Woods Hole Oceanographic Institution

MARINE RESOURCES DEVELOPMENT AND MANAGEMENT
A REPORT ON THE WOODS HOLE OCEANOGRAPHIC INSTITUTION SEA GRANT PROGRAM

By

Dean F. Bumpus

January 1976

TECHNICAL REPORT

Prepared for the Office of Sea Grant under Grant 04-4-158-8.

WOODS HOLE, MASSACHUSETTS 02543

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Approved for Distribution Ferris Webster

Ferris Webster
Associate Director for Research

MARINE RESOURCES DEVELOPMENT AND MANAGEMENT

1974-1975 ANNUAL SEA GRANT REPORT

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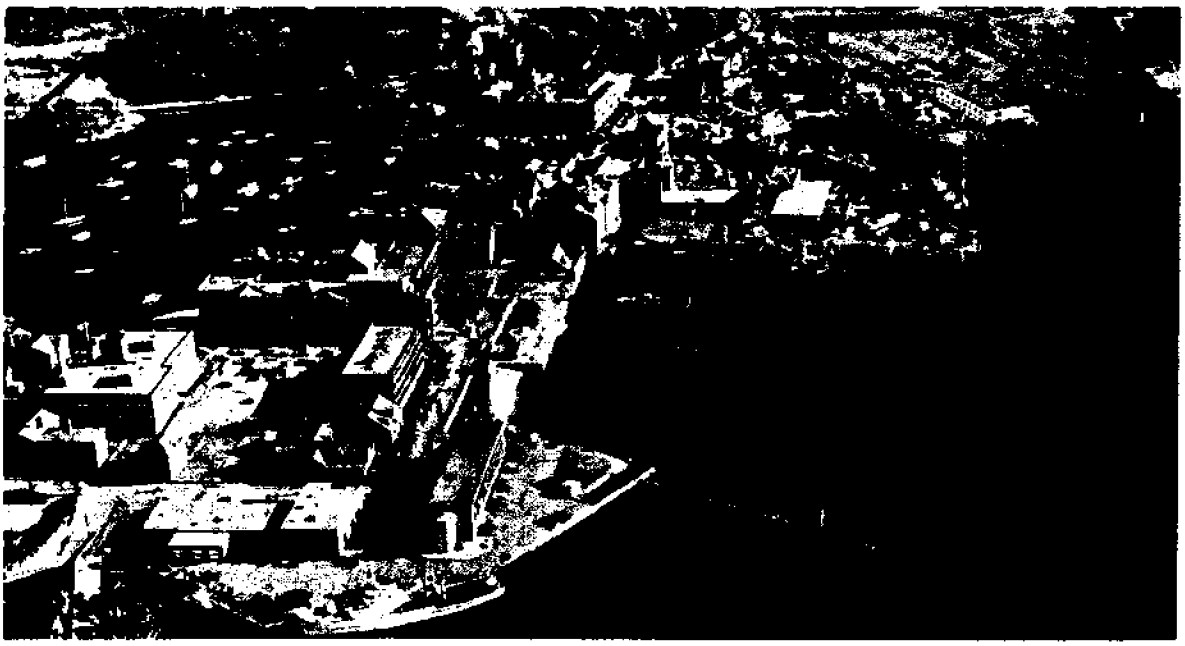

Introduction

In addition to conducting excellent scientific inquiry and providing an effective graduate education in all aspects of Marine Science and Engineering, the Woods Hole Oceanographic Institution has a commitment to apply its knowlege and skills to the solution of man's needs in the field of marine resources. Our activities involve the delineation and enhancement of marine resources, basic studies of the marine environment and its interaction with oil spills and waste materials, the development of skilled scientists and engineers, and the providing of an opportunity for professionals from non-marine related fields to interact with marine scientists and engineers in ocean affairs. Some of these activities, not a part of the Sea Grant Program, involve industrial participation through the Institution's Ocean Industry Program, a waste water renovation and retrieval system, and international efforts through our cooperative investigation in Spanish Coastal Waters and fisheries research on the Matamek River in Canada.

Our Sea Grant Program is endeavoring to respond to the increasing pressures for science to be "more relevant." In this our Second Annual Sea Grant Report we are pleased to relate our advances in:

- Marine polyculture based upon natural food chains and recycled wastes
- Chemical communication by marine animals.
- Limited effort programs in the New England fishery
- Marine Policy and Ocean Management
- High Resolution Sub-bottom Profiling
- Development of an acoustic probe for ocean bottom and sub-bottom profiling, and
- Solar energy conversion

At the end of this report we look ahead to the "need" related research our scientists and marine policy fellows have chosen to conduct. We are indeed grateful to the National Sea Grant Program and our beneficiaries who provide the matching funds for this opportunity to pursue these relevant objectives.

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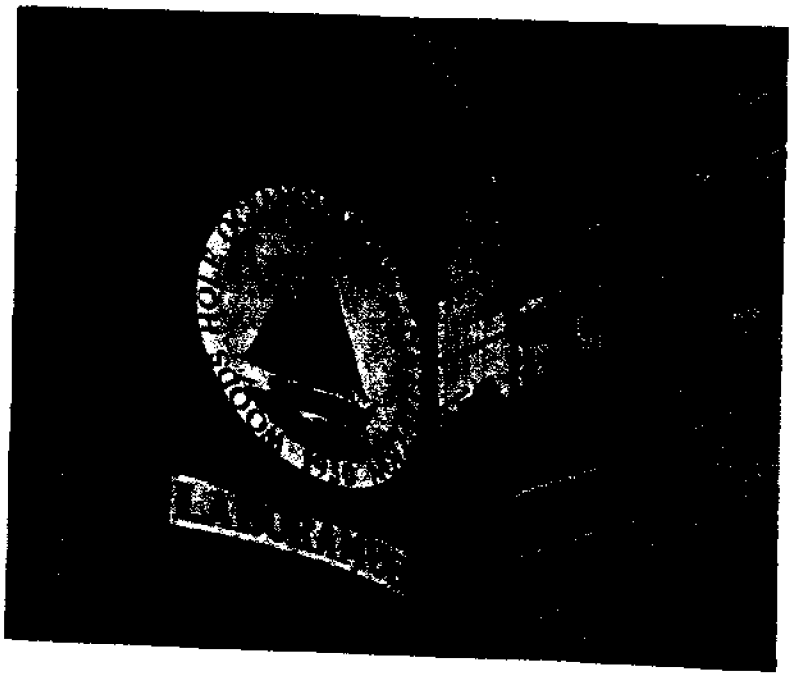
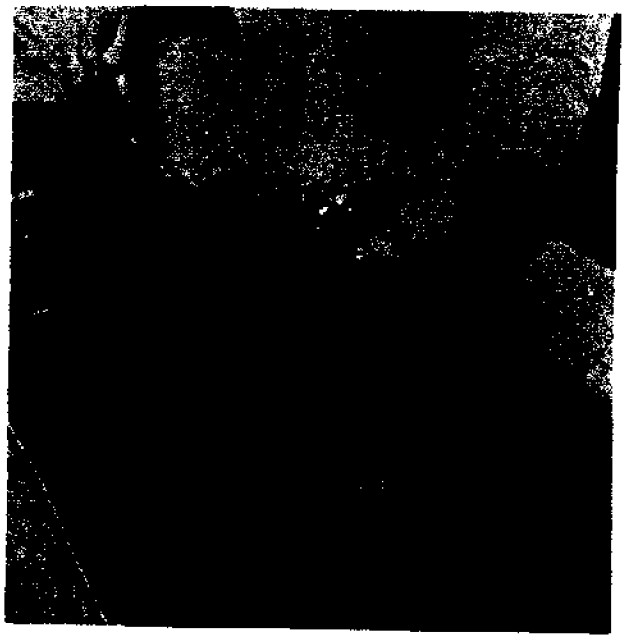


Aquaculture

MARINE POLYCULTURE BASED UPON NATURAL FOOD CHAINS AND RECYCLED WASTES

A biological tertiary sewage treatment-marine aquaculture system has been developed, tested, and now evaluated for over more than a one-year period on a "pilot-plant" scale at the Woods Hole Oceanographic Institution's Environmental Systems Laboratory. The effluent from secondary sewage treatment, mixed with seawater, is used as a source of nutrient to grow single-celled marine algae (phytoplankton) in mass (35,000 gallon), continuous flow-through cultures. Harvest from the algal cultures (experimentally varied from 25% to 75% of the culture volume/day), diluted with seawater, is fed into 40' × 4' × 5' (deep) cement raceways containing stacked trays of shellfish. The latter, stocked at densities ranging from 75,000 to 150,000 animals/raceway (1,500-3,000 per tray) have consisted of the American oyster *Crassostrea virginia* and the hard clam *Mercenaria mercenaria* , with smaller numbers of other shellfish species. The phytoplankton remove the nutrients from the sewage effluent, which has varied experimentally from 10% to 50% in the effluent-seawater mixture. The shellfish remove the phytoplankton from the water. Effluent from the shellfish cultures (i.e., the pond harvest and diluting seawater) prior to its discharge is passed through a culture of seaweeds, grown in suspended culture in raceways which serve as a final polishing step, removing nutrients not initially assimilated by the phytoplankton and those regenerated by excretion of the shellfish and decomposition of their

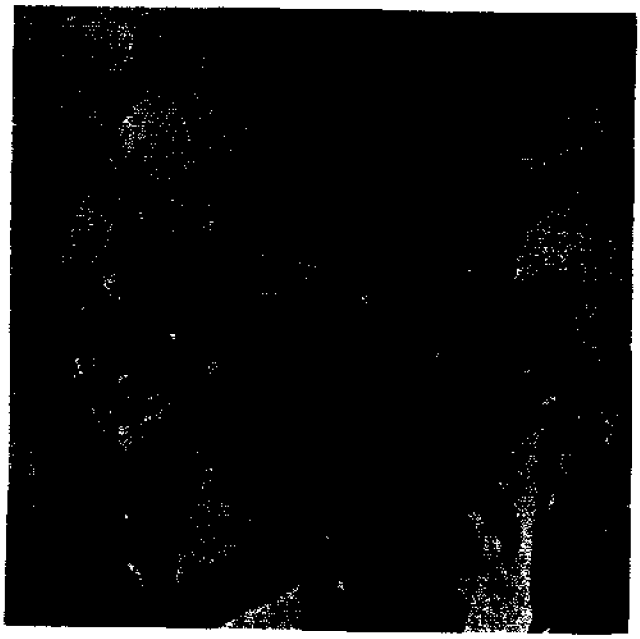
solid wastes. After initial experimentation with several seaweed species, research was concentrated on two red algae of potential commercial value, *Gracilaria foliifera* and *Agardhiella tenera* (which contain the polysaccharides, agar and carrageenan respectively).

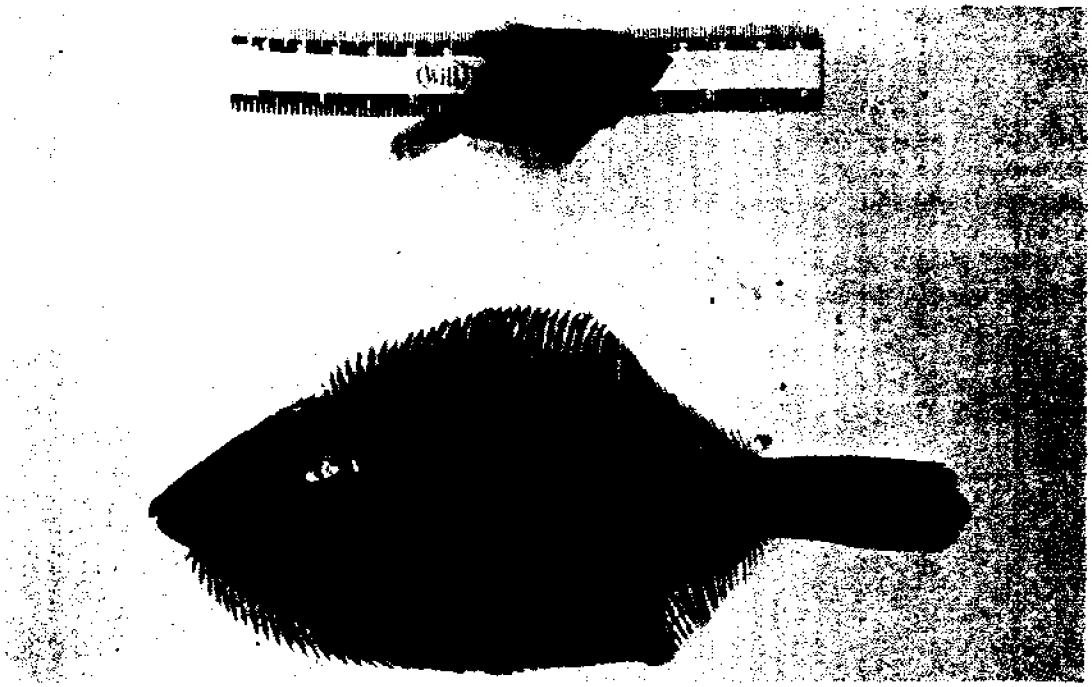


Solid wastes produced by the shellfish and uneaten phytoplankton support dense populations of small invertebrates (amphipods, polychaete worms, etc.). These serve as food for secondary commercial crops of marine animals, the American lobster *Homarus americanus* and the winter or blackback flounder *Pseudopleuronectes americanus* which were stocked in respective raceways with the shellfish.

The primary objective of the research is to develop a biological tertiary sewage treatment process capable of removal of all inorganic nitrogen from secondary sewage effluent prior to its discharge into the environment. Earlier studies had established the fact that nitrogen is the nutrient limiting and controlling algal growth in and eutrophication of the coastal marine environment. Thus nitrogen removal may be considered as synonomous with tertiary sewage treatment of effluents to be discharged to the sea.

The second objective of the process is to develop a marine aquaculture system consisting of a primary crop of shellfish and secondary crops of other commercially-valuable marine organisms (seaweeds, lobsters, finfish), the value of which will pay for or help defray the cost of the tertiary sewage treatment process.



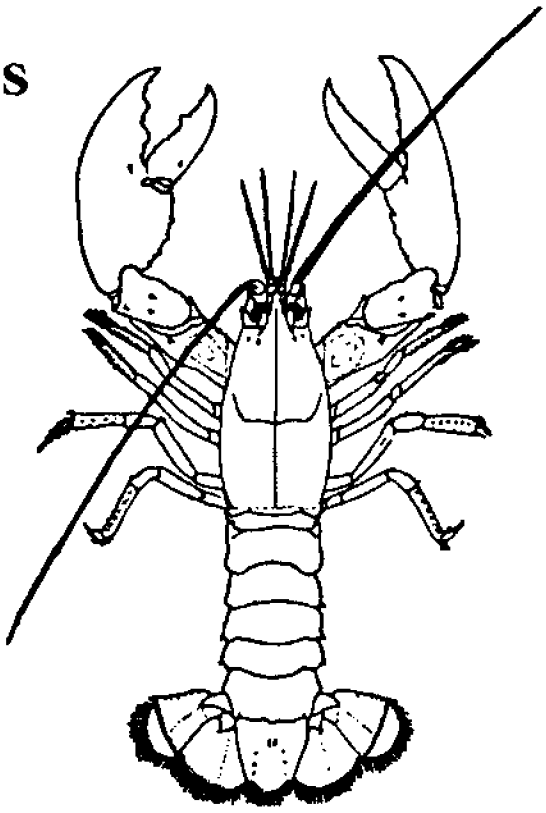


Potential users of the system are coastal communities in the tropics or subtropics where sufficient land is available (ca. 25-50 acres/10,000 capita) to add the system to a present or future secondary sewage treatment system. Smaller scale studies are currently being undertaken in Fort Pierce, Florida. Growth yields, and nutrient removal by both unicellular algae and seaweeds are being studied on a seasonal basis. While it is unrealistic to compare the performance of the pilot-scale Woods Hole facility with that of the smaller Florida project, preliminary indications are that growth and nutrient removal of both unicellular and macroscopic algae are, on the average, considerably greater throughout the year in Florida than for the Spring to Fall period in Woods Hole. On that basis, extrapolation of the seasonal performance of the Woods Hole system to a year-around operation in a climate such as Florida is not unreasonable and may be conservative. Because the marine organisms in question, except for the phytoplankton, grow slowly or not at all at temperatures below about 15° C (60° F), the system is unsuitable for year-around operation in temperate or more northern climates. Seasonal operation in coastal resort areas at temperate latitudes, where both population pressure and the need for tertiary sewage treatment are greatest in summer, is a practical alternative. Population size is not a constraint *per se*, but initial applications should be small, utilizing the wastes of 10,000-100,000 capita, until experience

with the system is gained. Application should be restricted to communities producing largely if not exclusively typical domestic wastes with little or no inputs of industrial wastes. Wastes that comply with most existing water quality standards are satisfactory. An economic evaluation of such a waste water-aqualculture system has been conducted. The largest of these systems, treating the waste water from a city of 100,000 people and using free heat from a power plant effluent (or located in a warm climate) could be profitable.

Living Resources

BEHAVIOR OF LOBSTERS IN A SEMI-NATURAL ENVIRONMENT AT AMBIENT TEMPERATURES AND UNDER THERMAL STRESS



Homarus americanus

The American lobster *Homarus americanus* is a marine inshore crustacean both of major economic importance and of intrinsic interest. Two approaches have contributed to the knowledge of lobster behavior. One is comprised of laboratory studies under controlled and structured conditions by various investigators. For instance, the study of shelter-related behavior and activity of the animal as well as aggressive communication and interactions and effects of isolation versus group-holding conditions on aggressive behavior have been described quantitatively. Finally, a relationship between dominance and molting patterns in pairs of juvenile lobsters has been demonstrated. However, as in most laboratory studies of behavior, application of findings to the natural environment may be limited.

At the other extreme are studies of lobster activity, migration, and shelter-related behavior under field conditions. Lobsters are nocturnal, however, and direct observation of behavior is difficult under field conditions. Questions such as whether lobsters are territorial can be approached only in an indirect manner. For instance, through repeated observations of lobsters in the same burrows, rather than in defense of territory.

An approach which bridged the gap between these two types of studies was needed. The main interest was in a long-term view of the behavior of individual lobsters living in an environment with as much space as possible, ample shelter, and a variety of other organisms which co-occur with *H. americanus*

locally. This necessitated a compromise between a field study and more highly structured laboratory approach to behavior.

The primary objective of this study was to observe the behavior of *H. americanus* under conditions approximating the natural state. A second objective was to observe effects of higher than normal temperatures on the behavior of lobsters and other organisms in our naturalistic habitat.

The reward of this approach was information about lobster behavior which would have been difficult to obtain by other methods. Perhaps more important than the data *per se*, however, are the questions raised which are of interest to the student of lobster behavior and ecology, and those interested in lobster culture.

In January, 1974 we established semi-natural habitats in two 10 ft diameter, octagonal aquaria, with five lobsters in each, plus several crabs *Cancer irroratus* , eels *Anguilla rostrata* , winter flounder *Pseudopleuronectes americanus* , and cunner *Tautoglabrus adspersus* . The lobsters, with respect to size and sex, were identical as possible between tanks, as were the numbers of other species. The aquaria, which received ambient seawater, were arranged identically with an oyster shell substrate, and cement blocks, rocks, and ceramic pipes to provide a surplus of shelters.

Observations, spanning from February through August, were made both during the day, following feeding, and (using red light) just after sunset, when lobsters are active under natural conditions. Types of behavior we were able to quantify included occupation of specific shelters, feeding, activity, and social behavior.

Lobsters in these large laboratory aquaria appeared to be much less aggressive than generally has been reported. Aggression was most frequent during feeding. Observations at night revealed few encounters, and these were usually either one sided avoidance without pursuit, or mutual ritualized displays.

Neither an animal's size nor sex seemed to determine its relative dominance. Dominance shifted somewhat between different animals during the study, complicated by territorial behavior in the larger individuals. In one tank, only the two adult females were territorial from February through mid-May, following which no lobster showed stability of residence. In the second tank, only one animal, a female, was territorial for more than several weeks, until early June, when the largest male established a reproductive territory lasting until the end of August. The large aquaria space may have been too limited for all animals to be territorial.

Lobsters appeared to lose their position in the hierarchy just prior to, and for up to a

month or more following the molt. Such animals were often observed on top of shelters, in exposed locations, where other lobsters apparently did not harass them. Although captive lobsters are considered quite cannibalistic, we lost only one animal, a juvenile female, out of six molts.

Female lobsters about to molt sought out, took up residence, and actively courted the tank's largest male. The males were very non-aggressive toward these females, and yet during this period made violent attacks against other males as well as fish. In each case following mating, the males returned to the shelter and fed on the cast shell. Cohabitation, in or around the males' residences, continued for several days following mating.

Diurnal activity, which was evoked by the presence of food, showed little change over the range of 5-28° C. Nocturnal activity, which was more spontaneous, was similar in both tanks through mid-June (range 5-18° C). The level of activity was as high in late February - early March as in late May, with a dip in activity in late March - late April, a period marked by storms. From mid-June on, the nocturnal activity in tank I increased with the increasing temperature, leveling off when the peak temperature of ∿28° C was reached. In contrast, activity in tank II did not increase at temperatures above 20° C, and remained at a much lower level than in tank I.

Although patterns of residence and dominance in the lobsters changed seasonally, the direction of change was rather different in each tank and did not seem correlated with temperature. Other factors, such as molting and loss of dominance prior to mating in previously aggressive females, were probably more important than temperature effects. The frequency of aggressive behavior in the temperature range 22-28° C was similar to levels at ambient temperatures.

Interspecific relations between lobsters and other species were mainly pacific, although predation on *Cancer* by *H. americanus* may have occurred.

The response of the eels to temperature increases was consistent between tanks. Swimming was first observed at 8° C, and feeding at 10° C. Further, the eels in both tanks became markedly aggressive when the temperature reached 26° C.

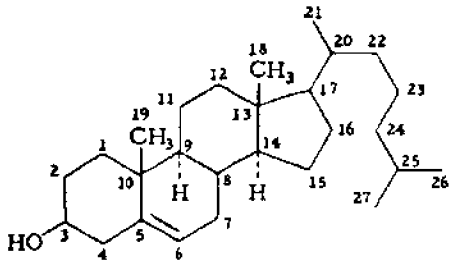
Deleterious effects of thermal stress on lobster behavior seem unlikely in the temperature range 4 to 28° C or with sudden increments not exceeding about 5° C. One must be cautious, however, in assuming that no harm will be done to the population as a whole, since other life stages--embryonic, larval, juvenile--were not studied.

THE SOURCES OF IMPORTANT BIOCHEMICALS IN MARINE CRUSTACEA

Successful culture of marine crustacea is dependent to a large extent on the understanding and control of diseases. The analysis of the organisms metabolic products provides us with information to better evaluate dietary or stress factors, or to detect crustacean diseases through the detection of metabolic disorders. From these metabolic studies, it is also possible to study the compounds and the biochemical processes responsible for aggression in lobsters. Lobster aggressiveness is one of the major problems in lobster culture work and results leading to its control would be quite beneficial to increased yields.

Hormones have been used quite successfully by agricultural researchers in the control of growth of insects both in increasing and decreasing their size. Studies involving these steroidal reproductive, respiratory, and growth hormones in lobsters could lead to both increased size of the animals and the speed at which they attain it.

Although the isolation and structure determination of these steroidal organic compounds in crustacea have received a great deal of attention in recent years, very little work has been accomplished on the sources of these compounds in marine animals. Previous work has shown that most species of crustacea cannot biosynthesize important biochemicals



stereochemical configuration and numbering system of cholesterol

such as cholesterol or other sterols (steroid alcohols) through normal biosynthetic pathways. Selected crustaceans, e.g., lobsters, shrimp, and crab can, however, biosynthesize cholesterol from other sterols such as campesterol, β-sitosterol, ergosterol, and brassicasterol. Cholesterol and these sterol precursors to cholesterol must, therefore, be acquired by crustacea from external sources in the form of food such as marine invertebrates, phytoplankton, and fish or through absorption or filtration of sterols from the dissolved or particulate fraction of seawater.

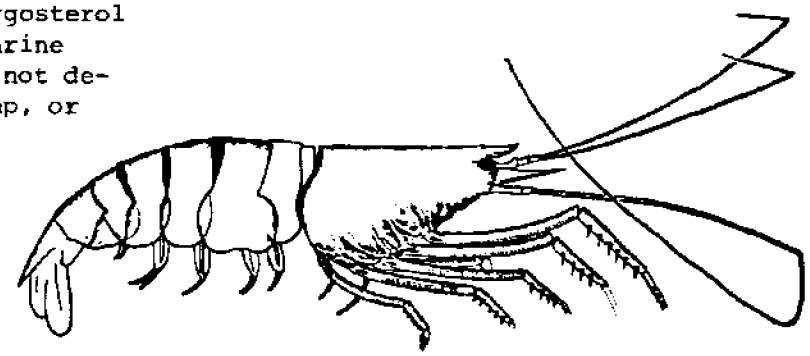
Sterol distributions for the lobster *Homarus americanus* and shrimp *Pandalus borealis* have been determined. Cholesterol was found to be the most dominant sterol in both species. This is consistent with previous results of other workers that cholesterol is the most abundant sterol in the advanced invertebrates. The more primitive invertebrates have much more diversified sterol compositions. Also found were 24-methylcholesterol and 24-ethylcholesterol and to the

best of our knowledge, these two compounds have not been reported previously for any species of marine decapod crustacea of the suborder *Macrura*. Desmosterol, 24-methylenecholesterol and 22-dehydrocholesterol, three sterols observed in our samples, are the only sterols reported in decapods other than cholesterol. Fucosterol, a common brown algal sterol; brassicasterol, a diatom sterol; stigmasterol and norcholestadienol were not detected by our procedure.

Examination of the sterol distribution in the lobster's and shrimp's seawater environment revealed the presence of cholesterol and β-sitosterol as the major sterols with high concentrations of campesterol in early summer phytoplankton blooms. Lower concentrations of other sterols such as fucosterol, 24-methylenecholesterol, 22-dehydrocholesterol, norcholestadienol, brassicasterol, and stigmasterol were also found.

One of the major sources of campesterol in the marine environment appears to be marine yeasts. In addition, a few species of phytoplankton, and molluscs have also been found to contain small quantities of campesterol. Although ergosterol is the major sterol in marine yeasts and fungi, it was not detected in lobsters, shrimp, or seawater. This sterol may, therefore, be metabolized rapidly to cholesterol or any other organic compounds by crustacea or is possibly metabolized by microorganisms in seawater. A major sterol in terrestrial plants is β-sitosterol. It may enter the marine environment through river runoff or aeolian transport on particulates. This sterol has also been found in coastal grasses in the Gulf of Mexico and in low concentrations in molluscs.

As mentioned above, lobsters and shrimp are able to convert campesterol and β-sitosterol to cholesterol; however, low concentrations of these two sterols still persist in these animals. Both these sterols are over 10^4 times higher in concentration in *Homarus* and *Pandalus* when compared with sterols isolated from the animal's seawater environment. These crustacea, then, are not converting all the ingested campesterol and β-sitosterol to cholesterol, and a steady state concentration of these two compounds appears to exist in these organisms. More work, however, is clearly needed before this hypothesis is proven.



Pondulus borealis

From our results, it appears that caution should be exercised when comparing sterol distributions among members of the same species sampled from different locations. The sterol content of the marine fauna and flora in the animals' surrounding oceanic environment should also be considered. The sterols present in the animals' seawater environment may be an indication of this faunal and floral contribution to the overall sterol content of the animal.

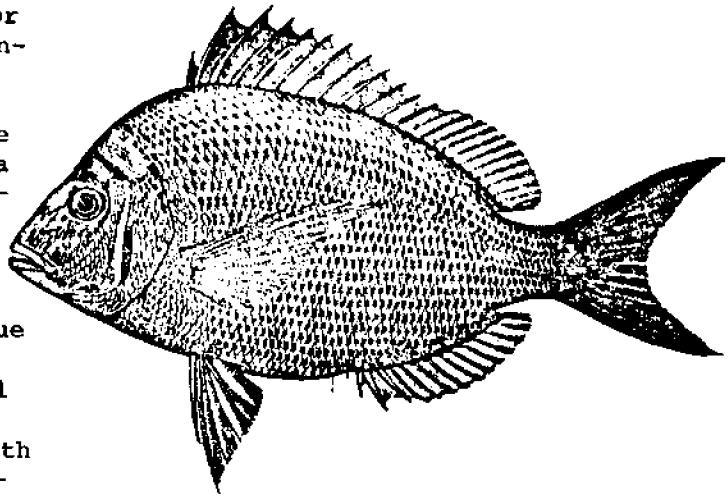
EFFECT OF PETROLEUM HYDROCARBONS IN MARINE FISHES

Studies of the metabolic and biochemical effects of low levels of petroleum hydrocarbon contamination in fish have been initiated, and are continuing. The aims of this work are 1) to develop and evaluate methods for detection of effects of environmental levels of petroleum hydrocarbons in marine fish, and 2) to evaluate the significance of potential effects in an area where an increased input of petroleum is expected.

We have examined carbohydrate (energy) metabolism and lipid metabolism in liver tissue of the marsh minnow *Fundulus heteroclitus* and the commercial species *Stenotomus versicolor* which have been contaminated with petroleum hydrocarbons both experimentally and in the environment. We find that low level (<1.0 ppm) contamination produces little or no change in the rates or pathways of carbohydrate utilization in either species, when measured after a period of at least eight days exposure. There does, however, appear to be a reduction in the rate at which lipid is synthesized in contaminated fish.

By separating the various types of lipids we were able to determine that phospholipid and cholesterol, major components of cell membranes, and triglyceride, the major energy storage lipid, were being produced at different rates in various contaminated and control fish. *Fundulus* exposed to 180 parts per billion of petroleum hydrocarbon for eight days showed greatly increased rates of cholesterol synthesis while those environmentally contaminated over a period of months showed elevated rates of phospholipid synthesis. Electron microscopic examination of liver cells shows greater amounts of endoplasmic reticulum within the cell and less fat in environmentally contaminated fish than in uncontaminated fish. These identified structural changes are consistent with the above biochemical changes.

Stentomus versicolor (Scup)



The type of differences in phospholipid and cholesterol have suggested to us that intracellular membrane is being affected by petroleum in some contaminated fish while in others the plasma membrane at the cell surface is affected. How petroleum hydrocarbons might elicit the changes suggested by our data is at this point uncertain. Our studies do suggest that petroleum effects on these processes are dynamic and differing exposure periods and exposure levels will produce a variety of responses. In any case, such changes can be expected to considerably alter the function of these membranes and the activity of enzymes located in the membrane structures, thereby altering the normal activity of the cell.

Also continuing is our investigation of the mechanism of the hydrocarbon metabolizing system in fish and the effects of petroleum on various parameters of this system. We believe this system will be very useful as a low level pollution effect indicator, as well as in providing further information concerning the potential effects of petroleum. Currently we are determining levels of activity of this enzyme, the mixed function oxidase system in several species, and are studying the details of the enzyme system so that the effects of exposure will be able to be validly interpreted.

It is clear from our studies that fish are able to metabolize hydrocarbons enabling them to more readily dispose of the contaminant. Factors such as nutritional status, sex and habitat temperature have been identified as probable modifiers of this ability. A valuable offshoot of this work is the basic information which can be used by others investigating the mechanisms of petroleum hydrocarbon metabolism. For example, we have determined that in some fish species, the ligand in the enzyme active site is the imidazole of the amino acid histidine.

To date we have been successful in identifying certain distinct changes in cellular metabolism and structure which result from petroleum hydrocarbon contamination of fish. We have also identified the hydrocarbon metabolizing system in fish and some factors which might alter its activity. Our current and future studies will expand our knowledge of these and other biochemical parameters, in order to develop the most useful and convenient indicator for detecting effects of petroleum in fish, and firmly determine the nature and seriousness of low level effects of petroleum.

Socio-Economic and Legal Studies

LIMITED EFFORT PROGRAM FOR THE NEW ENGLAND FISHERIES

The New England fishery is faced with a combination of rapidly declining catches of traditional species (largely as a result of improved technology and increased effort by foreign fleets), likely extension of the coastal resource zone to 200 miles, and probable adoption of a National Fisheries Plan. Although the International Commission for the Northwest Atlantic Fisheries (ICNAF) will probably continue to regulate the fishery through catch quotas for U.S. and foreign fishermen even after an extended resource zone and/or a national fisheries plan are enacted, increasing quotas and catches can be expected for the U.S. fishermen under an extended resource zone. Foreign fleets would undoubtedly be allowed to continue fishing within the 200-mile zone because of their historic rights, but they will be more restricted in their catches than they have been by ICNAF regulations alone. It is expected that New England fishermen will be allowed gradually to increase their catches and take over a larger share of the fishery.

Certainly New England fishermen speak enthusiastically not only of having exclusive rights to the species they have traditionally sold on the fresh market but also of the possibilities of expanding catches of fish to be processed in U.S. ports.

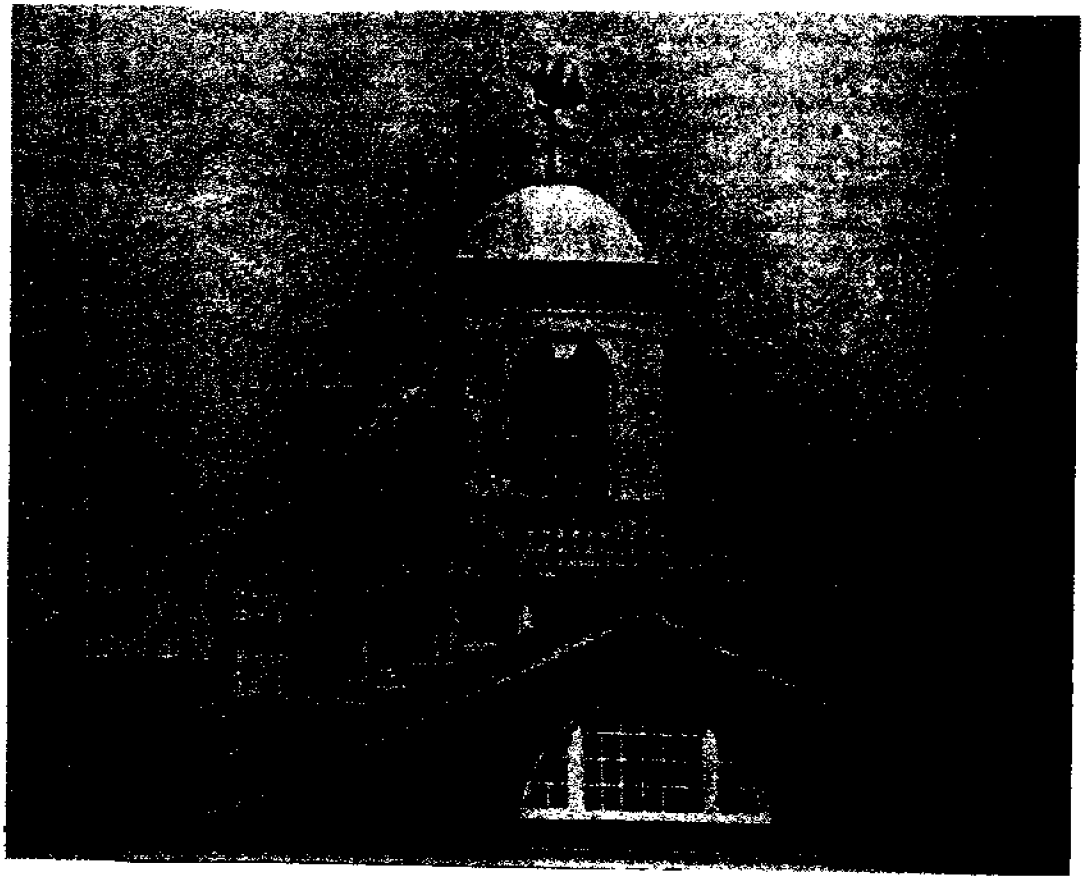
Existing regulations of the New England fishery concentrate on biological issues. The National Marine Fisheries Service (NMFS) collects biological data to assess the spawning, recruitment and distribution of various commercial species. The ICNAF quotas by country and by species are supplemented by closed areas and seasons and on mesh size. However, the regulations do not consider directly the men and boats engaged in the fishery. It seems necessary to consider the economic and social conditions of New England's fishing industry before any further regulations are proposed.

We plan to make several suggestions for regional fishery management, incorporating social and economic data on New England fishermen, information from limited effort programs elsewhere, projections of U.S. quotas of fish in the Northwest Atlantic, and possible changes in the U.S. territorial limits.

In order to suggest several plans for managing the New England fishery, information has been gathered since July 1974 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 interviews have elicited information about fishermen's experience, personal background, attitudes, and economic situation as well as physical data on their boats and fishing operations. So far the following ports have been examined: New Bedford, Chatham, Provincetown, Gloucester, Boston, Rye, Rockland and Portland. Information about fish processing in these ports has also been collected, since processing is a vital shore-based aspect of the fishing industry. We have prepared a paper describing in detail the fish processing industry in New Bedford.

Information about limited effort programs in individual states and other countries has been gathered and summarized as another step in preparing suggestions for a New England fisheries management program. We have written a paper describing some elements of fisheries management with particular emphasis on programs which limit entry.

In the remainder of the research period we shall continue to collect the information described above for the other New England ports. Then we plan to build descriptive models of the fishery and recommend elements of a New England fisheries management plan.



MARINE POLICY AND OCEAN MANAGEMENT

A major change for the Program in 1974-1975 was the initiation of a major group project. The subject selected was the interaction between fishermen and a possible offshore petroleum industry off the East coast. Supplementary funding was obtained from the American Petroleum Institute to provide support for travel, workshops, and the employment of a consultant from the fishing industry. The study involved the participation of the Marine Policy and Ocean Management fellows and an advisory committee formed from the staffs of the Woods Hole institutions.

The project addresses the interactions to be anticipated between a possible offshore petroleum industry and the domestic commercial fishing industry off the East coast asking the following questions: What will be the nature and character of the interaction? What specific areas of conflict and cooperation can be identified? What recommendations can be made to minimize conflict and maximize cooperation?

The final report will also attempt to be generally useful by describing in some detail the character and technology of both

the offshore petroleum and fishing industries, the physical environment of the Atlantic OCS, and the legal and regulatory framework governing OCS development.

The study approach taken was primarily pragmatic and judgmental rather than analytic. Team members made field trips to the Gulf of Mexico and to the North Sea. Contributors to the study included a working member from both industries. Some new information was developed by a workshop involving oil industry representatives and working fishermen as well as by interviews with fishermen. Extensive interviews were conducted with many individuals in the Federal agencies. All the state governments in the New England and Mid-Atlantic regions were visited in order to see how the states were planning to deal with offshore developments. As varied as these activities were they consistently identified the same rather limited number of problems which can be anticipated as potential sources of conflict between the two industries.

The study addresses these conflicts in three categories: At Sea (loss of fishing space, obstructions, navigation, etc.), On Shore (harbors, services, etc.), and Pollution Effects. Attempts will be made to estimate the possible significance of these to the fishing industry as well as to suggest how the effects can be minimized.

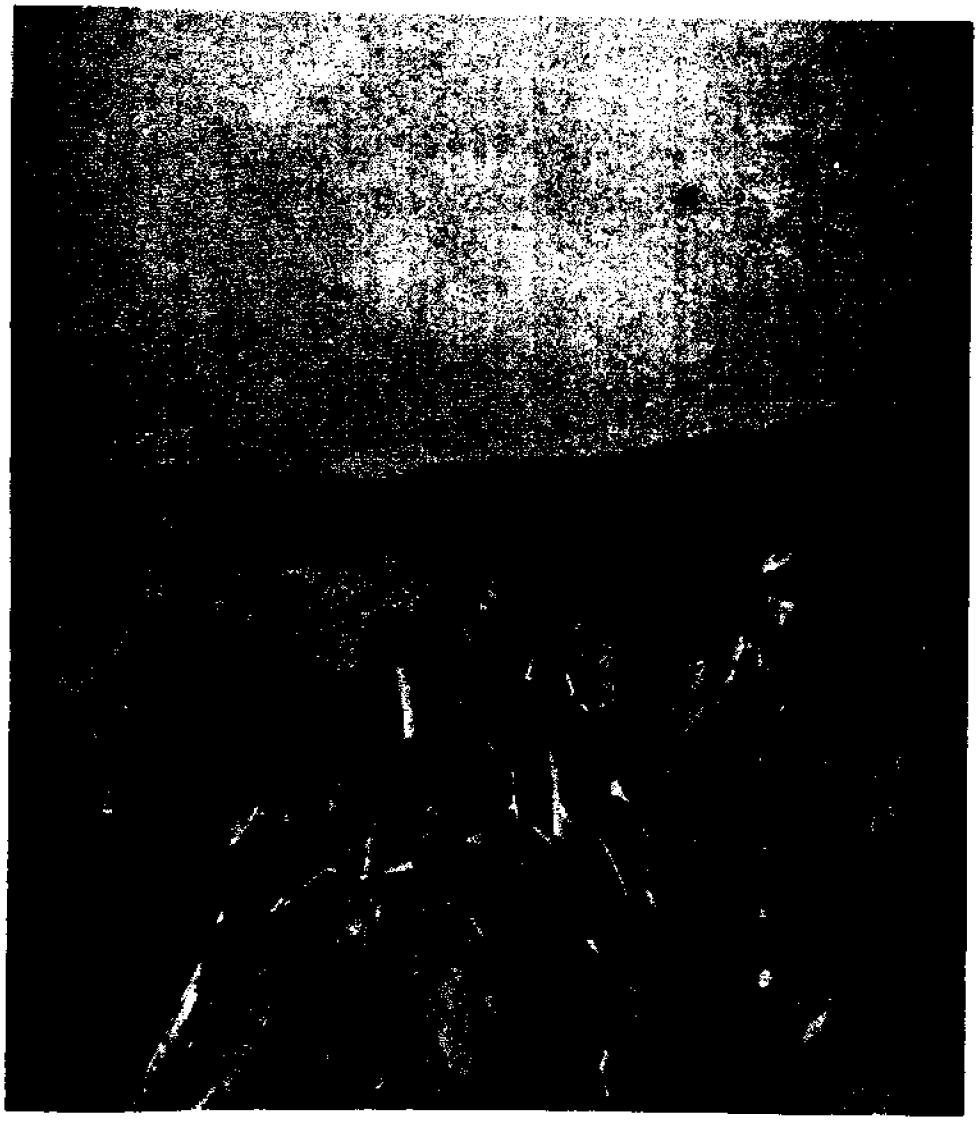
A second workshop where preliminary results were presented was held in mid-September 1975.

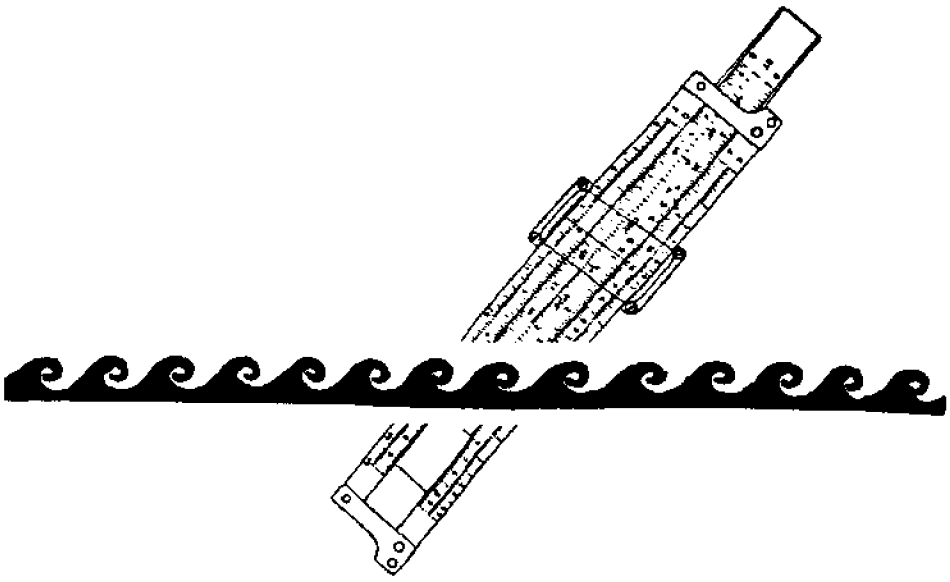
Another joint study was pursued during the year on the London Dumping Convention. This is an attempt to combine the scientific background with an international legal analysis of the treaty.

In addition to these joint study activities, Fellows pursued individual programs of research and education including:

- Legal and regulatory aspects of OCS development
- Some aspects of International Law of Gas and Oil and delimitation of continental shelf areas in certain regions.
- International legal problems concerning the insurance and re-insurance of the risks connected with open sea mining.
- The binding force of the convention of the Law of the Sea upon third parties.
- Development of offshore petroleum resources in the People's Republic of China.
- Marine affairs in Latin America, oil pollution problems.
- Limited effort programs in the New England fishery.

The J. Seward Johnson Lectures included: Coastal Zone Management and Offshore Oil Development, Federal vs. State Relationships by Senator Ernest F. Hollings and Energy and Marine Resources by the Honorable Dixy Lee Ray, Assistant Secretary of State.





Marine Technology Research and Development

HIGH RESOLUTION SUB-BOTTOM PROFILING

It is the plan of this project to improve geophysical reflection seismography by designing a large parabolic downward looking acoustic reflector system which would provide a much higher directivity and signal to noise ratio. Its use should result in better resolution of thin, translucent or warped sedimentary layers. This technique capitalizes on the fluid medium rather than being merely an extension of land developed techniques.

The physical validity and geologic usefulness of the concept has been discussed with a wide range of acousticians, engineers and geologists. The idea was met with considerable enthusiasm as one technically proper way to approach the problem of improved seismic techniques for limited area study.

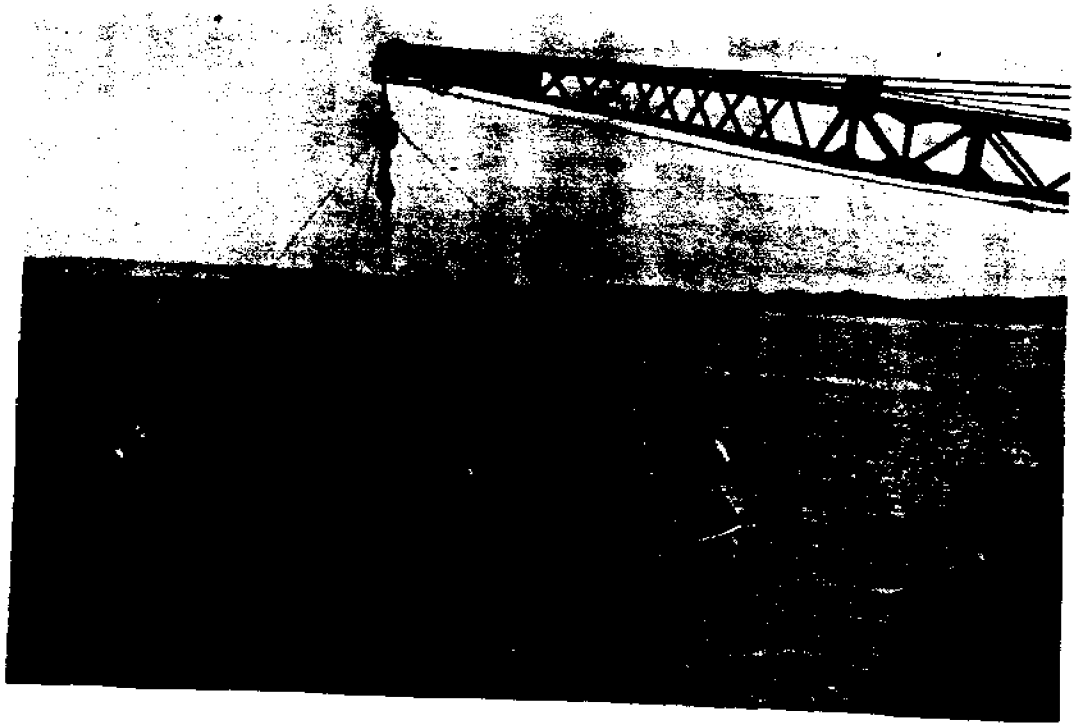
A 10-foot diameter aluminum parabolic reflector with a 38-inch focal length was purchased and covered with neoprene sheeting cemented to the concave surface of the reflector, thus providing a smooth, continuous underwater reflective surface. A 12 kHz transducer (UQN-1-B) was mounted at the focal point and the reflector suspended at a water depth of 5 to 8 feet from three floats.

This suspension configuration resulted in unstable reflector attitudes during initial tow tests, hence a model was made and several flotation systems were studied under simulated towing conditions in the MIT tow tank. The test configuration that appeared to be best was that of a single float with a three point suspension of the reflector beneath. A styrofoam float was

fabricated and shaped for minimal wave disturbance and maximum vertical dampening of the system. This method also allowed a means of flipping the reflector to the surface so it could be skimmed along at a much faster tow speed. Two days of testing in calm water showed the reflector stability to be speed dependent, in tow depth ranges from 12-18 feet at speeds of 1/2 to 4 knots. Surface towing was achieved at a maximum speed of 8 knots.

Several modifications to the 10-foot reflector were made subsequently. A horizontal stabilizer and vertical fin were attached as well as a 20-foot mast to more clearly indicate the reflector attitude when submerged. Once proper reflector and tow line lengths were determined and stable tow attitude determined the reflector was able to be towed submerged at speeds up to 5 knots.

Attention was then turned to a larger 28-foot model so that some actual sub-bottom profiling could be done. A military surplus radar antenna (28-foot diameter aluminum dish) was acquired. It consists of six equal-size outer sections with a 14 x 16 foot hexagonal center section. The entire concave surface was covered with plywood panels to which 1/4 inch neoprene sheeting was bonded. These panels were then wired to the dish screening to form a continuous curvature of 720 square feet. A hexapod to hold the acoustic transducer was fabricated from aluminum pipe and guyed at the focal point (13 ft).

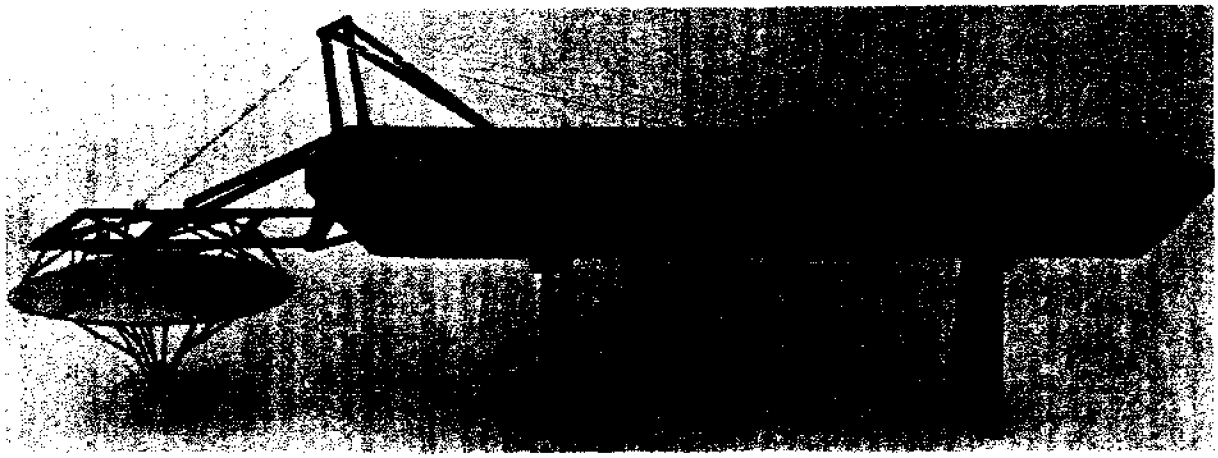


Tests and calibration of the transducer assembly from the W.H.O.I. wharf four feet below the surface of the water showed the beam width to be about 3° to the half-power points with a 3.5 kHz transducer array kindly loaned by the Geological Survey.

The next phase was to try some actual handling and seismic profiling since increased gain and resolution of the system had been demonstrated. The center section was bolted in and four ORE TR-75A 2.5 kHz transducers were mounted in the hexapod. To deploy the dish it was decided to utilize an 80 foot crane fixed to a 90 x 30 foot barge with a tender supplying mobility and electric power. Initial testing at dockside gave too many extraneous echoes so two short cruises away from the pier were undertaken. Another test in Vineyard Sound done in a light chop with 3 to 4 foot swells caused the dish to oscillate erratically so the graphic results obtained were intermittent in their usefulness. However, it was apparent that sub-bottom profiles were showing about 10% of the time, though no typically conventional profile was obtained.

The viability of this system will come only when financing will permit appropriate rigging and a modest amount of test time in local waters. Logically linked coupling of a structurally improved reflector to a stable barge hull would eliminate much random wave excitation and provide the stable platform required. A deployment system would allow the reflector to be lifted clear of the water while in transit.

The preliminary investigation does seem to indicate significant improvements in both signal to noise ratio and three dimensional resolution over multichannel sources.



DEVELOPMENT OF AN ACOUSTIC PROBE FOR OCEAN BOTTOM AND SUB-BOTTOM SURVEYS

Past experience has indicated that high frequency echo-sounders operating in shallow water are capable of up to 40 fathoms penetration of the bottom, at least in some areas.

Some time ago we considered the idea that if a high powered, high frequency short pulse echo sounder were to be designed to operate close to the bottom in any depth of water, the structure of bottom and sub-bottom sediment layering in many areas of the world might be resolved in considerable detail. For example, the resolution at 12 kHz could theoretically approach six inches.

The chances that such resolution along with good penetration could be realized in actual practice are increased tremendously by the fact that both transmitter and receiver would be operating close to the bottom thus eliminating the high attenuation of the high frequency sound over the long two-way transmission path between surface and bottom in deep water. Also, the full power of the transmitted pulse is now concentrated over a small area of the bottom and hence the averaging of returns from a wide region which may be far from uniform, no longer takes place. Also confusing side echoes vanish.

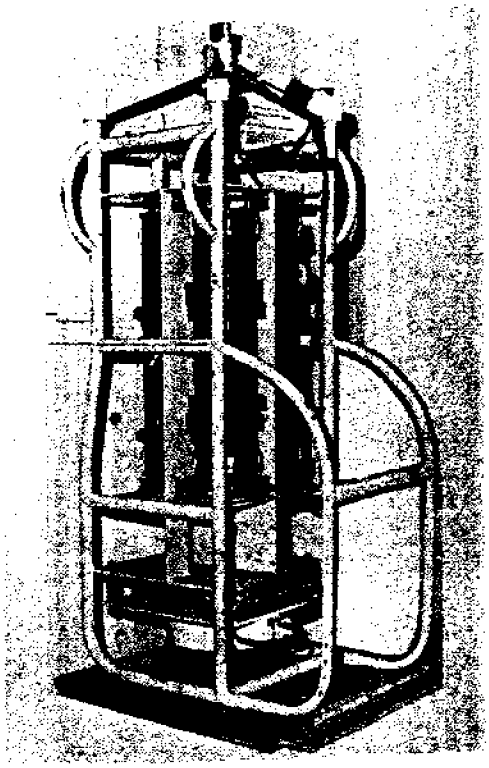
If the reflectivity of various common sediments were known from prior measurement, and if the receiver in the deep gear was calibrated, and made amplitude linear over a wide dynamic range, it might be possible not only to micro-contour bottom and sub-bottom layering, but eventually to *predict* from reflectivity their probable composition and mineral character.

With these concepts in mind a proposal was submitted to Sea Grant in 1974 to design and construct an experimental sounder along these lines.

Specifications of the transmitter called for an extremely short (250 μsec) high level pulse containing only 1-2 cycles of energy at 12 kHz, and a peak power approaching 120 dB/microbar, or up to 30 dB higher than conventional sounders. The receiver would have a dynamic range of 80 dB to accommodate the wide range of amplitudes expected in bottom and sub-bottom returns. The deep sounder would be self-contained, battery operated, and capable of being lowered to 20,000 feet in the ocean by the 1/4-inch diameter single conductor logging cable which is standard equipment on most of our vessels. The electrical conductor would serve to relay a trigger pulse, originating at a graphic recorder keying contact,

to fire the deep transmitter, and also to conduct output signals from the deep receiver back to the same recorder for display purposes. A perfectly synchronized record would thus be produced on line, and all data would also be recorded on magnetic tape for future analysis.

The electronics of the deep instrument are contained in three titanium pressure cases mounted within a frame. One case houses the transmitter, another the receiver together with its power supply consisting of rechargeable alkaline cells, and the third case contains the transmitter power supply consisting of an 18 volt, 21 A.H. stack of silver cells capable of operating the transmitter continuously over an eight hour period before recharging.



Adjustable lead bar weights help to trim and steady the package in the upright position. By increasing the total instrument weight to 420 lbs, they also help maintain tension on the logging cable thereby permitting a safe lowering speed of 60 meters per minute without danger of cable relaxation and kinking.

The transducer is a 12 kHz ADP crystal unit similar to the familiar EDO type UQN-1.

A single six-foot relay rack houses all the gear required to operate the system except for recording. These include a monitor scope, a line amplifier and filter system for processing the signals from the deep receiver prior to readout on a Precision Graphic Recorder, a calibration signal generator, a special trigger generator which supplies pulses to fire the deep transmitter, a keying chassis for the generator, and various power supplies and battery chargers to operate these units and to recharge batteries in the deep instrument.

On a trial cruise several lowerings were made in an area just north of Bermuda. The records showed multiple layering to about 15 fathoms depth where a layer apparently impervious to 12 kHz effectively prevented deeper penetration. Resolution appeared to be excellent to this depth, although the on-line records were difficult to read because severe ship-roll caused the logging cable to execute vertical excursions up to 12 feet in amplitude.

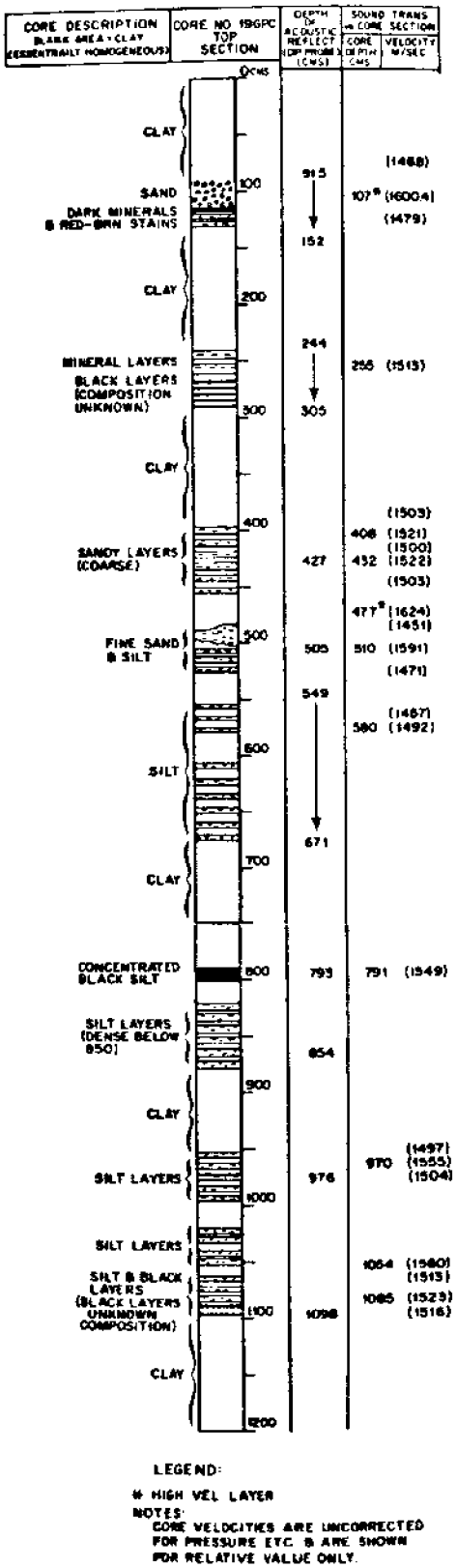
A later two-day trial cruise proved that minor electronic problems encountered in the earlier cruise had been effectively solved in the interim, and that the system was now working as designed.

The best proof of the potential and utility of the new instrument would be realized if the acoustic records of bottom and sub-bottom structure could be substantiated by actual sediment cores taken at the same site.

An excellent opportunity to do this was offered on an expedition to the Rockall Trough area southeast of Iceland where operations with the Giant Core were scheduled.

Stratigraphic columns were made from the core samples and compared with the acoustic reflectors shown on the record from the Deep Probe. These were also compared with sound velocity measurements on the core sample. The absolute values may appear low because they are uncorrected for static pressure, etc., but the relative measurements tell the story. In each case, as expected, there is an abrupt increase in velocity in each layer of silt or sand vs. the adjacent material. This produces a reflective interface which coincides neatly with the corresponding depth of reflectors as recorded by Deep Probe.

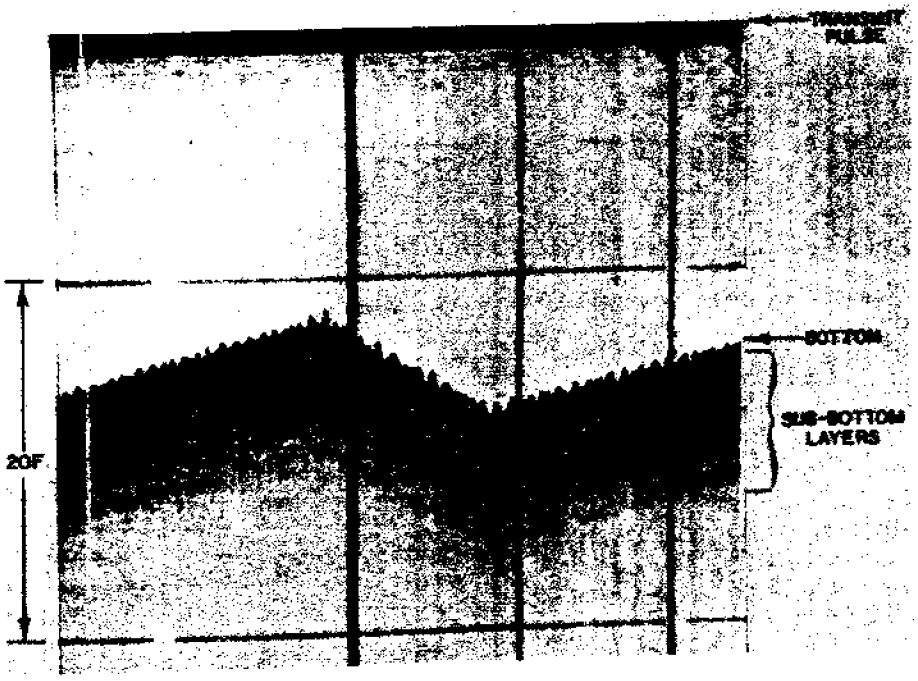
A typical record (shown on the following page) for another area, with the deep probe located 15-20 fathoms off the bottom, shows there are 8 sub-bottom layers spaced from two to six feet apart with random structure between.



For comparison, the same area as viewed from the surface through 1360 fathoms of water via the ship's profiling echo-sounders (set for highest resolution) revealed only the two strong reflectors shown at depths approximately six and twenty-four feet below the seafloor, and these two layers were comparatively hazy and ill-defined. The complete analysis of the Deep Probe records coupled with further study of sediment material in the corresponding cores should improve our capability to predetermine the general composition of such sediments by acoustic means.

To sum up, we now believe we have ample evidence that Deep Probe is capable of producing an accurate indication of bottom and sub-bottom reflective layering to depths ranging from 40-240 feet below the seafloor depending on the transparency of the sediments to 12 kHz transmission.

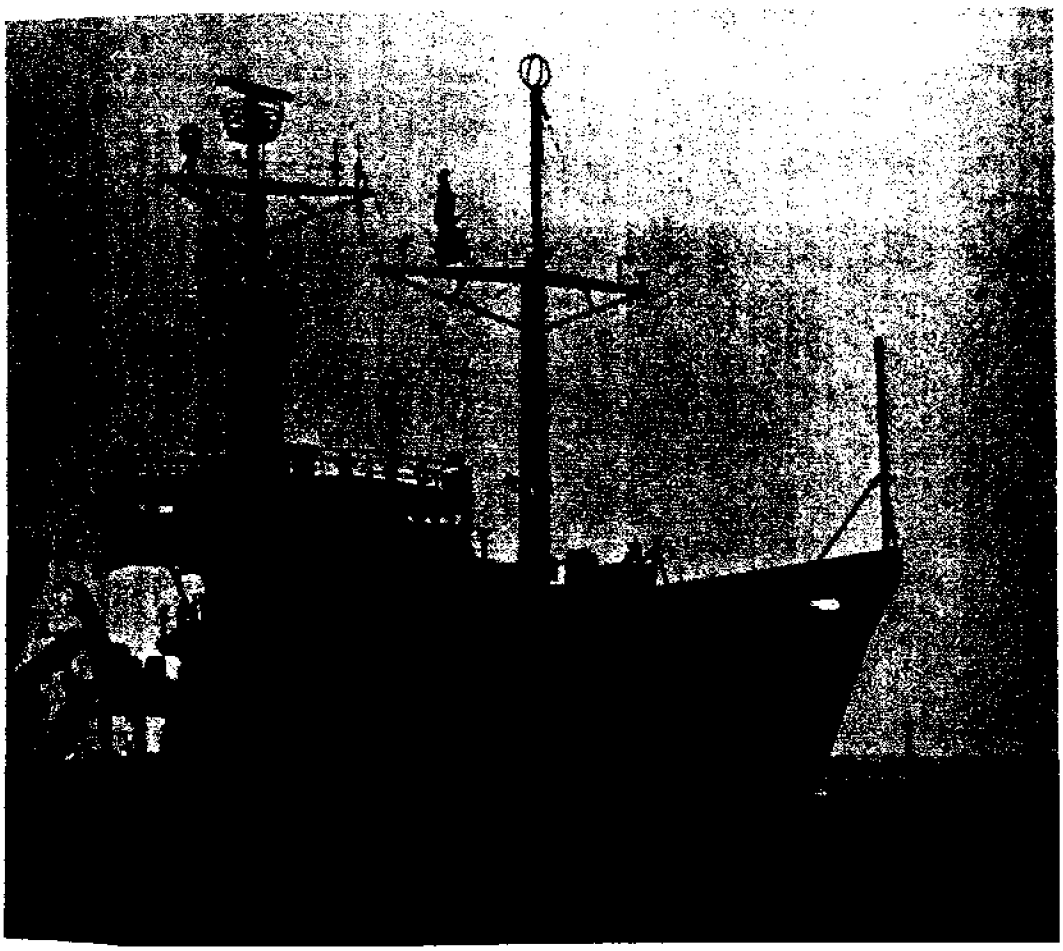
Furthermore, the resolution in the acoustic records is sufficiently high that excellent correlation of deep reflectors with reflective layering in sediment cores can generally be realized. Finally, this resolution appears far superior to that attained with conventional echo sounders operating from the surface, at least for water depths of 1500 fathoms or more.

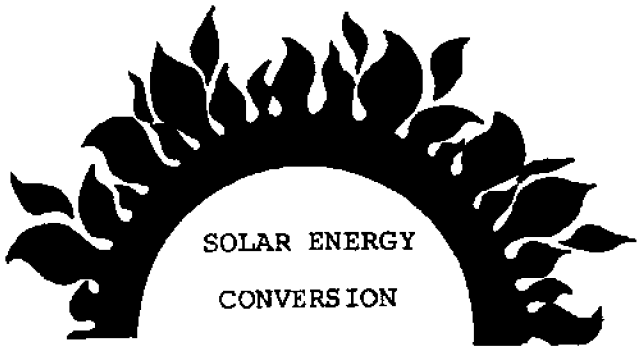


As to future development, we believe that if an alternate sounder operating at 3.6 kHz were added to the deep package, the maximum penetration could be increased significantly in many areas, but at a sacrifice in resolution proportional to wavelength. In any case the capability of switching to either frequency as conditions warrant would add greatly to the general utility of the instrument.

However, in its present form the probe has proved to be a very useful device for detailed in situ examination of the seafloor and sediments beneath it.

The physical structure of the instrument limits towing speeds to 1 knot. Streamlining the Deep Probe in a towed fish configuration would increase the towing speed to 4 knots.





A study* has been made of energy production from natural processes. This has included the energy involved in geophysical (including gravitation), biological, and botanical processes (including those induced by man). These have been ranked by order of their total power, compared with the present world power demand. Also, a further study was made of each cycle in terms of the environmental disturbance(s) that may be expected. This has suggested an upper limit of power production which is constrained by possible undesirable climatic change and led to an estimate of the power level at which mankind could survive indefinitely within the limits imposed by the natural energetic regimes of the earth and sun.

Solar power in direct and indirect forms (wind, ocean, thermal differences, and photosynthesis) offers sufficient energy per unit time to supply the present needs of the industrialized world. The problem is how to put solar power into useful forms. A compound approach involving sunlight, wind, and photosynthetic storage has been singled out for trial.

An experiment has been planned in which solar energy may be converted into technically useful forms. Large volumes of hot brine can be produced under solar radiation (Tabor effect). This hot brine can be used directly for heating purposes and for hyperthermic bioconversion to produce hydrogen and methane using the Oswald-Golueke method of forced production of aquatic plants (fresh water or marine) in culture. Both the hot water and gases can be stored long enough to smooth out the day-night effect. More significantly, algae can be stored for later bioconversion into gas thus smoothing out the seasonal variations of production, and making it feasible to meet changes of power demand from season to season and place to place.

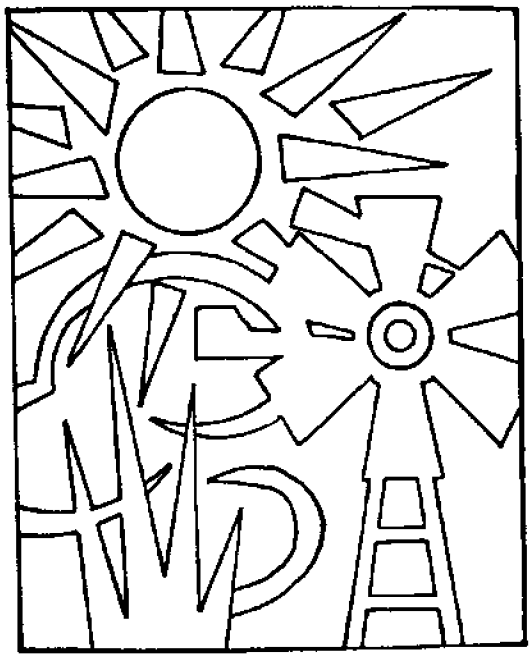
The planned experiment will conserve all mass; only the incoming flux of solar energy and the output of heat and mechanical power will be exchanged with the environment. The small amounts of electric power required to conduct the experiment

*Von Arx, W. S., 1974, "Energy: Natural Limits and Abundances," Trans., Am. Geophys. Un. 55(9): 828-832.

are to be supplied by a wind-driven generator and ballasting battery.

Calculations indicate that a compound system for solar energy conversion yielding both hot water and high energy fuel can be operated in middle latitudes. The "tuning" of both physical and biological elements to optimize and stabilize production on a pilot scale is the object of the inquiry.

To date we have been unsuccessful in obtaining sufficient funds to conduct this experiment.



Reports

AQUACULTURE

Goldman, J. C. and J. H. Ryther: DEVELOPMENT OF A WASTE RECYCLING-MARINE AQUACULTURE SYSTEM. Presented at the International Conference on Biological Water Qualtiy Improvement Alternatives, March 3-5, 1975, University of Pennsylvania, Philadelphia.

Goldman, J. C. and J. H. Ryther: WASTE RECLAMATION IN INTEGRATED FOOD-CHAIN SYSTEMS. Joint Conference on Wastewater Treatment and Reclamation Conservation of Freshwater Resources. Sponsored by the American Friends of the Hebrew University of Jerusalem and the University of Miami Sea Grant Program, October 23, 1974, Dupont Plaza Hotel, Miami, Florida (Proceedings to be published).

Huguenin, J. E., 1975: DEVELOPMENT OF A MARINE AQUACULTURE RESEARCH COMPLEX. Aquaculture 5(2):135-150.

Lapointe, B. L., L. D. Williams, J. C. Goldman, and J. H. Ryther: THE MASS CULTURE OF MACROSCOPIC MARINE ALGAE. Presented at the 38th Annual Meeting of ASLO, Halifax, Nova Scotia, June 23-26, 1975.

McLarney, W. O., S. Henderson, and M. M. Sherman, 1974: A NEW METHOD FOR CULTURING *Chironomus tentans* FABRICIUS LARVAE USING BURLAP SUBSTITUTE IN FERTILIZED POOLS. Aquaculture 4(3):267-276.

Mitchell, J. R.: A POLYCULTURE SYSTEM FOR COMMERCIALLY IMPORTANT MARINE SPECIES WITH SPECIAL REFERENCE TO THE LOBSTER (*Homarus americanus*). Proceedings of the World Mariculture Society 6th Annual Workshop, Seattle, Washington, January 27-31, 1975.

Ryther, J. H., 1975: MARICULTURE, Oceanus 18(2):10-23.

Ryther, J. H., 1975: PRELIMINARY RESULTS WITH A PILOT-PLANT WASTE RECYCLING MARINE-AQUACULTURE SYSTEM, W.H.O.I. Ref. #75-41:50 p.

Ryther, J. H., J. C. Goldman, C. E. Gifford, J. H. Huguenin, A. S. Wing, J. P. Clarner, L. D. Williams, and B. E. Lapointe, 1975: PHYSICAL MODELS OF INTEGRATED WASTE RECYCLING MARINE POLYCULTURE SYSTEMS. Aquaculture 5:163-177.

Ryther, J. H. and J. C. Goldman: A WASTE RECYCLING-MARINE AQUACULTURE SYSTEM. Fourth Food-Drugs from the Sea Conference, University of Puerto Rico, Mayaquez, Puerto Rico, November 17-21, 1974 (Proceedings to be published).

Ryther, J. H. and J. C. Goldman, 1975: MICRO-ORGANISMS AS FOOD IN MARICULTURE. Ann. Rev. Microbiology, 29:429-443.

Ryther, J. H. and J. C. Goldman: A WASTE RECYCLING-MARINE AQUACULTURE SYSTEM. Workshop on Biological Control for Water Quality Enhancement. Gainseville, Florida, January 29-31, 1975 (Proceedings to be published).

Smith, L. and J. E. Huguenin: THE ECONOMICS OF WASTE WATER-AQUACULTURE SYSTEMS. Ocean '75 Conference Record. Joint IEE-MTS Meeting, 22-25 September, 1975, 285-293.

LIVING RESOURCES

Anderson, J. W., R. C. Clark, Jr., and J. J. Stegeman, 1974: CONTAMINATION OF MARINE RESOURCES BY PETROLEUM HYDROCARBONS. Marine Bioassay. G. Cox (ed.), Mar. Technol. Soc.: 36-78.

Atema, J. and L. S. Stein, 1973: EFFECTS OF CRUDE OIL ON THE FEEDING BEHAVIOR OF THE LOBSTER *Homarus americanus*. Environ. Pollut. 6:77-86.

Atema, J. and G. Bard, 1975: CHEMOTACTIC RESPONSES OF THE MARINE MUD SNAIL, *Nassarius obsoletus*, TO JUICES OF SYMPATRIC MOLLUSCS. J. Chemical Ecology 1:243-257.

Burns, K. A. and D. J. Sabo, 1975: ENVIRONMENTAL CONTAMINATION AND THE INDUCTION OF MICROSOMAL MIXED FUNCTION OXIDASES IN AN ESTUARINE FISH, *Fundulus heteroclitus*. Fed. Proc. 34: 810.

Gagosian, R. B., 1975: STEROLS IN THE WESTERN NORTH ATLANTIC OCEAN. Geochimica et Cosmochimica Acta 39.

Gagosian, R. B., 1975: STEROLS OF THE LOBSTER, *Homarus americanus*, AND THE SHRIMP, *Pandalus borealis*. Experientia 31:878-881.

Gagosian, R. B., : THE CYCLING OF LABILE ORGANIC COMPOUNDS: STEROLS IN THE NORTH ATLANTIC OCEAN (Submitted to "Symposium on Prediction of Sound Scattering in the Oceans"), N. Anderson, Ed., ONR.

Gagosian, R. B. and R. A. Bourbonniere, 1975: ISOLATION AND PURIFICATION OF THE MOLTING HORMONES FROM THE AMERICAN LOBSTER, *Homarus americanus*. Comp. Biochem. Physiol. 50B.

Sabo, D. J., J. J. Stegeman, and L. S. Gottlieb, 1975: PETROLEUM HYDROCARBON POLLUTION AND HEPATIC LIPOGENESIS IN THE MARINE FISH, *Fundulas heteroclitus*, Fed. Proc. 34:811.

Stegeman, J. J., 1974: HYDROCARBONS IN SHELLFISH CHRONICALLY EXPOSED TO LOW LEVELS OF FUEL OIL. Pollution and Physiology of Marine Organisms. J. F. Vernberg, W. B. Vernberg (eds.), Academic Press: 329-347.

Stegeman, J. J. and D. J. Sabo: THE EFFECTS OF PETROLEUM HYDROCARBONS ON LIPID METABOLISM IN FISH. Presented at symposium on "Pollution and Physiology of Marine Organisms," Milford, Conn., November, 1975.

Stegeman, J. J. and D. J. Sabo, 1975: UPTAKE AND RELEASE OF PETROLEUM HYDROCARBONS BY MARINE ORGANISMS AND SOME METABOLIC IMPLICATIONS. Proc. Conf. on Env. Implications of Resource Dev. Outer Cont. Shelf, E. Cronin (ed.), Estuarine Research Federation.

Stein, L., S. Jacobson, and J. Atema, 1975: BEHAVIOR OF LOBSTERS, *Homarus americanus*, IN A SEMI-NATURAL ENVIRONMENT AT AMBIENT TEMPERATURES AND UNDER THERMAL STRESS. W.H.O.I. Technical Report 75-48: 49 p.

SOCIO-ECONOMIC AND LEGAL STUDIES

Ciobanu, D., 1975: NOTE ON INTERNATIONAL TERRORISM, American Journal of International Law 69 (January 1975): 138-140.

Ciobanu, D., 1975: THE CONCEPT AND THE DETERMINATION OF "THE ARMED CONFLICT NOT OF AN INTERNATIONAL CHARACTER," Rivista di Ditutto Internazionale 58 (January 1975):43-79.

Ciobanu, D., 1975: IMPACT ON THE CHARACTERISTICS OF THE CHARTER UPON ITS INTERPRETATION. In Current Problems of International Law, A. Cassese, ed., Milano, Editore Giuffre: 3-79.

Dykstra, J. J., M. F. Baldwin, and F. N. Ikard, A PANEL DISCUSSION ON: DRILLING FOR OIL OFF THE EAST COAST OF THE UNITED STATES. J. Seward Johnson Lectures in Marine Policy, 2 May 1974, Woods Hole, Massachusetts

Friedman, J. M., 1975: ATLANTIC OFFSHORE OIL: THE NEED FOR PLANNING AND REGULATION, Oceanus 19(1):22-31.

Gallardo, V. A.: ITACIA UNA POLITÍCA DE ADMINISTRACÍON DE LA ZONA COSTERA DE CHILE. Seminario sobre Preservacíon del Medio Ambiente Marino, Santigo, Chile, 25-27 September, 1975. Departmento de Estudios Internacionales, Universidad de Chile.

Gallardo, V. A., 1975: CONSIDERCIONES PRELIMINARES EN TORNOAL DERRAME CAUSADO POR EL VARAMIENTO DEL BUQUE TANQUE VLCC METULA EN EL ESTRECHO DE MAGALLANES, CHILE. La Semana Científica 136, April 17, 1975, Santigo, Chile (Comisíon Nacional de Investigacion Científica y Technologica).

Hollings, E. F.: COASTAL ZONE MANAGEMENT AND OFFSHORE OIL DEVELOPMENT: FEDERAL VS. STATE RELATIONSHIPS. J. Seward Johnson Lectures in Marine Policy, 9 May 1975, Woods Hole, Massachusetts.

Jayakumar, S. and S. M. Thompson-Flores: A PANEL DISCUSSION: THE LIMITS OF NATIONAL JURISDICTION AND THE COMMON HERITAGE CONCEPT. J. Seward Johnson lectures in Marine Policy, 27 April 1973, Woods Hole, Massachusetts, M. S. McDougal, Moderator.

Ray, D. L.: ENERGY AND MARINE RESOURCES. J. Seward Johnson Lectures in Marine Policy, 18 March 1975, Woods Hole, Massachusetts

Smith, L. and S. B. Peterson: FISHERIES REGULATION: RESEARCH AND REALITY, Workshop in Living Resources, NSF, 30 April 1975.

MARINE ENVIRONMENTAL RESEARCH

Bumpus, Dean F., 1976: REVIEW OF THE PHYSICAL OCEANOGRAPHY OF GEORGES BANK. ICNAF Research Bull. 12 (in press).

Stewart, R. S. and J-O. Willums, 1975: OFFSHORE APPLICATIONS OF MODELING TECHNIQUES, I: MODELS FOR WEATHERING AND SPREADING OF OIL SPILLS. Northern Offshore 4(9):50-57.

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

Willums, J-O., 1975: MARINE ENGINEERING UNDER ARCTIC CONDITIONS. Review of the 1975 POAC Conference, Fairbanks, Alaska, Northern Offshore 4(9).

PROGRAM

Bumpus, D. F., 1974: MARINE RESOURCES DEVELOPMENT AND MANAGEMENT; A report on the Woods Hole Oceanographic Institution Sea Grant Program for July 1973-June 1974. WHOI-74-98, 35 p.

PROGRAM SUMMARY

Program Area	Project Support '71-'72	Project Support '72-'73	Coherent Program '73-'74	Coherent Program '74-'75
Marine Resources Development				
Aquaculture				
Marine Polyculture Based upon Natural Food Chains and Recycled Wastes - Ryther		N	C	C
Finfish Research at Matamek, Quebec - Backus			N	*
Culture of Midges - McLarney			N	T
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 Crustacea - Gagosian		N	C	T
Effects of Petroleum Hydrocarbons in Marine Fishes - Stegeman, Sabo				N
Socio-Economic and Legal Studies				
Marine Economics				
Limited Effort Programs in the New England Fishery - Smith, Peterson				N
Socio-Political Studies				
Marine Policy and Ocean Management - Fye		N	C	C
Marine Technology Research and Development				
Ocean Engineering				
High Resolution Sub-Bottom Profiling - Vine				N
An Acoustic Probe for Ocean Bottom Surveys - Dow				N
Solar Energy Conversion - von Arx				NT
Marine Education and Training				
Course Development				
Ocean Engineering - Mavor	N	C	T	
Program Management and Development - Bumpus			N	C

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

During FY'75 the Woods Hole Oceanographic Institution Sea Grant Program consisted of:

9 Research Projects
1 Program Management

Personnel associated with the Sea Grant Program were:

Scientific Staff - 11
Technical Staff - 12
Departmental Assistants - 33
Undergraduate Students - 16
High School Students - 2
Post-Doctoral Fellows - 7
Pre-Doctoral Fellows - 1
Visiting Investigators - 3
Consultant - 1

Budget Summary - 1974-1975

	Sea Grant	Matching*	Total
Marine Resources Development			
Aquaculture	130,000	80,000	210,000
Living Resources	155,000	5,000	160,000
Socio-Economic and Legal Studies			
Marine Economics	40,000	4,200	44,200
Socio-Political Studies	30,000	120,800	150,800
Marine Technology Research and Development			
Ocean Engineering	56,700	000	56,700
Program Management and Development	20,000	11,600	31,600
Total	431,700	221,600	653,300

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

Postscript

The foregoing reports our Sea Grant activities for last year. Our combined attention is now directed toward the following:

John Ryther's polyculture program will be directed toward certain problem areas in phytoplankton culture, bivalve mollusk culture, sea weed culture and culture of detrital-feeding invertebrates and their predators.

John Stegeman's and Dennis Sabo's Effect of Mixed Petroleum Hydrocarbon study will continue.

Allyn Vine will complete his investigation of a High Resolution Sub-bottom Profiling System, and

Steven Dexter, who produced a handbook of Oceanographic Engineering Materials--Metals and Alloys as part of our Education program three years ago, will rewrite and up-date his handbook and add a section on non-metallic materials.

The Marine Policy Program expects to expand its activity with the establishment of a core staff for the program and the maintenance of closer links with the scientific research and technological work of the Institution. A twelve lecture seminar course, directed towards graduate students and research scientists at the Institution and in the joint program with MIT who are interested in learning more about the history and development of ocean policy, will be offered during the spring of 1976.

Individual fellows and groups of fellows will:

- Complete work on the report of the interaction analysis of the commercial fishing and offshore petroleum industries in the Northeastern United States (sponsored by American Petroleum Institute);
- Complete studies of the structure and economics of the New England fishing industry;
- Assist the local governments of Marthas Vineyard in establishing policies for the management of shoreline and great ponds;
- Prepare a monograph (based on previous research) on a century of growth and decline in the Columbia River salmon industry;
- Work on the relationship between biological and social boundary systems in marine environments; the implications of cultural practices, and ways of measuring change in social well-being distributions and the factors involved in them;
- Prepare a model interstate compact for management of anadromous fisheries on an interstate river;
- Consider the factors involved in energy facility siting in the coastal zone;
- Study the use of navigational techniques by deck officers in the Merchant Marine based on data collected on a series of voyages on ships of different types. The

study will consider job satisfaction and comparison of training for the job with the work actually performed;

- Study the human aspects of ship casualties with particular reference to causative effects in collisions and groundings;
- Examine problems and possibilities in marine technology and technological capability transfer to developing countries.
- Initiate a Coastal Zone Management course in the Massachusetts Maritime Academy's Continuing Education Program.

Other new programs will include:

John Gibson's study of the Interactions of Fluviatile Salmonoid Species. This study will allow predictions on the interactions of imported species with indigenous ones.

Colin Summerhays will examine the Sediment Dispersal in New Bedford Harbor and Western Buzzards Bay. The program is

hardly underway yet the feedback to local, state, and federal agencies concerned with the management of New Bedford Harbor is already in progress.

The Sea Grant Coordinator is actively trying to broaden our program with some seed money for new initiatives and rapid response programs.

- The assistance to the Martha's Vineyard Commission and the Coastal Zone Management course mentioned above are two of these initiatives.
- Others involve the outwash plain estuaries of Falmouth, Massachusetts with a view of how to manage them for optimum shellfish production for both commercial and recreational use, including:
- A study of the tidal prism and tidal exchange of Bournes Pond and the migration of its unstabilized inlet conducted by a High School Science teacher and his students.
- The genetic component of variable growth and survival in seed quahogs;
- The distribution of food sources in relation to growth of shellfish in Bournes Pond;
- A final initiative will develop a set of sampling designs and estimation procedures for investigating time varying populations, particularly plankton and ichythyoplankton populations in coastal waters. This study should result in the reduction of cost and time involved in environmental surveys.

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2. Living Resources
3. Socio-Economic and Legal Studies
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