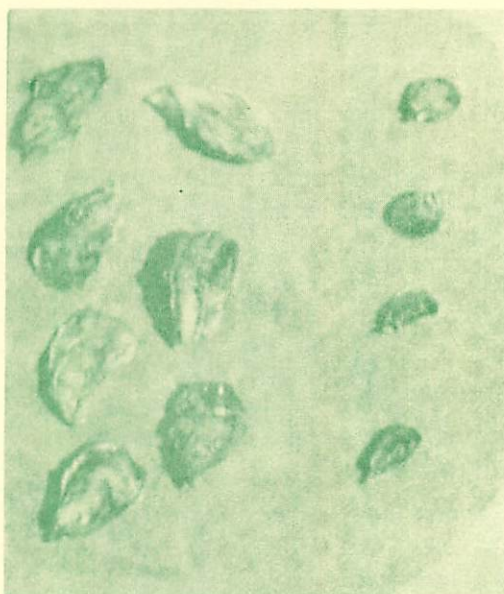
Phaeodactylum and various green algae were already known to be poor to indifferent foods for larval and very young juvenile clams and oysters, this appeared to be the explanation for the poor growth.

At the same time, however, small numbers of juvenile Manila clams (*Venerupis semi-decussata*) and European oysters (*Ostrea edulis*) were obtained. Both species survived and grew well on the same food that failed to support *C. virginica* and *M. mercenaria*.

During the past year, larger lots of *O. edulis* and stocks of Japanese oysters (*Crassostrea gigas*) were introduced. The results with *O. edulis* were somewhat equivocal, some growing well and others dying, but the reason is believed to be damage or injury of some of the seed during shipment (i.e., from as far as the United Kingdom). The *C. gigas* stocks have all grown well.

Thus the earlier problem of the inability to produce algal species suitable as food for the indigenous species of oysters and clams, if not solved, appears to have been circumvented by use of exotic shellfish species capable of utilizing the kinds of algae that can now be mass produced. Preliminary results also indicate that the local bay scallop (*Argopecten irradians*) may be included among the latter group.

Initially, the seaweed species used as the final "polishing" step of our multi-stage polyculture system was *Chondrus crispus* (Irish moss). We found, however, that *Chondrus* at best grew slowly in our system, became heavily epiphytized with other species of undesirable algae, and could not tolerate the high (>20° C) local summer temperatures. *Chondrus* was therefore replaced with two species that occur in the Woods Hole region as summer annuals, *Neogardhiella baileyi*, a cartilage producer like *Chondrus*, and *Gracilaria foliifera*, an agar-containing plant.



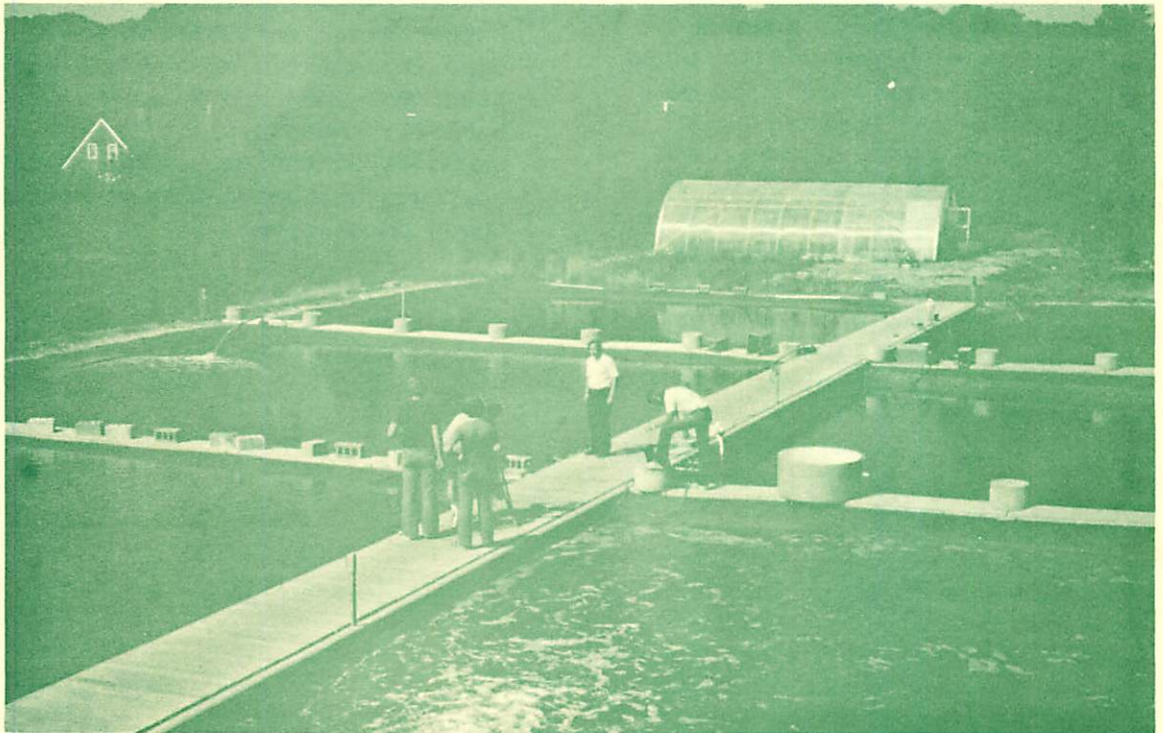
Both have proved highly successful except for the winter months (December-March) when growth ceased entirely presumably due to a combination of low temperature and solar radiation. Despite that, annual dry weight yields averaged 15 g/m²/day for *Neogardhiella* and 9 g/m²/d for *Gracilaria*. Experiments have also now been undertaken to investigate the use of these seaweeds in a one-step nutrient removal-aquaculture system in which the plants are grown directly on mixtures of sewage effluent and seawater.



Chondrus
(after Ihsan Al-Shehbaz)

Some very preliminary studies have also been carried out on the production of carrageenan by *Neogardhiella baileyi* and the relationship between the content of hydrocolloid, residual nitrogen content of the culture medium, nitrogen:carbon ratio of the plant tissue, and the red pigment (phycoerythrin) content of the alga. By studying these relationships, it is hoped that the carrageenan content and hence the commercial value of seaweeds can be quickly and easily assessed by visual inspection or by simple chemical tests. The carrageenan content

of *N. baileyi* was highest (about 36% of ash-free dry weight) in plants grown at very low concentration of nitrogen. However, the plants grew much faster at higher nutrient concentrations so that, although their specific weight content of the hydrocolloid was significantly lower, its rate of production per unit area was higher.



THE GENETIC COMPONENT OF
VARIABLE GROWTH AND SUR-
VIVAL IN SEED QUAHOGS

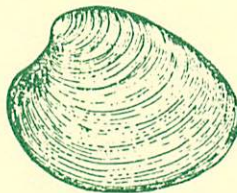
- Judith P. Grassle

The object of this research (which was initiated in January 1976) is to use variant enzyme proteins at a number of single gene loci as markers in hatchery seed clams, and natural populations of *Mercenaria mercenaria*.

Four enzyme systems have been found which represent seven distinct polymorphic genetic loci (PHI, LAP1 and LAP2, TO, PGM1, PGM2, and PGM3) which have been surveyed using electrophoretic techniques in hatchery stocks and local field populations.

A total of 2000 individual seed clams from three separate hatchery stocks have been individually numbered and measured and placed in raft culture in Quahog Pond and Bourne Pond. These clams are being measured once a month to chart their individual growth. At the end of the growing season in October samples from each stock will be electrophoresed, and a comparison will then be made of the frequencies of the electrophoretic variants in each stock of a) the initial population versus survivors, and b) fast growers versus slow growers.

Seed clams from one hatchery stock have been planted in mesh-covered frames on the bottom of Quahog Pond and in Bourne Pond in areas close to the stations where the phytoplankton populations are being monitored (see page 23).



Mercenaria

(after Keen, 1963)

Natural populations of *M. mercenaria* have been sampled in Eel Pond, Falmouth Harbor, and Wild Harbor River. All three populations are relatively unexploited due to recent single pollution events (an oil spill in Wild Harbor River in 1969) or to chronic domestic sewage pollution (Eel Pond and Falmouth Harbor). Age-specific frequencies of the electrophoretic variants are being determined in these populations.

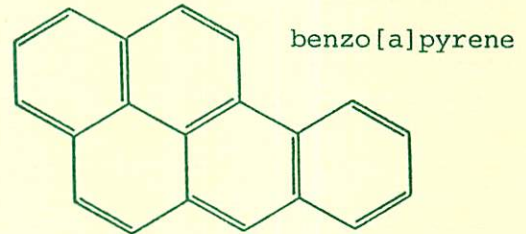
LIVING RESOURCES

EFFECTS OF PETROLEUM HYDROCARBONS IN MARINE FISHES

- John J. Stegeman and Dennis Sabo

The real nature and extent of the biological and ecological consequences which may result from input of petroleum into marine waters remain largely unknown, particularly the effects resulting from chronic low level contamination. The lack of understanding of these problems is in large part related to the extreme diversity, complexity, and variability of living systems, of their environments, and of crude or refined oils which may contaminate these environments. A study of the biological effects of petroleum in fish may thus be doubly fruitful, providing not only useful information concerning the nature of and mechanisms by which effects are exerted, but also basic information about the physiology of fishes, a major protein source.

In this project the effects of low levels of petroleum contamination on various biochemical and metabolic parameters in fish have been the subject of continued investigation, with the objective of developing and evaluating methods for detecting such effects, and evaluating the significance of potential effects in regions receiving a given input of hydrocarbons. The investigations have centered principally on various aspects of intermediary metabolism and the metabolism of foreign compounds (xenobiotics) in the



marsh minnow *Fundulus heteroclitus* and the commercial species *Stenotomus versicolor* (scup).

Patterns or pathways of carbohydrate metabolism exhibit little or no change in response to environmental or experimental contamination of either species at less than 0.2 ppm of No. 2 fuel oil. There were, however, decided changes in lipid metabolism in contaminated fish, generally appearing as a decrease in the net rate of lipid synthesis in liver, but also, under certain conditions, in gill, muscle and brain tissue. In liver this change was further related to changes in patterns of net synthesis of triglycerides, the energy storage form of lipid, and of phospholipid and cholesterol, major components of cell membranes. In addition changes in the cell structure of liver cells have been observed with both the light and the electron microscopes. Certain of these structural changes confirm the observed alterations in lipid metabolism, particularly the pattern of triglyceride synthesis.

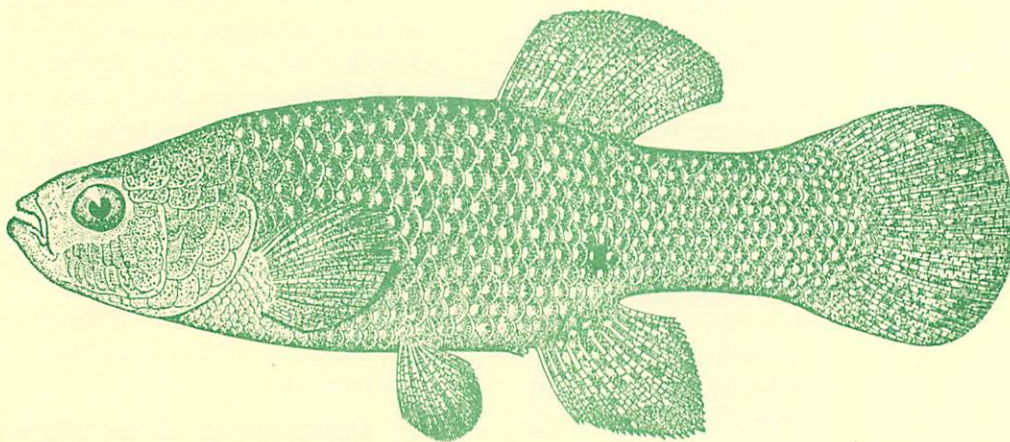
Analysis of blood chemistry of these fish is providing confirmation and extending the

observation of effects on metabolism in fish. In addition to assessing the feasibility of using hematological analysis of fish as a diagnostic for assessing environmental insult by petroleum, this aspect of the investigation should be useful in gauging the action of petroleum on certain hormone systems, effects which are indicated by the results in lipid metabolism.

An investigation of the sources and extent of normal individual variation of these metabolic parameters in a population of fish is necessary to realistically interpret the significance of changes apparently caused by petroleum. To date we have found that petroleum effects on lipid metabolism are in some respects similar to the results of dietary restriction, and are often within the range of values found in members of a given population. These studies, deemed essential to our program, are continuing.

Substantial progress has been achieved in the characterization of hepatic microsomal mixed-function oxidase system which metabolizes drugs, hydrocarbons and other xenobiotics, in marine fish. This enzyme system has several components with the hemoprotein termed cytochrome P-450 as the principal catalyst acting in the metabolism or "biotransformation" of hydrocarbon compounds. The activity of this system in several fish species has been determined using a variety of substrates, including the carcinogenic aromatic hydrocarbon benzo(a)pyrene. In addition to the catalytic properties, the optical and magnetic properties of the system in fish have been characterized as well.

Treatment of *Stenotomus* with the polynuclear aromatic hydrocarbon 3-methylcholanthrene results in a substantial increase in the catalytic activity benzo(a)pyrene hydroxylase, but



Common mummichog (*Fundulus heteroclitus*), Maryland. From Jordan and Evermann.

there are no accompanying changes in the levels of cytochrome P-450, nor changes in its optical or magnetic properties. This is distinct from the results of treatment of mammals with the same compound, and may provide a fruitful area of research concerning the mechanisms of xenobiotic metabolism.

It has been thought that an induction of benzo(a)pyrene hydroxylase by low levels of petroleum, similar to that effect caused by 3-methylcholanthrene, might be used as an indicator of biological effect. Examination of *Fundulus* from several marshes, including some with known sources of contamination, has demonstrated differences in levels of mixed-function oxidase activity in fish from the different areas. Many of the observed differences, though not all, however, were found to be related to an effect of size on this enzyme activity. Clearly a detailed study is required before the utility of this assay as an indicator of biological effect can be properly determined.

It is expected that results of the studies outlined above, and others in progress, will provide the understanding necessary to determining the nature and seriousness of low level effects of petroleum and to developing an index and perhaps an indicator of such effects in fish, to be used in a predictive capacity. In addition, results of these studies are important as they are providing detailed information on medical and pharmacological aspects of fishes, knowledge essential to developing successful finfish aquaculture programs.

POPULATION, DENSITY AND DISTRIBUTION OF *Limulus polyphemus* IN CAPE COD WATERS

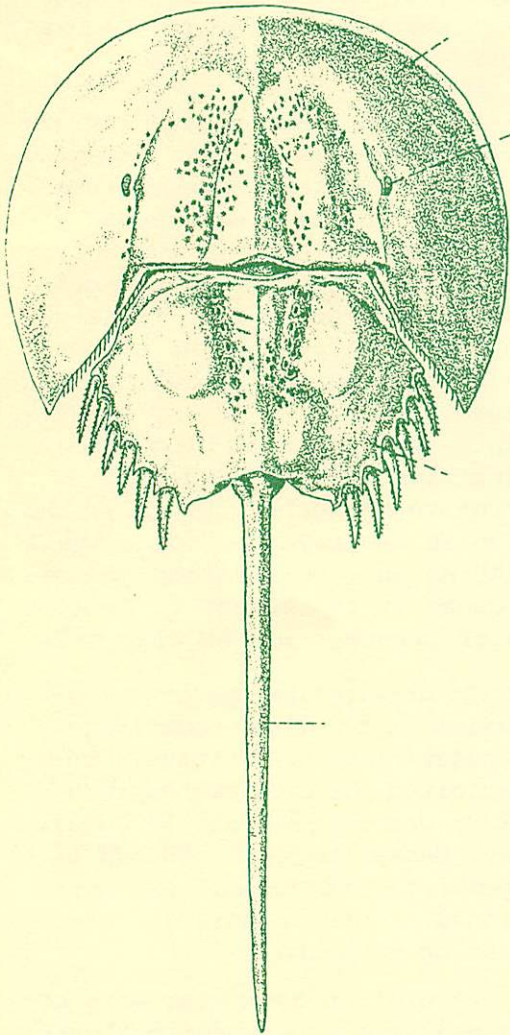
- Woollcott K. Smith

As the number of uses of a coastal resource increase, the biological and economic issues become more complex. An interesting example of this problem may soon present itself to federal and local fisheries regulators. The horseshoe crab (*Limulus polyphemus*) whose life history, population dynamics and migration patterns have received little attention, is now fished by three conflicting groups. The horseshoe crab is the only effective bait for the increasing eel and conch trap fishery on the east coast. The scientific and medical community is rapidly expanding use of *Limulus*, since an extract of blood is a sensitive indicator of Gram-negative bacteria. Finally, the crab is destroyed by local shellfishing and conservation groups because it is thought to be a major predator in the clam beds.

To obtain some basic information on the horseshoe crab population in a relatively unexploited area, a tag capture study was carried out in Cotuit Bay, Massachusetts. In addition, commercial fishermen were questioned to obtain data on total fishing pressure.

Population estimates were obtained from a capture-recapture tagging study in June during the spawning sequence. The tagging study indicates that spawning population in Cotuit Bay was about 7,000. Of 640 individuals

tagged, 32 animals were recovered. While a remnant population inhabits Cotuit Bay during July and August, the majority of *Limulus* migrated seaward. These crabs are quite mobile during the weeks preceding the mating and spawning period, and may travel as far as 5 kilometers.



Limulus polyphemus
(after Van der Hoeven from Page)

In a second segment of this study, local fishermen were surveyed to determine the overall fishing pressure in Massachusetts and Rhode Island, particularly in Cape Cod and Narragansett Bay. The relative population densities were also estimated from their catch and fishing effort information. The survey of commercial trawlers indicates a substantial *Limulus* population at the present time. This population appears to be unaffected by fishing pressure from conch and eel fishermen. However, increasing interest in *Limulus* lysate by private research and pharmaceutical companies may change this situation. For example, between thirty and fifty thousand animals a year have been taken from Pleasant Bay on Cape Cod by eel and conch fishermen and by collectors for lysate research. As a result, the female *Limulus* population has diminished significantly, according to collectors in the area. If the demand for *Limulus* lysate increases, prices for the animal will rise. Increased bait cost may then make the conch and eel trap fisheries unprofitable. If alternate baits cannot be found, these fisheries may be abandoned.

MARINE ECONOMICS

LIMITED EFFORT PROGRAMS FOR THE NEW ENGLAND FISHERIES

- Leah Smith and Susan Peterson

The New England fishery will be operating under new management conditions when 200-mile extended economic jurisdiction becomes effective March 1, 1977. Although some foreign fishing will continue within 200 miles of the U.S. coast the domestic fleet will have improved prospects for expanding their share of the catch in the future.

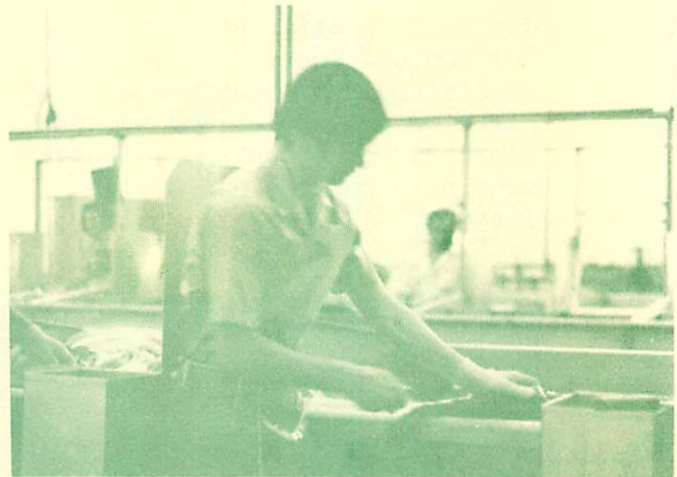
Existing regulations for the fishery off New England will probably continue to be enforced, with more stringent enforcement for the foreign fleets than has been possible in the past. Major responsibility for managing the fisheries will now rest with the regional councils, which will be established in the fall of 1976.

To prepare background material for proposing new management programs for the New England fishery, we have gathered information from interviews with fishermen and processors and from published and unpublished NMFS, ICNAF, and other sources on the biology and economics of the fishery.

The ports included in the study are: Boston, Chatham, Gloucester, New Bedford, Menemsha, Provincetown, Massachusetts; Newport and Port Judith, Rhode Island; Rye, New Hampshire; Stonington, Connecticut, and Rockland and Portland, Maine. Each is described in terms of its offshore fishing fleet and fishermen. Fish processing is also discussed for each

port, since processing and marketing have such strong influence on the primary fishing industry.

Limited effort programs used in other fisheries as a management technique have been described.



Limited effort programs are among the most frequently suggested management techniques for dealing with the extended fisheries jurisdiction, so they bear examination for possible application in New England.

We have prepared papers during this year describing the fish processing industry in New Bedford and analyzing the relationships among fishing boat income, capital and labor in New Bedford. In May a workshop was held to discuss fisheries management under extended jurisdiction; fishermen, government representative economists and anthropologists with fisheries research attended. A final report is in preparation which will include description of the fishing and processing industries in major and some minor New England ports, a discussion of limited entry programs in other parts of the world, and suggestions for constructing a management plan for the New England fishery.



OCEAN LAW-COASTAL

REGULATION OF HARBORS AND PONDS OF MARTHA'S VINEYARD

- James Friedman

In response to a request from the Martha's Vineyard Commission for assistance in Problem Identification and Management Prospects for the Harbors and Great Ponds of Martha's Vineyard, members of the Institution's Marine Policy and Ocean Management Program provided a legal analysis of the powers of the Commission and the towns of Martha's Vineyard with regard to the regulation of harbors and great ponds. This resulted in four reports:

- Some Questions and Answers about the Law of Harbors and Great Ponds
- Public Access to Great Ponds and the Seashore
- Regulation of Shellfishing
- Permits for Structures and Alterations in Tidal Waters

in language and format which ordinary citizens can understand and frequent consultations with the Martha's Vineyard Commission.



DRAFT LEGISLATION FOR THE MASSACHUSETTS LOBSTER FISHERY

- Susan Peterson and James Friedman

The objectives of this project, which commenced in May 1976, are:

- to provide information on types of limited entry programs which have been used elsewhere in order to provide background for the development of limited effort legislation for the Massachusetts lobster fishery,
- to assist the Massachusetts Division of Marine Fisheries and the Massachusetts Lobstermen's Association in drafting legislation to conserve the Massachusetts lobster fishery.

Working with the above organizations we are in the process of interviewing all commercial lobster license holders. The purpose of the interviews is to elicit opinions of commercial lobstermen on trap limitation, the cost of licenses, number of licenses, quotas, etc. This information will be used to ensure that the prepared management scheme for the lobster fishery will not be an abstract, academic endeavor.

The drafting of a state lobster fishery law presents several constitutional issues in addition to the more common problems which attend the drafting of any legislation. Limited effort legislation for the

Massachusetts fishery will raise questions concerning interstate commerce, equal protection, and the privilege of immunities of U. S. citizens. Each of these constitutional issues will be studied so that the legislation

can be properly drafted.

We anticipate this study will be completed in time for the introduction of draft legislation for the General Court of Massachusetts in the Autumn of 1976.



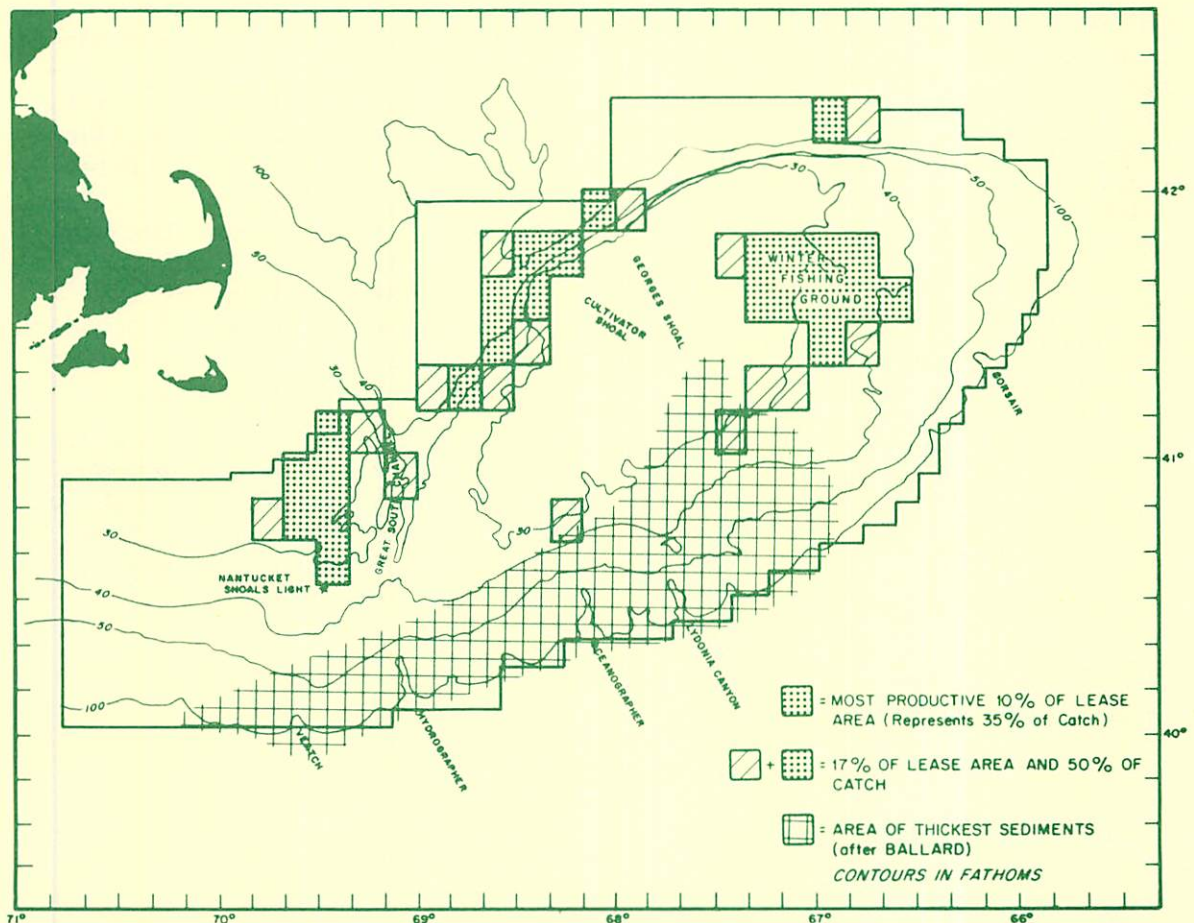
SOCIO-POLITICAL STUDIES

MARINE POLICY AND OCEAN MANAGEMENT

- Robert A. Frosch

During the year 1975-1976 the group project on the interaction between fisheries and oil exploration and production off the East Coast of the United States was completed. A report "Effects on Commercial Fishing of Petroleum Development off the North-eastern United States" has been published.

Several Fellows cooperated with Martha's Vineyard, and prepared the Martha's Vineyard Commission report on the legal and regulatory framework within which town meetings and Selectmen might regulate the harbors and great ponds of the island (see p. 13). This work resulted in several papers which were published as a manuscript report for the use of the townspeople in preparing for town meeting discussions on harbors and great ponds.



Two of the staff have been studying various aspects of New England commercial fisheries and are preparing a report on possible new management programs for the New England fishery (see p. 11). Related to this work, the program sponsored a workshop at the Institution in which representatives of all aspects of commercial and sports fishing discussed the subject of extended fisheries jurisdiction and possible managerial problems and solutions in the context of limited entry. A report on this workshop has been prepared and will be issued in the near future.

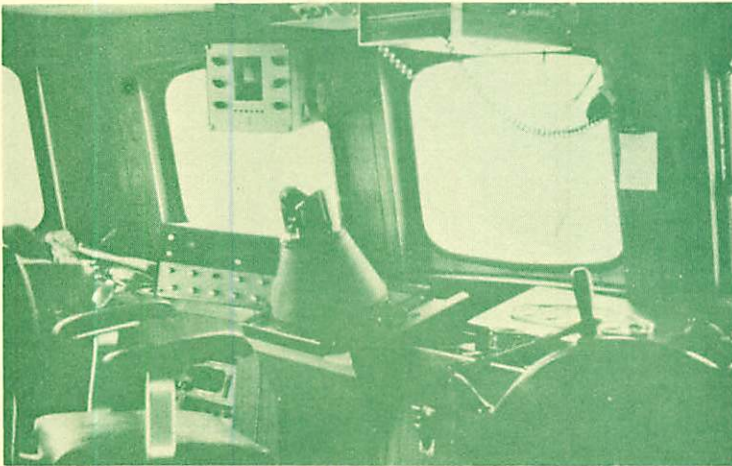
Two of the Fellows participated in the meetings of the UN Conference on the Law of the Sea, both as observers and in special capacities, one as advisor to a delegation, and another as a member of the Secretariat. They have been able to keep the group of policy fellows at the Institution and many of the scientists up-to-date on the activities of the Conference, and the possible consequences for international ocean law and for scientific research in the oceans.

Initial steps and considerable planning have been undertaken for a cooperative program of science, engineering, and policy in the stimulation of increased useful biological production in salt marshes. The intent is to examine, experimentally and theoretically, the possibility of increasing the useful productivity of salt marshes by fertilization and other methods of manipulation of the living system. Such a possibility raises some interesting questions of possible useful alternatives to fully controlled aquaculture, but also raises a number of questions of law, regulation and policy formulation. This is a multi-year experiment covering several salt marshes and leading to an understanding of what possibilities exist in this direction. It is being undertaken under the aegis of the policy group, but involves other branches of the Institution and links with other aspects of the Sea Grant Program.

In addition to these activities involving several members of the group, individual Fellows have worked on a number of individual projects of research and self-education:



- The background of interstate fish compacts and regulatory authority including an examination of the possibility of extension of this managerial mechanism into other areas.
- Study of the ways in which the education and training of ships officers relate to their performance and use of their educational background in work on the navigational bridge of a ship.



- A paper on technology transfer in marine science.
- A number of examinations of individual legal problems relating to ocean environment management.
- Work on the impact on fisheries management of innovation by fishermen.
- A study of fishing boat income, capital and labor in a New England port.

A J. Seward Johnson lecture was given by Dr. Vincent E. McKelvey, Director of the United States Geological Survey. The lecture dealt with the probable impacts of the Law of the Sea Conference on exploration and exploitation of resources at sea, in the light of the political development of the Conference.

- Individual examinations of the text of the negotiating documents of the Law of the Sea Conference with regard to the background of views on scientific research and the probable outcomes for such research, as well as an examination of the influence and interest groups within the Conference itself.
- The preparation of a book on the evolution of the Pacific salmon industry, based on data previously collected.



MARINE TECHNOLOGY TRANSFER
AS FOREIGN AID TO LESS
DEVELOPED COUNTRIES: A
SEARCH FOR AN EFFECTIVE
MECHANISM

- M. Lamin Sarr

This study was designed primarily to describe the status of marine sciences in the less developed countries (LDCs) and to determine the potential importance of such science in these countries. Also, to investigate the types of cooperative programs that exist now between oceanographic institutions, particularly in the U.S. and LDCs, including the exchange of scientists, joint research programs, and training programs in the recipient countries.

One of the objectives is to suggest new approaches on the methodology of marine technology transfer that will yield maximum benefit and growth in the LDCs, and at the same time be of value to the donor institutions. The identification of the problems and mistakes which have caused the failures in technical assistance in training and marine science education in the past may now possibly be solved by generating inherent training capability in the developing countries.

OCEAN ENGINEERING

HANDBOOK OF OCEANOGRAPHIC
ENGINEERING MATERIALS

- Stephen C. Dexter

Work on the Handbook of Oceanographic Engineering Materials, Volume II - Nonmetallic Materials, began in June, 1975, and is continuing.

The "Handbook" is conceived as a publication to which planners, designers, and engineers dealing with ocean-related problems but with little or no knowledge of materials science could go to obtain preliminary information on the basic properties of a variety of metals, alloys, and non-metallic materials most useful in sea water environments.

It is meant to be a quick reference from which a person can quickly gather sufficient information on the properties, availability, and cost of a variety of materials, already known to be useful in sea water, thus narrowing his choices to 5 or 6 possible fabricators for a given application. The final selection will still have to depend on advice from trained materials engineers or on additional information gathered from the literature or the manufacturer/supplier.

Volume I of the Handbook entitled, "Metals and Alloys," was completed in the preliminary form in 1972 and contained information on over 70 materials.

It has now been documented and updated to include information on the noble metals, several new stainless steels and super alloys that have recently become commercially important, as well as the latest information on the older materials. A glossary of technical terms has been added, and some trade names have been used in addition to the generic names where appropriate.

The data gathering stage of Volume II is nearing completion and it is anticipated that the parts of the Handbook designed to combine Volumes I and II will soon be started. These include an index of typical applications and the rankings of all materials covered in order of decreasing values of their various physical properties such as yield strength, density, etc. An effort has been made throughout both volumes to indicate both the advantages and shortcomings of each material, especially those properties such as severe crevice corrosion or a tendency to stress corrosion crack which might lead to sudden and dangerous failure if used improperly.

RESEARCH in DIRECT SUPPORT of COASTAL MANAGEMENT DECISIONS

THE DESIGN OF ENVIRONMENTAL SURVEYS OVER TIME

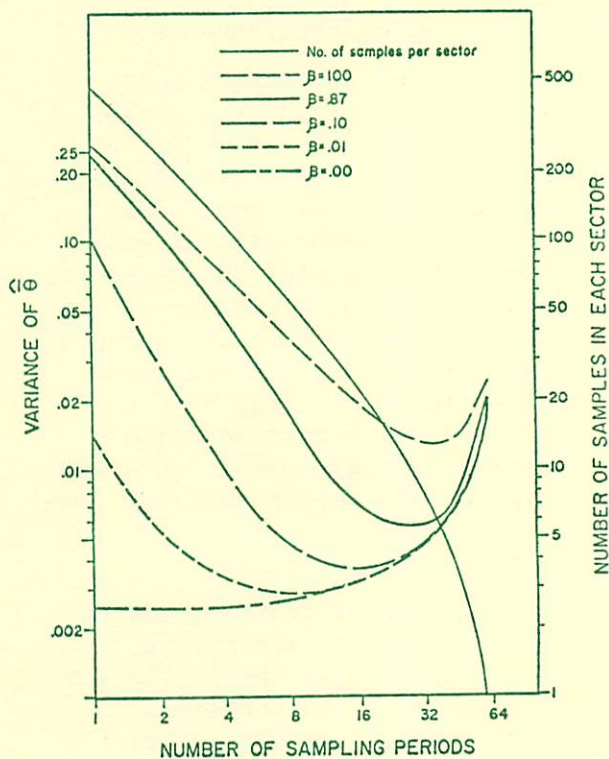
The need to determine the environmental impact of man's activities on coastal water has brought about a rapid increase in the number, size and cost of environmental surveys. The design of these surveys determines both the cost of the surveys and the information gained from the surveys. In a time varying system an important decision for the designer is how frequently to sample over time and how many samples to take at a single time point. If the cost of the survey is fixed there is clearly a trade-off between obtaining precise information about single time points and information about the average behavior of the system over time.

The sampling theory of stochastic processes was used to investigate this environmental survey design problem. An optimum sampling strategy was found for estimating the mean properties of a time varying system. The optimum design depends on: the cost of adding additional samples within a time period and of adding additional time periods to the survey; the sampling error within a time

- Wollcott K. Smith

period; and the rate and magnitude of change of the process over time.

A three year ichthyoplankton survey in Narragansett Bay was used used to illustrate the general survey design problem. A paper has been submitted for publication.



ECOSYSTEMS RESEARCH

INTERACTIONS OF FLUVIATILE SALMONID SPECIES

- R. John Gibson

An experimental stream tank has been built to study the possible interactions of fluvial exotic salmonids with native species. These experiments will be conducted between October and May after the summer field studies have concluded.

The stream tank is elliptical in shape, and is thirty feet long and ten feet wide. There are two channels, one four feet wide and two feet deep, and the other two feet wide and two feet deep. They are joined at one end by a 'pool' five feet wide and three feet deep. The inside of the apparatus has plexiglass windows, so that observations can be made from the center. The water is driven around the tank by a propeller, which is placed at the opposite end from the pool, out of the observation section. The

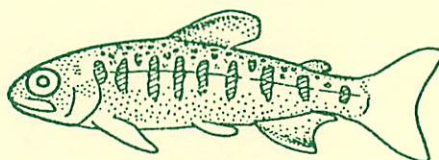
propeller is driven by an electric motor, and a series of gears allows water velocities to be varied. Water temperatures can be controlled by an immersion heater and a cooler. Incandescent and fluorescent lights are suspended above the tank, and photoperiod is controlled by a time switch.

One preliminary experiment was made before the field season. Six coho salmon smolt and six brook trout were observed together, with a water velocity of about 20 cm/sec in the fast channel, and 10 cm/sec in the slow channel. The dominant and most aggressive fish in this experiment was a coho salmon, whose main station was in the upstream section of the pool, in mid-water, in a water velocity of about 7 cm/sec. Brook trout were



found mainly in the slow channel (≈ 10 cm/sec) but were occasionally in the pool, usually close to the bottom. The remaining coho salmon smolt were in the downstream section of the fast water channel, an unusual location for them, as juvenile coho are reputed to be pool dwellers. They were possibly driven there by the dominant coho smolt.

Coho were kindly supplied by the University of New Hampshire, and brook trout by the Massachusetts Department of Fisheries and Wildlife. Experiments are planned next winter for coho, brook trout, Atlantic Salmon, and rainbow trout.



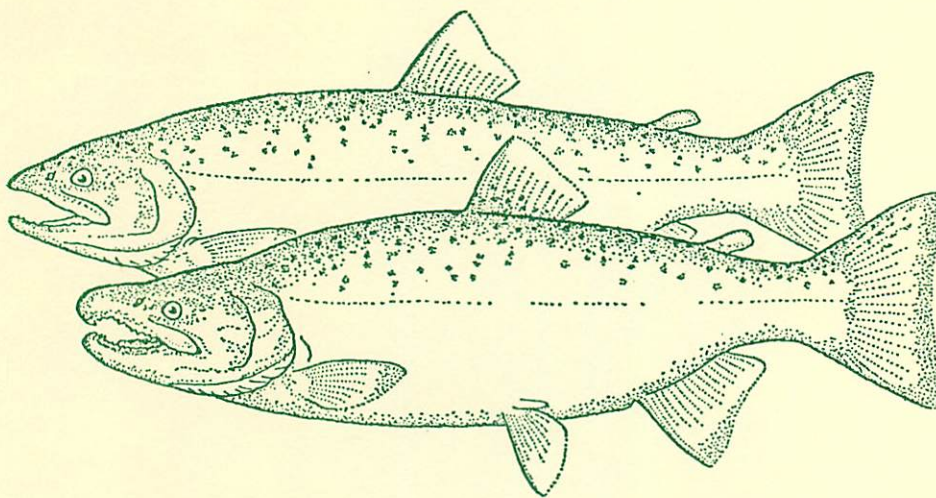
Oncorhynchus kisutch

juvenile

(after Scott and Crossman, 1973)

COHO SALMON

Oncorhynchus kisutch (Walbaum)



DISTRIBUTION OF POTENTIAL FOOD RESOURCES FOR SHELLFISH IN BOURNES POND

- Larry Brand

Bivalve shellfish are an important recreational and commercial resource on Cape Cod. Studies are being conducted in Bournes Pond, an outwash plain estuary on the south coast of Falmouth, Massachusetts, to determine the source and distribution of potential food resources for bivalve shellfish and how they can be utilized efficiently for greater shellfish productivity.

The basic objective is to correlate the distribution of potential food resources for shellfish with the growth rates of shellfish in different parts of the estuary. Samples are taken from several parts of the pond and analyzed for the amount of particulate organic matter (potentially usable by filter-feeding shellfish) and phytoplankton (unicellular plants which form the base of the food chain and can be utilized by shellfish) present in the water. The usefulness of the data is complicated by the fact that the diverse components of the particulate organic matter and the several phytoplankton species differ in their quality and usefulness for shellfish growth and these differences are poorly understood at the present time. For this reason, data on phytoplankton



Modiolus demissus
(after Smith, 1974)

species composition and distribution are also collected. To correlate particulate organic matter and phytoplankton biomass and species composition to shellfish growth, rafts of shellfish are moored in various parts of Bournes Pond. The shells of the individuals are numbered and their rates of growth monitored. The shellfish used in this study are the American oyster *Crassostrea virginica*, the hard clam *Mercenaria mercenaria*, the blue mussel *Mytilus edulis*, and the ribbed mussel *Modiola plicatula*. The growth rates of the shellfish are then correlated with the particulate organic matter and phytoplankton in the water where they are moored.

Temperature and salinity data are collected throughout Bournes Pond to also correlate with shellfish growth and mortality and to gain an understanding of the water circulation pattern in Bournes Pond. The water circulation is a very important factor determining the distribution of the suspended particulate organic matter and phytoplankton. Analysis of the circulation patterns and the distribution of

phytoplankton species will help determine whether the phytoplankton populations present are indigenous or are carried into the estuary from Vineyard Sound by tidal action. This is important to know since the entrance to Bournes Pond from Vineyard Sound is unstable and often blocked by drifting sand (see page 29). Large changes are seen in the circulation

pattern when the entrance is blocked. Future decisions by the Town of Falmouth to stabilize this entrance could have an important effect on the phytoplankton populations in Bournes Pond and thus on the shellfish productivity.



POLLUTION STUDIES

SEDIMENT DISPERSAL IN NEW BEDFORD HARBOR AND WESTERN BUZZARDS BAY

- Colin P. Summerhayes

Over many decades, man has realized that his estuaries and harbors are being filled relentlessly by fine-grained sediments. Until the past decade it was thought that rivers directly supplied most of this fill. But we now know that rivers that open into estuaries tend to drop their loads at that junction. In many estuaries downstream there is a net landward transport of fine-sediment from the continental shelf.

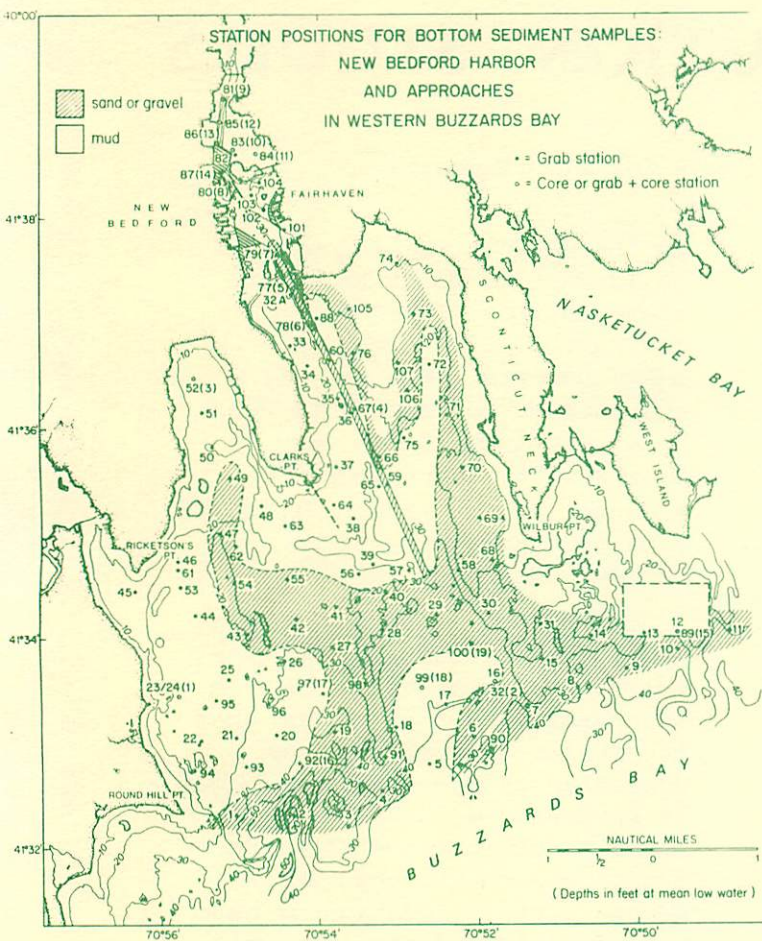
Whatever their source and because of their high surface areas, these fine-grained sediments are important in the transport of chemical pollutants that become adsorbed onto their surfaces. Furthermore, industrial waste and human effluent that is not in dissolved form is usually in the form of fine particles, and travels with the fine-grained sediments as they are moved about by waves and tidal currents. As a result, estuaries (and associated harbors) are thought to operate as pollutant sinks, effectively preventing the transfer of solid and adsorbed pollutants to the open ocean.

In order to test this model, we have been trying to determine the role that fine-grained sediments play in the dispersal of sewage and industrial effluent

in the nearest major source of pollutants to Woods Hole, the shared harbor of New Bedford and Fairhaven in southern Massachusetts. Not only is this harbor convenient to Woods Hole, but also it has very little river input from the Acushnet River, thereby removing a major complication from the system under observation.

Our object is to generate a model that adequately explains pollutant dispersal in this environment, and that can be used to predict desirable or undesirable changes that may occur in response to future environmental modifications (like pollution abatement, changes in sewage outfall location or output, dredging of navigational channels, and modification of the hurricane barrier that presently restricts circulation in the inner harbor). Future plans call for testing this model by applying it to similar coastal environments like Greater Boston Harbor.

One of the keys to the success of this study is the combination of sedimentological and geochemical analyses. The geochemical work is being carried out by one of our associate investigators, Dr. Peter Stoffers of the University of Heidelberg in Germany. Using geochemical tracking methods we can produce an integrated picture of the effects of variable



oceanographic properties on the dispersal of toxic wastes and sewage. To put it another way, in the bottom sediments around pollutant and sewage outfalls, there exist dispersal halos that reflect the sum of the effects of complex local motions of waves and currents. The sediment column can be regarded as a complex historical tape recording of pollutant history, which also shows how much lateral dispersal of pollutants there has been. Since we know when and where pollutant discharge began, we can determine rates and directions of sediment and pollutant dispersal.

We can then use this information to model the long term oceanographic controls of sediment dispersal and environmental contamination. The advantage of this knowledge to the local communities cannot be too highly stressed, particularly with respect to ocean uses involving, for example, the recreation and shellfishing industries.

To date, we have established the regional geological framework of the region, and can show that it is dominated by a drowned, ancient, N-S drainage system. Major N-S trending ridges and depressions control tidal flow and sediment (i.e., pollutant and effluent) dispersal. Beneath the floors of the depressions are up to 50-60 feet of what appears to be sand that may be of value to the local construction industry. The ridges appear to be rocky, with a thin gravelly mantle. By collecting over 100 samples of bottom sediment, including 10 cores up to 2 m long, we have shown that muds presently dominate sedimentation in the depressions, while ancient gravelly and sandy sediments cover the ridges. Rates of mud accumulation approach 40 cm/100 years in the inner harbor. In the absence of significant river input, the open waters of Buzzards Bay are regarded as the main source of this material.

From more than 400 samples of sediment in suspension, collected as part of a bi-monthly study of active sediment dispersal, we know that most of this fine sediment travels as aggregates or flocs quite near to the seabed. This sediment

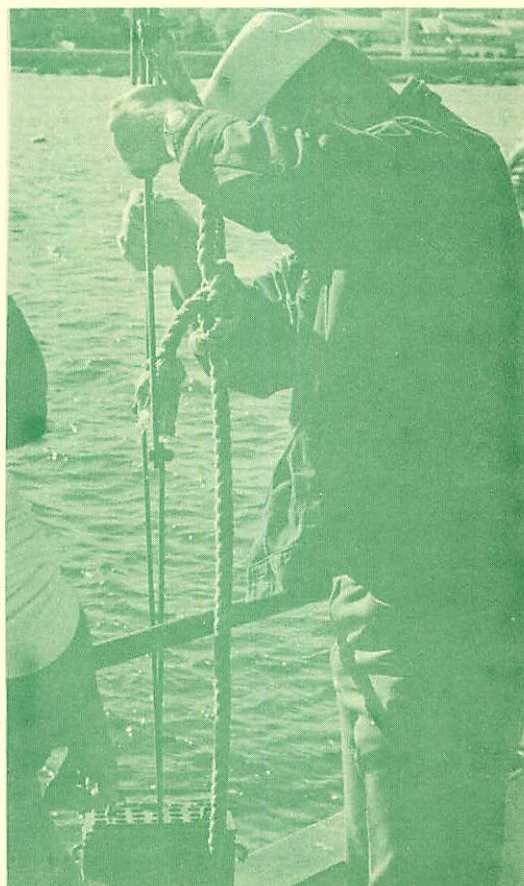
is brought into suspension by waves, and transported laterally by tidal currents, with the flood being more important than the ebb.

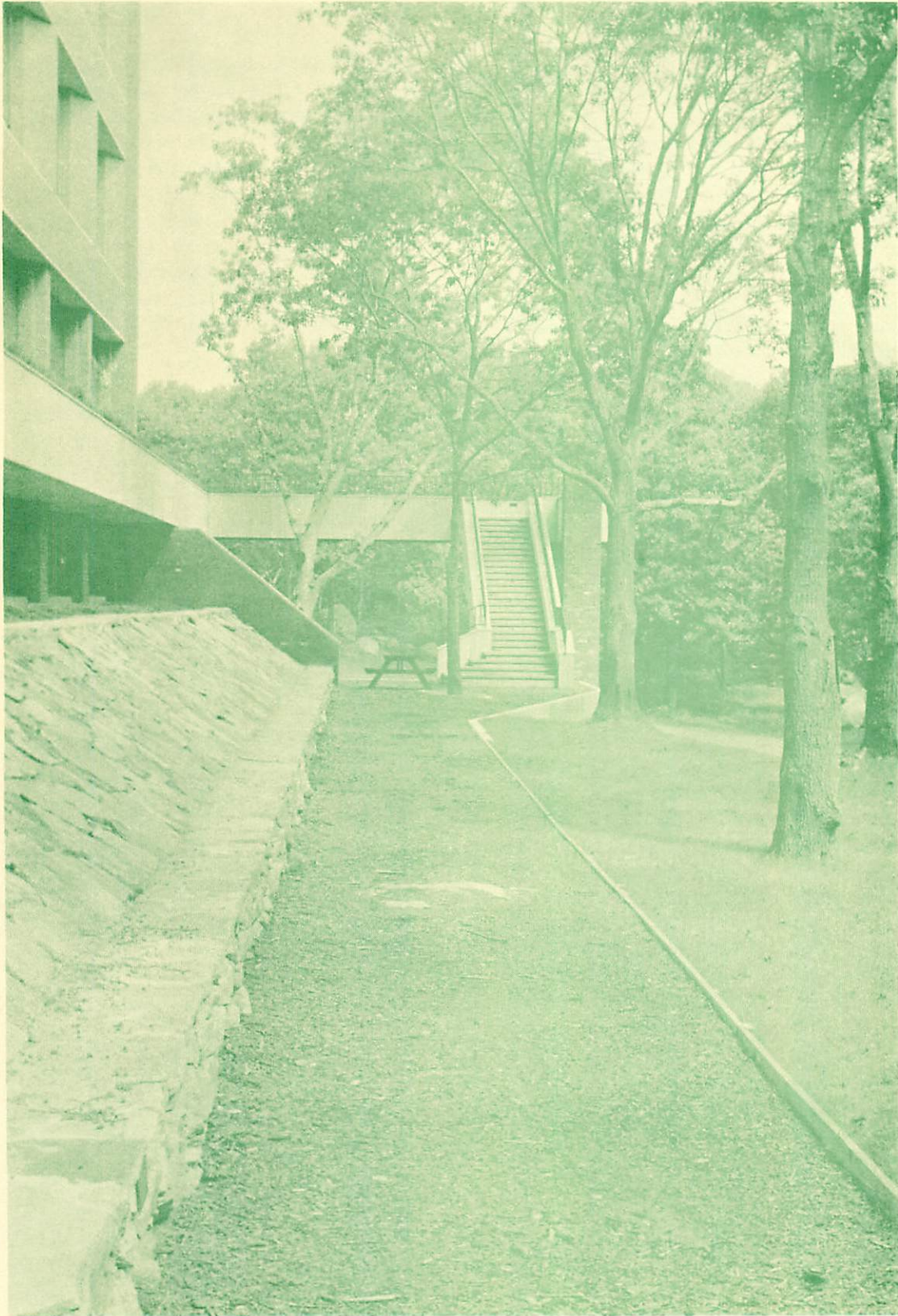
These sedimentological findings would tend to support the 'pollutant sink' model. However, our geochemical data contradict this model in certain respects, showing it to be an oversimplification of this dynamic environment. Local industrial sources discharge (or have discharged) into the harbor substantial amounts of toxic metal pollutants including Cd, Cr, Cu, Pb, and Zn (we have not yet completed analyzing for other metals). These metals are found to be most concentrated in the clay fraction (smaller than 2 micrometers) of the bottom sediments, and occur in enormous quantities, particularly within the inner harbor where we have recorded levels of up to 0.68% Cu, 0.54% Zn, 0.33% Cr, 0.09% Pb, and 0.13% Cd by weight of the clay fraction. (The clay fraction amounts to 10% of the total sample.) The clay fraction containing the most of all of these metals taken together, contained almost 1 percent of metal. The highest concentrations usually occur within the top 20 cm of the sediment column. Considering that Cu is currently mined in certain rocks where its concentration exceeds a mere 0.2%, the inner harbor muds may have some recycling potential.

Away from the point source formed by the inner harbor, there is a steady seaward decrease in the amounts of these

metals in the clay fraction, as well as in the total thickness of sediment carrying metal pollutants. The important point is that this polluted sediment almost reaches across the entire New Bedford embayment to the edge of Buzzards Bay, a distance of some 5 miles from the inner harbor. Ingestion of this metal-rich clay fraction by bottom dwelling organisms is likely to occur almost anywhere within 3-4 miles of the hurricane barrier.

The next step in our program is to document the patterns of sewage dispersal, and then to establish and quantify the mechanisms whereby metals (and probably sewage effluent) are dispersed throughout this broad embayment.





ENVIRONMENTAL MODELS

STABILITY OF A SMALL COASTAL INLET

- John Moody

During the past year an oceanography class in the Falmouth High School has investigated two major problems at the Bournes Pond inlet:

1. Sediment transport balance at the mouth of the inlet.
2. Tidal flow in the inlet.

The initial results of each are discussed below.

Studies of sediment transport balance in December 1971 using dyed sand indicated that the littoral transport along the beach was small ($\sim 1 \text{ m}^3/\text{day}$) and sporadic. Assuming little or no littoral transport a study area was chosen surrounding the mouth of the inlet which was large enough to enclose all probable sediment movement.

During the entire period from December 1975 to April 1976 the net change of sediment volume within the study area was a loss of 312 m^3 or about 3%. This was probably carried offshore beyond the limits of the study and would correspond to a net transport of $3.8 \text{ m}^3/\text{day}$ which is of the same order of magnitude as the estimate for littoral transport.

Three results seem to become apparent from this study of the sediment transport.

1. Most sediment transport is confined within a fixed area enclosing the mouth of the inlet and littoral transport appears negligible.

2. The source of the sediment which filled in the channel and eventually closed the inlet comes from the large hills of dredging spoils. The closing process might be postponed if these spoils were moved outside the area enclosing the mouth of the inlet.

3. The inlet closed several times when the channel ran SE since the ebbing current aids the SW waves in building a spit across the mouth. When the inlet channel and ebbing current ran SW into the wave direction this was not observed.

Table 1

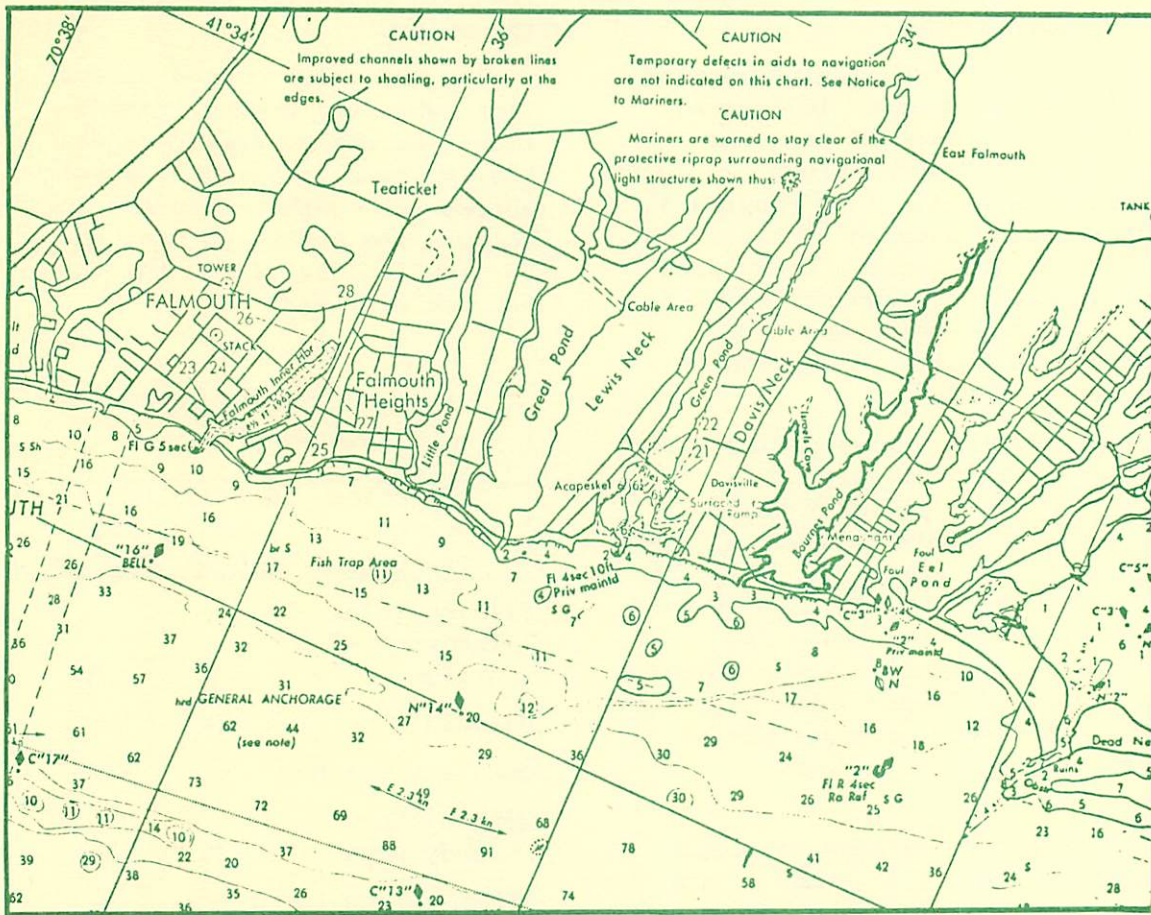
Sediment Transport at Bournes Pond

Direction of Transport	Dec 27 to Feb 15	Feb 15 to Apr 19
Filling inlet landward of bridge	11%	8%
Seaward	62%	-
Onto the beach	-	57%
Within the study area	27%	35%
TOTAL volume moved (m^3)	1963	2073

The tidal flow is very different and quite variable for ebb and flood situations. There is a shallow water tidal harmony which causes the asymmetry of the tide curve. Other factors which contribute to the difference and variations in ebb and flood currents are the cross-sectional area and length of the channel.

A model for tidal flow into basins connected by an inlet was attempted using the frictional

coefficient K (used by Keulegan), however this single frictional coefficient model did not predict the correct delay of high water inside the estuary relative to outside. This model cannot be used to explain the tidal flow in Bourne's Pond Inlet because the duration of flood and ebb are unequal and the cross-sectional area and inlet length depend on time and these two parameters are different for ebb and flood situations.



MARINE EDUCATION

COASTAL ZONE MANAGEMENT: A COURSE FOR PRACTITIONERS

- Robert Black

This project attempted to develop a course of study for adult users of coastal resources which would acquaint the student with coastal ecosystems and physical processes and assist in understanding the effect of human interaction with these processes. It also familiarized the learner with policy issues and decision-making organizations dealing with use of the coastal zone and investigated management techniques in current use.

A general course outline was developed and offered as part of the continuing education curriculum of the Adult Education Division at the Massachusetts Maritime Academy. Twenty students with varied backgrounds (harbor master, fisherman, biologist, seaman, and planners) participated in the 2-1/2 hour per week, 20-week course, which covered the following topics:

- A Systems View of the Coastal Zone
- The "Management" in Coastal Zone Management
- Coastal Geomorphology (visiting lecturer with slides)
- Ecological Aspects of the Water's Edge (visiting lecturer with slides)
- Human Ecology and the Social Space of the Coastal Zone

and TRAINING

- Human Interaction and Coastal Abuse (with slides)

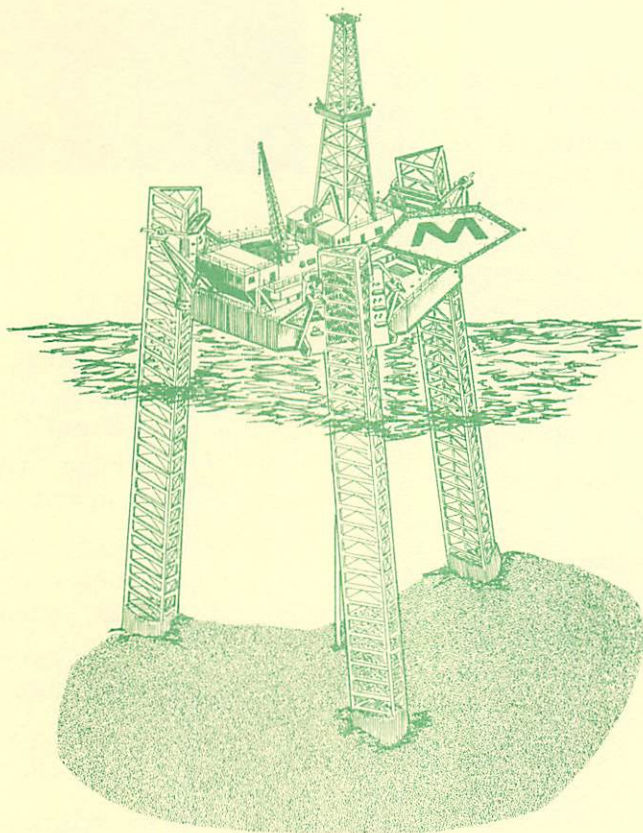


- The Coastal Zone in Legal Perspective (visiting lecturer)
- Planning and Resource Management
- Coastal Zone Management at the State and Federal Levels (with film)
- Citizen Participation and Coastal Resource Planning
- Planning-Management Strategies in the Coastal Zone
- Presentation and Discussion of Student Research Projects
- The Marine Transportation Industry

- Offshore Oil and Gas Development
- Commercial Fishing

Since no written examinations were given evaluating the results relied on other less traditional measures. A term paper was required and the topics of these varied from "Seasonal Effect of Vehicular Traffic on Cape Cod" to "Coastal Effects of Oil Drilling in Georges Bank." Student critique at the end of the course

revealed general satisfaction with the approach and content although concern was expressed about a certain amount of repetition and the absence of sufficient library references required for background reading. In addition to the successful completion of the course by a majority of the students, a detailed course syllabus and bibliography-reading list was developed for each of the instructional hours.



JACK - UP RIG

Reports

AQUACULTURE

- DeBoer, J. A., J. H. Ryther, and B. E. Lapointe, 1976. YIELDS OF THE SEaweEDS *Neogardhiella baileyi* AND *Gracilaria foliifera* IN A WASTE RECYCLING-POLYCULTURE SYSTEM.***
- DeBoer, J. A. and B. E. Lapointe, 1976. EFFECTS OF CULTURE DENSITY AND TEMPERATURE ON THE GROWTH RATE AND YIELD OF *Neogardhiella baileyi*.***
- DeBoer, J. A., B. E. Lapointe, and C. F. D'Elia, 1976. EFFECTS OF NITROGEN CONCENTRATION ON GROWTH RATE AND CARRAGEENAN PRODUCTION IN *Neogardhiella baileyi*.***
- D'Elia, C. F., J. H. Ryther, and T. M. Losordo, 1976. PRODUCTIVITY AND NITROGEN BALANCE IN LARGE SCALE PHYTOPLANKTON CULTURES.***
- D'Elia, C. F., P. A. Steudler and N. Corwin, 1976. DETERMINATION OF TOTAL NITROGEN IN AQUEOUS SAMPLES USING PERSULFATE DIGESTION.***
- D'Elia, C. F., J. A. DeBoer, and J. H. Ryther, 1976. SOME ASPECTS OF THE NUTRIENT UPTAKE KINETICS OF THE MACROSCOPIC RED ALGA, *Neogardhiella baileyi*.***
- Goldman, J. C. and J. H. Ryther, 1975. NUTRIENT TRANSFORMATIONS IN MASS CULTURES OF MARINE ALGAE. Jour. Env. Eng. Div. Proc. Am. Soc. Civil Eng. 101(E3): 351-364.
- Goldman, J. C., J. H. Ryther, and L. D. Williams, 1975. MASS PRODUCTION OF MARINE ALGAE IN OUTDOOR CULTURES. Nature 254: 594-595.
- Goldman, J. C., 1976. IDENTIFICATION OF NITROGEN AS A GROWTH-LIMITING NUTRIENT IN WASTE WATERS AND COASTAL MARINE WATERS THROUGH CONTINUOUS CULTURE ALGAL ASSAYS. Water-Research 10: 97-104.
- Goldman, J. C. and J. H. Ryther, 1976. TEMPERATURE-INFLUENCED SPECIES COMPETITION IN MASS CULTURES OF MARINE PHYTOPLANKTON. Biotechnology and Bioengineering 18: 1125-1144.
- Goldman, J. C. and J. H. Ryther, 1976. TEMPERATURE-INFLUENCED SPECIES COMPETITION IN MASS CULTURES OF MARINE PHYTOPLANKTON.***
- Goldman, J. C., 1976. TEMPERATURE EFFECTS ON PHYTOPLANKTON GROWTH IN CONTINUOUS CULTURE.***

- Goldman, J. C., 1976. BIOMASS PRODUCTION IN MASS CULTURES OF MARINE PHYTOPLANKTON AT VARYING TEMPERATURES.***
- Huguenin, J. E. and J. H. Ryther, 1975. THE USE OF POWER PLANT WASTE HEAT IN AQUACULTURE. Proc. Tenth Ann. Conf. Marine Technology Soc.: 431-445.
- Huguenin, J. E., 1976. HEAT EXCHANGERS FOR USE IN CULTURING OF MARINE ORGANISMS. Chesapeake Science 17(1): 61-64.
- LaPointe, B. E., L. D. Williams, J. C. Goldman, and J. H. Ryther, 1976. THE MASS OUTDOOR CULTURE OF MACROSCOPIC MARINE ALGAE. Aquaculture 8: 9-21.
- Mann, R. and T. M. Losordo, 1976. THE GROWTH OF SIX SPECIES OF BIVALVE MOLLUSCS IN A WASTE-RECYCLING AQUACULTURE SYSTEM.***
- Mann, R. and S. J. Glomb, 1976. PRELIMINARY STUDIES OF THE EFFECT OF TEMPERATURE ON GROWTH AND AMMONIA EXCRETION IN THE MANILA CLAM *Venerupis semidecussata*.***
- Nicotri, M. E., 1976. THE IMPACT OF CRUSTACEAN HERBIVORES ON CULTURED SEAWEED POPULATIONS.***
- Ryther, J. H., 1975. PRELIMINARY RESULTS WITH A PILOT-PLANT WASTE RECYCLING-MARINE AQUACULTURE SYSTEM. Proc. Internatl. Conf. on Renovation and Reuse of Waste Water through Aquatic and Terrestrial Systems. Bellagio, Italy, July 1975. Marcel Dekker, Inc., Publ.
- Ryther, J. H. and K. R. Tenore, 1976. INTEGRATED SYSTEM OF MOLLUSK CULTURE. In Harvesting Polluted Waters, O. Devik, Ed. Plenum Pub. Corp., N.Y.: 153-167.
- Tenore, K. R., 1976. FOOD CHAIN DYNAMICS IN A POLYCULTURE SYSTEM. Aquaculture 8: 23-27.

LIVING RESOURCES

- Mather, F. J. III, B. T. Rothschild, G. T. Paulik, and W. H. Lenarz, 1974. ANALYSIS OF MIGRATIONS AND MORTALITY OF BLUEFIN TUNA, *Thunnus thynnus*, TAGGED IN THE NORTHWESTERN ATLANTIC OCEAN. Fishery Bull. 72(4): 900-914.

***To be printed collectively as a WHOI manuscript report in Marine Polyculture.

Mather, F. J. III, H. L. Clark, and J. M. Mason, Jr., 1975. SYNOPSIS OF THE BIOLOGY OF THE WHITE MARLIN, *Tetrapturus albidus* POEY (1861), NOAA Tech. Rept. NMFS SSRE-675 pt. 3: 55-94.

Sabo, D. J. and J. J. Stegeman, 1976. SOME METABOLIC EFFECTS OF PETROLEUM HYDROCARBONS IN MARINE FISH. Pollution and Physiology of Marine Organisms, II, A. Calabrese and J. F. Vernberg, Editors, Academic Press (In Press).

Stegeman, J. J., 1976. BIOLOGICAL AND ECOLOGICAL EFFECTS OF PETROLEUM IN THE MARINE ENVIRONMENT. Second IOC/WMO Workshop on Marine Pollution (Petroleum) Monitoring. Monte Carlo, Monaco, 14-18 June, 1976.

SOCIO-ECONOMIC AND LEGAL STUDIES

Allen, D. W., R. B. Allen, R. E. Black, J. M. Friedman, L. C. Mallon, R. W. Morse, S. B. Peterson, and L. J. Smith, 1976. EFFECTS ON COMMERCIAL FISHING OF PETROLEUM DEVELOPMENT OFF THE NORTHEASTERN UNITED STATES. A report from the Marine Policy and Ocean Management Program, Woods Hole Oceanographic Institution, W.H.O.I. Ref. #76-66: 80 pp.

Ciobanu, D., 1976. LITISPENDENCE BETWEEN THE INTERNATIONAL COURT OF FUTURE AND THE POLITICAL ORGANS OF THE UNITED STATES. In The Future of the International Court of Justice, L. Gross, Editor, Oceana, New York: 73 p.

Ciobanu, D., 1976. CREDENTIALS OF DELEGATIONS AND REPRESENTATION OF MEMBER STATES IN THE UNITED NATIONS, 1 International and Comparative Law Quarterly (January 1976): 34 p.

Fricke, P., 1976. Book Review - FISHERMAN OF GALILEE: THE HUMAN ECOLOGY OF A NEW ENGLAND COASTAL COMMUNITY by J. P. Poggie, Jr. and C. Gersuny, University of Rhode Island Marine Bull. 17, Kingston, R. I., 1974: 108 p. \$3.00. Maritime Studies and Management 3(3): 192.

Fricke, P., 1976. Book Review - A COMPARATIVE ANALYSIS OF COMPLEX ORGANIZATIONS by S. Etzioni, Revised and Enlarged Edition, New York, the Free Press, 1975: --XXIV, 584 pp. \$11.95 hardcover, \$5.95 paperback. Political Science Quarterly, February 1976.

Friedman, J. M., 1975. STATEMENT BEFORE THE HOUSE AD HOC SELECT COMMITTEE ON THE OUTER CONTINENTAL SHELF: OFFSHORE OIL DEVELOPMENT AND H.R. 6218, 13 September 1975.

- Friedman, J. M., R. A. Donnellan, and G. A. Nickerson, 1976. SOME QUESTIONS AND ANSWERS ABOUT THE LAW OF HARBORS AND GREAT PONDS. A PAMPHLET FOR THE TOWNS OF MARTHA'S VINEYARD. Martha's Vineyard Land and Water Commission.
- Friedman, J. M., R. A. Donnellan, and G. A. Nickerson, 1976. A REPORT TO THE TOWNS OF MARTHA'S VINEYARD AND THE MARTHA'S VINEYARD COMMISSION. W.H.O.I. REF. #76-56: 55 p.
- Gallardo, V. A., 1976. CHILE'S NATIONAL INTEREST IN THE OCEANS, Institute of International Studies, The University of Chile, Spec. Pubs. Ser. No. 10: 110 p.
- Hennemuth, R. C., 1976. BIOLOGICAL INFORMATION NEEDED UNDER EXTENDED JURISDICTION.^{††}
- Huguenin, J. E. and J. T. Kildow, 1974. SOCIAL, POLITICAL, REGULATORY, AND MARKETING PROBLEMS OF MARINE WASTE-FOOD RECYCLING SYSTEMS. Waste Water Use in the Production of Food and Fiber Proceedings, Environmental Technology Series, U. S. Environmental Protection Agency, EPA-660/2-74-041: 344-356.
- Lyman, H., 1976. CONTROLS FOR RECREATIONAL FISHING. Extended Jurisdiction Workshop, Woods Hole, MA 10-11 May 1976.^{††}
- Mallon, L. G., 1975. OFFSHORE OIL DRILLING AND ONSHORE IMPACT: THE LEGAL/INSTITUTIONAL FRAMEWORK. Proceedings of Estuarine Res. Fed. Outer Continental Shelf Conf. and Workshop: Marine Environmental Implications of Offshore Oil and Gas Development in the Baltimore Canyon Region of the Mid-Atlantic Coast, College Park, MD, December 2-4, 1974: 67-75.
- McKelvey, V. E., 1976. The Oceans - The National and International Policy Frontier. J. Seward Johnson Lecture in Marine Policy, 27 May 1976, Woods Hole, MA.
- Orbach, M. R., 1976. 'RIGHTS' TO FISHERIES RESOURCES. Extended Jurisdiction Workshop, Woods Hole, MA, 10-11 May 1976.^{††}
- Paredes, J. A., 1976. AN EXAMPLE OF SOCIAL DATA COLLECTION FROM A FISHING COMMUNITY ON THE GULF COAST OF FLORIDA. Extended Jurisdiction Workshop, Woods Hole, MA, 10-11 May 1976.^{††}
- Peterson, S. B., 1975. THE VIEW FROM NEW BEDFORD. Oceanus 18(2): 38-41.
- Peterson, S. B., 1976. FISH OR CUT BAIT: THE ROLE OF THE NEW ENGLAND FISHING INDUSTRY IN CHANGING OCEAN BOUNDARIES. W.H.O.I. Journal Club, 28 June 1976.

- Rittgers, J., 1976. SOME FUNCTIONS AND RESPONSIBILITIES OF THE NMFS REGIONAL OFFICES UNDER EXTENDED JURISDICTION. Extended Jurisdiction Workshop, Woods Hole, MA, 10-11 May 1976.^{††}
- Rao, P. S., 1975. THE PUBLIC ORDER OF OCEAN RESOURCES: A CRITIQUE OF THE CONTEMPORARY LAW OF THE SEA. M.I.T. Press: 313 p.
- Ross, D., 1974. COOPERATIVE RESEARCH PROGRAMS AT WOODS HOLE OCEANOGRAPHIC INSTITUTION. U. S. Marine Scientific Research Assistance to Foreign States, Proceedings of a Conference, National Academy of Sciences, Washington, D. C., 25-27 March 1974: 57-77.
- Smith, C. L., 1976. SOME COMMENTS ON P.L. 94-265. Extended Jurisdiction Workshop, Woods Hole, MA, 10-11 May 1976.^{††}
- Smith, L. J., 1976. FISHING BOAT INCOME, CAPITAL AND LABOR: A DISTRIBUTIONAL STUDY OF A NEW ENGLAND PORT. A Symposium: Economic Impacts of Extended Fisheries Jurisdiction, University of Delaware, 29-30 April 1976.
- Smith, L. J., 1976. FISHERIES REGULATION UNDER EXTENDED JURISDICTION: EXISTING RESEARCH AND NEW DIRECTIONS. Extended Jurisdiction Workshop, Woods Hole, MA, 10-11 May 1976.^{††}
- Smith, L. J. and D. A. Ross, 1976. TECHNOLOGY TRANSFER IN MARINE SCIENCE. Interscienca 1(1): 38-42.
- Wilson, J., 1976. CHANGES IN THE ECONOMIC CLIMATE AS THEY AFFECT THE NEW ENGLAND FISHING INDUSTRY. Extended Jurisdiction Workshop, Woods Hole, MA, 10-11 May 1976.^{††}
- MARINE TECHNOLOGY RESEARCH AND DEVELOPMENT
- Berteaux, H. O., 1976. BUOY ENGINEERING, J. Wiley & Sons, 314 p.
- Dow, W., 1976. DEVELOPMENT OF AN ACOUSTIC PROBE FOR DETAILED OCEAN BOTTOM AND SUB-BOTTOM SURVEYS, W.H.O.I. REF. #76-35: 13 p.
- PROGRAM
- Bumpus, D. F., 1976. MARINE RESOURCES DEVELOPMENT AND MANAGEMENT: A REPORT ON THE WOODS HOLE OCEANOGRAPHIC INSTITUTION SEA GRANT PROGRAM FOR JULY 1974-JUNE 1975. W.H.O.I. Ref. #76-4: 39 p.

^{††}To be printed collectively as a W.H.O.I. manuscript report on the Extended Jurisdiction Workshop.

Program Summary

Program Area	Project Support		Coherent Program		
	'71-'72	'72-'73	'73-'74	'74-'75	'75-'76
Marine Resources Development					
Aquaculture					
Marine Polyculture Based upon Natural Food Chains and Recycled Wastes - Ryther		N	C	C	C
Finfish Research at Matamek, Quebec - Gibson			N	*	*
Culture of Midges - McLarney			N	T	
The Genetic Component of Variable Growth and Survival in Seed Quahogs - Grassle					N
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 - Ateama		N	C	T	
The Sources of Important Biochemicals in Marine Crustacea - Gagosian		N	C	T	
Effects of Petroleum Hydrocarbons in Marine Fishes - Stegeman, Sabo				N	C
Population Density and Distribution of <i>Limulus polyphemus</i> in Cape Cod Waters - Smith					N
Socio-Economic and Legal Studies					
Marine Economics					
Limited Effort Programs in the New England Fishery - Smith, Peterson				N	C
Ocean Law - Coastal					
Regulation of Harbors and Ponds of Martha's Vineyard - Friedman					NT
Draft Legislation for the Massachusetts Lobster Fishery - Peterson, Friedman					N
Socio-Political Studies					
Marine Policy and Ocean Management - Frosch		N	C	C	C
Marine Technology Transfer as Foreign Aid to Less Developed Countries - Sarr					N

Program Area	Project Support		Coherent Program		
	'71-'72	'72-'73	'73-'74	'74-'75	'75-'76
Marine Technology Research and Development					
Ocean Engineering					
High Resolution Sub-bottom Profiling - Vine				N	T
An Acoustic Probe for Ocean Bottom Surveys - Dow				NT	
Solar Energy Conversion - von Arx				NT	
Handbook of Oceanographic Engineering Materials - Dexter					N
Marine Environmental Research					
Research and Studies in Direct Support of Coastal Management Designs					
The Design of Environmental Surveys over Time - Smith					NT
Ecosystems Research					
Interactions of Fluvial Salmonid Species - Gibson					N
Distribution of Potential Food Resources for Shellfish in Bournes Pond - Brand					N
Pollution Studies					
Sediment Dispersal in New Bedford Harbor and Western Buzzards Bay - Summerhayes					N
Environmental Models					
Stability of a Small Coastal Inlet - Moody					N
Marine Education and Training					
Course Development					
Ocean Engineering - Mavor	N	C	T		
Coastal Zone Management - Black					N
Program Management and Development					
Program Management and Development - Bumpus				N	C C

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

During FY'76 the Woods Hole Oceanographic Institution Sea Grant Program consisted of:

- 16 Research Projects
- 1 Education Project
- 1 Program Management

Personnel associated with the Sea Grant Program were:

- | | |
|------------------------------|----------------------------|
| Scientific Staff - 16 | Graduate Students - 8 |
| Technical Staff - 7 | Trainee - 1 |
| Departmental Assistants - 26 | Pre-Doctoral Fellow - 1 |
| High School Students - 12 | Post-Doctoral Fellows - 13 |
| Undergraduate Students - 1 | Visiting Investigators - 4 |



Budget Summary

1975-1976

	Sea Grant	Matching*	Total
Marine Resources Development			
Aquaculture	119,484	50,000	169,484
Living Resources	85,695	24,677	110,372
Socio-Economic and Legal Studies			
Marine Economics	50,000	00	50,000
Ocean Law - Coastal	896	7,160	8,056
Socio-Political Studies	15,456	171,200	186,656
Marine Technology Research and Development			
Ocean Engineering	20,000	4,400	24,400
Marine Environmental Research			
Research in Direct Support of Coastal Management Decisions	5,938	00	5,938
Ecosystems Research	16,369	32,183	48,552
Pollution Studies	35,000	17,500	52,500
Environmental Models	13,603	232	13,835
Marine Education and Training			
Course Development	4,444	100	4,544
Program Management and Development	58,115	14,200	72,315
TOTAL	425,000	321,652	746,652

* Matching Funds were provided by a number of benefactors of the Institution.

Postscript

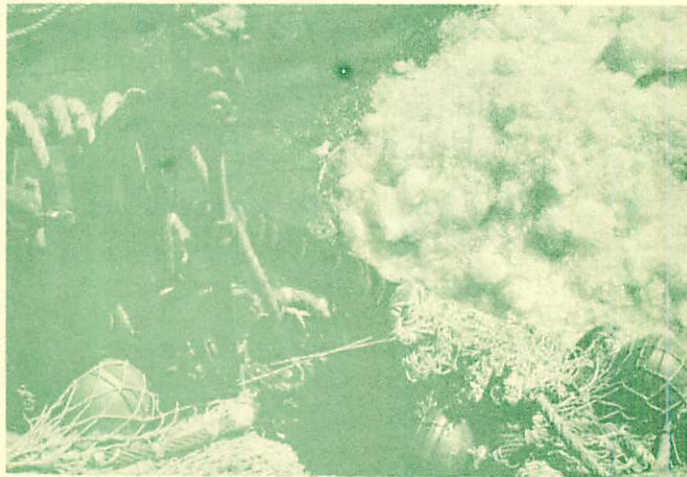
Our report of progress during the past year would not be complete, in our view, were we not to also reveal our plans for the immediate future. The following paragraphs describe our current commitments:

John Ryther's marine polyculture program will be re-directed to investigate the effects of sustained constant temperature (12, 15, 18, and 21° C) on shell growth, meat growth, glycogen deposition, gonad development, reproduction and general condition index of three species of bivalve molluscs. Also to investigate the comparative nutritional physiology and biochemistry of six species of bivalves with respect to their ability (or nonability) to use monocultures of *Phaeodactylum tricoratum* and other diatoms given in mass cultures of sewage-enriched seawater.

Judy Grassle will continue her study of the genetic component of growth and survival in raft cultured and natural populations of quahogs which she commenced during the last half of the last fiscal year with "new initiatives" funding.

John Stegeman and Dennis Sabo will continue their study of the effects of mixed petroleum hydrocarbons in marine fishes.

Our Marine Policy and Ocean Management Program under the leadership of Robert Frosch will continue to sponsor interdisciplinary studies for professionals who wish to work on problems generated by man's use of the sea.



While such studies have intrinsic value, a major objective is to increase the background in marine science of social scientists in order to make them more effective in their future careers. Another objective is to increase marine scientists' knowledge of policy problems.

William von Arx has devised an optical trap for the use of diffuse solar radiation in hyperthermal aquaculture. The object of the proposed research is to collect sunlight on an open water surface and trap the energy

through a combination of absorption on a blackened pond floor and total reflection at the free surface and at an artificially enhanced pycnocline. The low grade heat thus produced can be useful in space heating, air conditioning, sewage treatment and aquaculture systems.

Jim Mavor will examine the dynamics of an inclining spar current sensor. His information will be applicable to the design of ocean current measurement systems for ship navigation, flow studies near power plants, rivers or shore erosion sites, and for oil pollution dispersion measurements.

John Gibson will continue his study of the interactions of exotic salmonids with indigenous species. Inasmuch as several salmonids have been successfully introduced to many parts of the world, especially coho salmon, spring or chinook salmon, rainbow and brown trout. These species are being introduced to the east coast of North America and are increasing their range. This study will allow predictions of

the possible displacements of indigenous species, Atlantic salmon and brook trout, by these introduced salmonids.

Colin Summerhayes will complete his study of New Bedford Harbor and approaches.

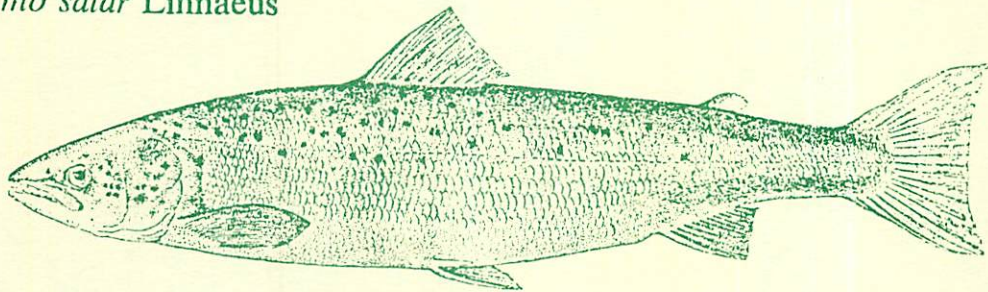
John Moody will complete his study of Bournes Pond inlet. This project, while providing useful information to our local Shellfish Warden and the Waterways Committee is also used as a learning vehicle through planning, collection and analysis of data, for students in our local High School.

David Wall, through the use of new initiative funding, is commencing an investigation of red-tide problems on Cape Cod. He will determine if *Gonyaulax tamarensis* is solely responsible for shellfish toxicity in Cape Cod waters, discover which salt ponds are most heavily infected with *G. tamarensis* cysts in the sediments, determine to what extent cysts and/or the thecae of this species can be detected in the stomach contents of *Mya* the soft clam, *Mytilus* the mussel and *Mercenaria* the quahog; and

ATLANTIC SALMON

Salmo salar Linnaeus

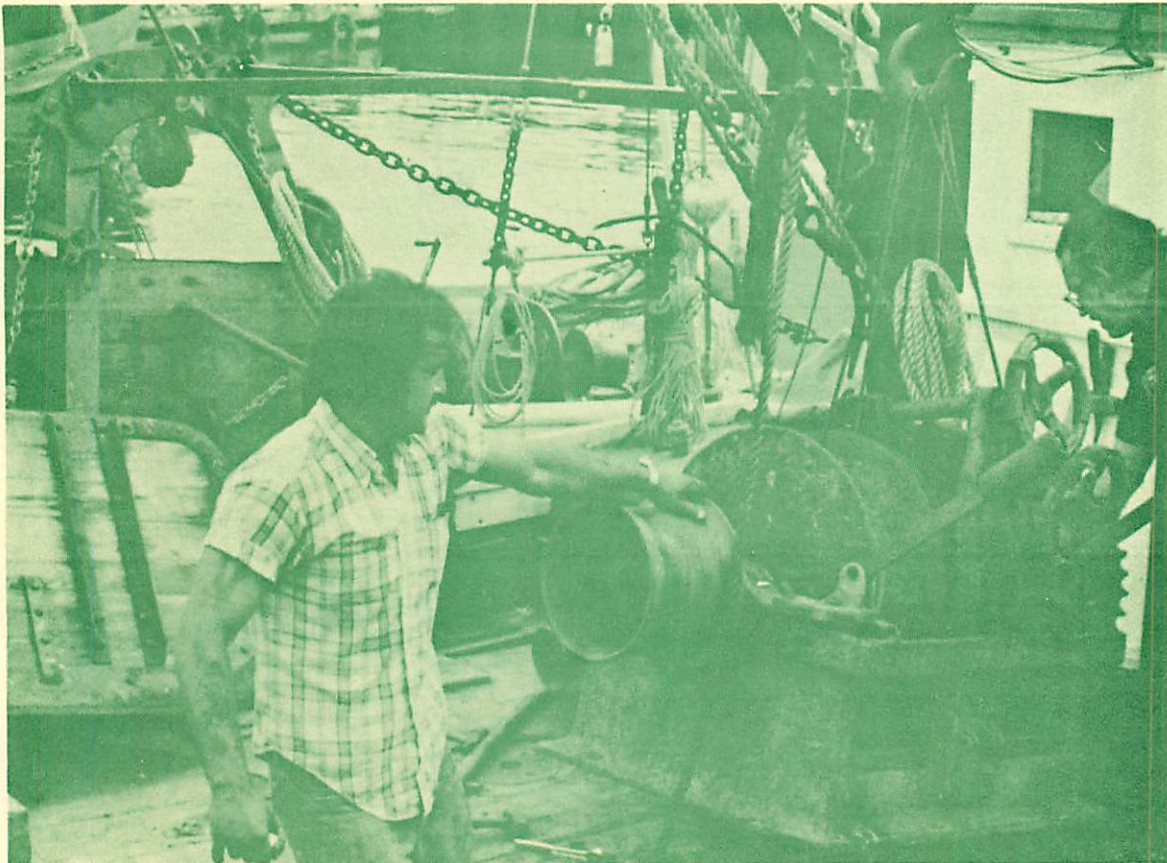
(after Scott and Crossman, 1973)



to query if there is a simple relationship between stomach content and toxin levels in different shellfish genera.

The research should increase the efficiency of predicting geographic sites where red-tide problems are potentially acute, thus avoiding the choice of such sites as areas for commercial or recreational shellfish development. It is hoped to develop an economical and rapid method of screening large numbers of shellfish for *G. tamarensis* contamination. Further, it is hoped that information about the cyst cycle can be used to design experimental control methods in fringe area-semi enclosed environments.

Carolyn Winn has undertaken the task of setting up a Marine Science Libraries Cooperative Network. The objective is to improve communication and cooperation among the marine science libraries and information centers located on the east and gulf coasts of the U.S. and Eastern Canada. A workshop of librarians will be held in Woods Hole to discuss common problems and design projects, a directory of east and gulf coast libraries and information centers will be compiled and published, and a union list of oceanographic atlases will be compiled and published. This project is receiving assistance from the Office of Coastal Zone Management and the Environmental Data Service.



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January 1977

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25	NOAA Library and Information Services(D825) 6009 Executive Bldg. Rockville, MD 20852

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