THE NATIONAL SEA GRANT COLLEGE PROGRAM

1987·1992

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Sea Grant Association

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THE NATIONAL SEA GRANT COLLEGE PROGRAM: 1987–1992

The Sea Grant program fills a unique niche in American marine science and among university science activities generally. The Sea Grant programs have developed a responsive network of institutions and scientists. As the examples in this book demonstrate, this network is a productive, innovative, and efficient enterprise which has provided many benefits to the nation.

The Sea Grant network has special capabilities to address the nation's marine resource and marine environmental needs and opportunities. If the problems caused by funding erosion can be addressed, and Sea Grant's unique role reaffirmed, the network will be even more effective in the future.

An Innovative Nationwide Network

The Sea Grant legislation is now entering its third decade as a living document, and the three original Sea Grant programs are in their nineteenth year of operation. The twenty-second Sea Grant College was designated in 1986, at about the same time that the newest Sea Grant program was celebrating its fifth birthday. Today the nationwide Sea Grant network is comprised of twenty-two Sea Grant colleges and seven institutional programs which together manage a total network of more than 300 universities and affiliated institutions, including a number from inland states.

This broad and effective network was created in a remarkably short span of time. An experiment—with only partial models to learn from—it has managed to combine research, education, technology transfer and public service in a university-based program designed to enhance and promote the wise use of Great Lakes and marine resources. Though the first programs were located at major marine-oriented universities—as were many who came later—institutions that originally were not part of the traditional marine community were soon participating and making major contributions. For instance, Sea Grant enlisted the great public universities of the midwest, and private institutions were brought into a publicly-oriented program.

Though some viewed Sea Grant as just another oceanography program, it soon became apparent that Sea Grant was more than that. It concentrated on the use and protection of resources. It focused largely on the nation's estuaries and coastal margins, partly for logistical reasons but more importantly because these are the most productive regions in terms of food, minerals, living space and recreation. They are also the regions where the most pressing resource and environmental problems occur. It emphasized the opportunities and problems confronting society, whether economic development, environmental protection, introduction of new fisheries, or something else entirely. And it brought new disciplines into the broad field of marine studies: the basic biological sciences (such as biochemistry, genetics, and microbiology); immunology, pathology, toxicology, and pharmacology; law and policy studies; food science, agricultural economics and other specialty disciplines hitherto focused primarily on land-based agriculture; a number of engineering disciplines, and many others. More radically, Sea Grant helped unite many of these disciplines in multidisciplinary—often even truly interdisciplinary—research and educational strategies.

And always, research was seen in the context of the need to transfer knowledge to those who needed it, through a broad approach to public service, including outreach education, technology transfer and communications. Today these achievements are routinely accepted by the public and by the universities, but at the time they were revolutionary—and the revolution was achieved in a span of less than one generation. To this day, some academic traditionalists reject the Sea Grant idea as a reality. At the other extreme, Sea Grant's success has alarmed bureaucrats who fear change and the creative capacity of the universities, as well as budget cutters who fear that a program which has achieved so much for so little is likely to be expanded as a creative investment for the future. Success has bred reaction among the inert, the timid and the fearful.

A child of the 1960s, Sea Grant embraced and pioneered many of the accepted strategies of the late 1980s, as once again society looks to the universities for ideas that will lead to technological and economic development and for solutions to environmental or resource conflicts. Among Sea Grant's timely attributes are the following:

- a broad multidisciplinary approach
- a combined university/industry/government partnership
- a network of institutions operating across the nation
- a grassroots, knowledge-based identification of problems
- a capacity for technology transfer and feedback

Competitively-funded, university-based research has always been America's unique contribution to the ongoing scientific revolution. Current national science policy is returning to the country's roots and reemphasizing old themes in new settings. A recent report, widely known as the Packard-Bromley report ("A Renewed Partnership," a Report of the White House Science Council, Office of Science and Technology Policy, Washington, D.C., 1986), emphasizes the need for multi-disciplinary, university/industry/government partnership approaches to science—areas where Sea Grant offers a model. This report calls for increased investment in university-based science as a fundamental base for economic growth and competitiveness.

The Sea Grant community endorses this concept and welcomes the National Science Foundation's Centers of Excellence and similar efforts to implement the strategy called for in the Packard-Bromley report. Nevertheless, it would be a loss if Sea Grant's ongoing efforts were to be bypassed in the rush to create something "new." If Sea Grant were dismantled, citizens everywhere would clamor for its reestablishment—but it would be at greatly increased costs in time, money, and lost opportunities. It is ironic that even now, as Sea Grant funding has been cut, Sea Grant-like programs are being formed and funded—to carry out activities that the program has been forced to cut or eliminate. These new undertakings underscore the need for continuing the existing capability and supporting it with adequate resources.

Sea Grant as a National Resource

Operating within the institutional framework described above, the Sea Grant network has proved that it is an effective instrument for the national good. Not only has Sea Grant created new institutions, it has contributed products—trained manpower, useful information, new methods, and access to the university knowledge base. All these have contributed to economic benefits, environmental enhancement and improved decision-making.

Today, Sea Grant is the principal national source of research and technology transfer for marine aquaculture and marine biotechnology. It is a major source of research and expertise in the areas of fisheries recruitment; underutilized fish species; seafood product improvement, quality and safety; estuarine processes; critical habitat; coastal processes; ocean technology; marine policy; and the fates and effects of toxic pollutants (particularly in the Great Lakes): all of which are national priority problems. Sea Grant's Marine Advisory Service is the nation's only marine technology and information transfer mechanism linking scientists with the users of the nation's marine resources and with various publics concerned with marine issues. Sea Grant is a primary national source of marine scientific and management personnel for the future.

This work continues. However, it is becoming increasingly focused in a series of related activities across the country. The network has identified the following main lines of approach, which illustrate the Sea Grant role in marine resource and coastal ocean studies:

- **Marine Biotechnology**—An increasing array of U.S. ocean-based industries will benefit from the breakthroughs made possible by innovative Sea Grant research that builds on the the revolution in the biological sciences over the past three decades.
- **Exclusive Economic Zone**—As the United States extends its boundaries further into the ocean, research will be the key to deriving the benefits of additional resources—resources that can be exploited without environmental damage. But a new generation of technology and new management capabilities—and a reexamination of ocean policy—are required to make this goal a reality.
- **Estuarine Habitat**—As more of the nation's population concentrates around the ocean and Great Lakes, fragile coastal habitats could be damaged or lost. Focused research is needed, if these important resources are to be preserved—research which Sea Grant universities are uniquely qualified to do.
- **Water Quality**—Toxic substances in Great Lakes and coastal waters have contaminated sediments, and indirectly fish, shellfish and birds, and created potential hazards to human health. Fundamental research on this problem is essential in order to control the sources and mitigate the effects of these substances. Sea Grant universities have taken the lead in this research.
- **Coastal Carrying Capacity**—As coastal areas attract more and more people, new demands are placed on water supplies, waste-disposal facilities, transportation, and other related infrastructures. Consequently, interdisciplinary research leading to better understanding and management is needed to guide coastal developments.
- **Fisheries Recruitment**—Coupling innovative fisheries and ecological research with oceanography, satellite technology, and improved modeling capabilities should lead to real time forecasting and management of fish stocks.
- **Aquaculture**—Culture of fish, shellfish, and seaweeds is producing high quality seafoods for this country, and should lead to more exports and fewer imports.
- **Seafood Technology and Quality**—Fundamental research on health aspects of seafood diets is needed, as is research leading to new seafood products and improved product quality.
- **Fisheries Development and Trade**—Increasing U.S. demand for fish and other seafoods has engendered a trade deficit that can be ameliorated through research leading to improved marketing techniques for domestic underutilized fish stocks.
- **Ocean Technology**—Exciting developments in aerial and underwater remote sensing, computers, underwater robotics, and ocean engineering are revolutionizing the marine sciences and creating new opportunities for both the public and private marine sectors.

These priorities will be redefined as needs change and new opportunities emerge.

Progress in some of these areas will be achieved, but only at the expense of existing resources—the erosion of recent years must be reversed if the vitality of Sea Grant is to be

maintained. For other areas, the newly defined Strategic Research Program described later will be necessary if the necessary results are to be achieved.

Over the past several years, what could well become a national plan for the marine sciences has emerged. (See, for example, "Ocean and Marine Resources: Research Priorities and Initiatives," reproduced by the Marine Division of the National Association of State Universities and Land-Grant Colleges, Washington, D.C., 1985.) This exciting development occurs at a time of ferment and innovation in the marine sciences. It should be embraced and encouraged.

Even so, some aspects still need to be refined. The current schemata does not deal adequately with food production and with the promises of biotechnology, nor has it incorporated the policy sciences. The Sea Grant network is essential to those aspects that deal with coastal ocean and estuarine processes, and with fisheries recruitment, and it can contribute to other parts of the plan.

Funding

Despite ample evidence that the Sea Grant network continues to be innovative, productive and forward-looking, there is also cause for concern that this capability is being seriously eroded:

- Nearly every university program has had to cut operations. Cuts extend to all areas of the programs—research, education, advisory services, and management. At the institutional level, these cuts in operating levels appear to exceed thirty percent.
- The NOAA Sea Grant office has noted that the total number of projects supported has declined by one-third, even as federal administrative costs continue to rise.
- During FY 1987, the Sea Grant institutions will be operating at a level below the across-the-board cut level of FY 1986.
- Most Sea Grant institutions are operating with fewer dollars in 1986 than in FY 1982. Modest growth for a few new and small institutions has been accomplished only by cutting other programs, regardless of quality.
- The total number of universities and educational bodies involved in Sea Grant nationwide has declined. The number of people involved is down in every area, dramatically so in some activities such as education.
- Total dollars for Sea Grant have declined even as NOAA's budget has risen by 20% in the past five years.
- In recent years, inflation has taken an additional toll of approximately 20%. Since inflation in the sciences and in the universities has exceeded the average inflation level substantially in recent years, the effect on Sea Grant probably has been greater.

University managers have reacted responsibly to this challenge. They have cut operating expenses across-the-board, while cutting much deeper selectively in various areas. They have stepped up the level of competition, looked for efficiencies, and availed themselves of new technologies, such as computers, word processors and improvements in telecommunications. Even so, it is evident that management capacity is diminished, educational expenditures are appallingly low, expenditures for most research components are well down, and the nationwide network of advisory service personnel is being cut. For a program as efficient and cost-effective as Sea Grant, the erosion has been damaging and demoralizing.

Legislative Needs for the Future

During the next few years, several areas need to be addressed in order to maximize the national benefits from the Sea Grant network.

- The decision needs to be made whether to utilize and maximize the existing Sea Grant network to address areas of emerging national opportunity and need—areas such as marine biotechnology, technology and policy for the Exclusive Economic Zone, and estuarine and coastal ocean resource studies, including fisheries recruitment/ oceanography. Sea Grant work in these areas is underway, and in most cases has been underway for some time, but the level of effort must be increased without further undermining other programs areas. In addition new operating mechanisms may be desirable for certain areas, and new kinds of human resources need to be trained. A new Strategic Research Program and a Postdoctoral Initiative will help in this regard. A decision on these matters will vastly affect Sea Grant and the future course of national marine science.
- Second, continuing attention needs to be given to the operating machinery of Sea Grant, including regional networking, multi-institutional planning and operations, interactions with other parts of NOAA and with other agencies, improved communications between the Sea Grant institutions and the national Sea Grant Review Panel, and better links to international marine resource activities. It should go without saying that continued effort in behalf of administrative efficiency should be encouraged. At the same time, the Congress needs to emphasize that diversity and pluralism are a hallmark of this program—as of American higher education more generally—and are to be encouraged.
- Third, the situation of NOAA needs to be addressed: its marine functions, its role in the marine sciences, its relationship with the activities of other agencies, and its relationship with the Sea Grant network and the university community. The status quo is not healthy— for groups like Sea Grant that must work with

NOAA, for NOAA itself, or for the country. While recent dialogue between the Sea Grant network and NOAA leadership has been fruitful, current operating constraints at the federal level hamstring planning and progress.

- Hopefully a reexamination of NOAA—and of Sea Grant's role—would come in the context of a broader study of national ocean policy. Given the changes of the 1980s, the policy differences between Congress and the executive branch, and the passage of time since the spate of ocean legislation of the early 1970s, such a study is needed.
- Fourth, and last, is the question of funding. It is essential— not for Sea Grant alone, but for the future of identified national priority areas where Sea Grant is the principal national instrument—that the pattern of funding erosion be reversed. It is also important that new resources be found to fund important new program activities in areas of national need and opportunity. This kind of national investment is necessary, even in a time of tight funding.

Conclusion

Sea Grant has been a successful national experiment during its first twenty years of operation. The network of Sea Grant universities and institutions is an effective national instrument for scientific progress, technology transfer and economic and social benefits. This network should be maintained and strengthened.

2. The National Sea Grant Network

A geographic listing of more than 300 academic and non-profit institutions that conduct or actively participate in the work of the National Sea Grant College Program

THE NATIONAL SEA GRANT NETWORK

Thirty Sea Grant colleges and institutions comprise the core of the National Sea Grant College Program. A unique Sea Grant creation, these programs function as the primary planning, goal-setting, management and accountability units of the national program, and they are the main source of continuity and long-term commitment to the purposes of the National Sea Grant College Program Act.

In 1986, the National Sea Grant Task Force surveyed the core Sea Grant institutions, asking for a list of other educational institutions participating in local programs since 1980. A "participant" was defined as (1) an administratively separate campus or system level entity and (2) a recipient of Sea Grant funds and/or a required signatory for a Sea Grant institutional proposal.

The Task Force also checked the annual listing of projects prepared by the National Sea Grant College Program Office. It should be noted, however, that this list does not show subcontractors or participants in multi-institutional projects.

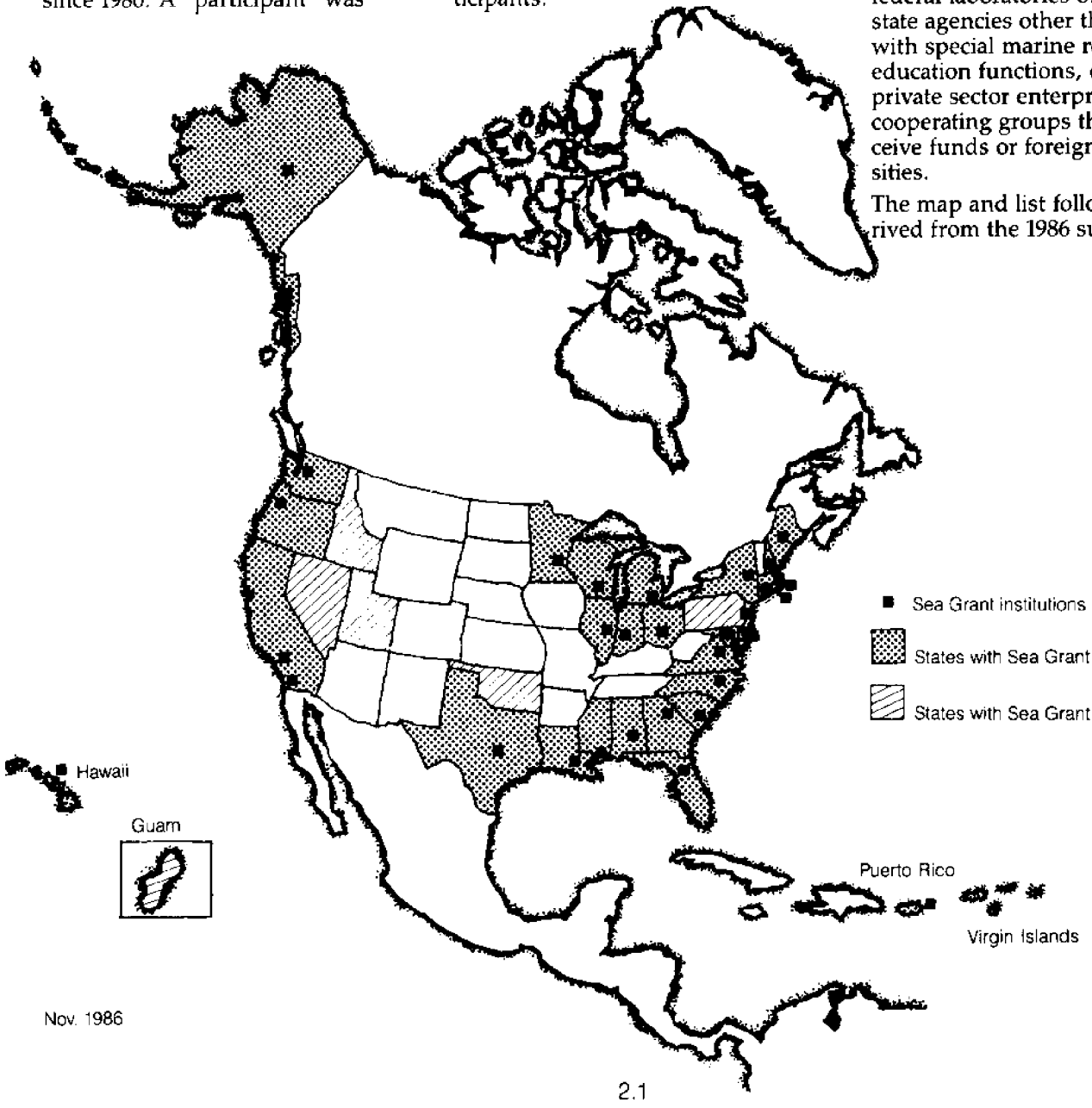
Over the years, the national office has awarded a number of grants for individual projects, separate from the core institutional programs. Records of these grants were checked for additional participants.

The survey results, which follow, show that more than three hundred institutions have participated actively in the program since the reauthorization of the National Sea Grant College Program in 1980.

270 institutions of post-secondary education
2 elementary and secondary schools or school systems
30 nonprofit institutions with marine-related educational and research missions.

These institutions are located in 34 states (all 30 coastal and Great Lakes states and 4 inland states), the District of Columbia, Puerto Rico, the Virgin Islands and Guam. The list does not include federal laboratories or agencies, state agencies other than those with special marine research and education functions, cooperative private sector enterprises, other cooperating groups that do not receive funds or foreign universities.

The map and list following are derived from the 1986 survey.



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Medical College of Wisconsin
University of Wisconsin, Extension
University of Wisconsin, Green Bay
University of Wisconsin, Madison
University of Wisconsin, Marinette
University of Wisconsin, Milwaukee
University of Wisconsin, Parkside
University of Wisconsin, Stevens Point
University of Wisconsin, Superior
University of Wisconsin, System

3. A University Based Resource
Descriptions of major Sea Grant programs conducted by 30 universities in coastal and Great Lakes states and Puerto Rico; and some recent benefits and accomplishments of these programs

Alaska "Fish Grant" Supports State's Number One Private Employer With Education, Training, Technology Transfer and Research

In 1985, Alaska's fish landings were the nation's most valuable at $590.8 million, a catch that was the nation's second in volume at 1.2 billion lbs. In the FCZ off Alaska lies the nation's greatest potential for fisheries expansion, where foreign fleets landed more than 1 million mt of fish in 1985. Among Sea Grant programs only Alaska's can be called "Fish Grant", concentrating its effort on the state's premier fisheries potential.

The University of Alaska statewide system of higher education comprises three senior college campuses, 11 community colleges, 14 learning centers, the Cooperative Extension Service and the Fishery Industrial Technology Center. The university's Sea Grant College Program supports research, education and public service projects that are carried out at one or a combination of these units. While formal research may be conducted at a major campus, Sea Grant also brings hands-on training to the fishing industry.

Recent projects have been supported through:

University of Alaska, Fairbanks: Institute of Marine Science, Agricultural & Forestry Experiment Station, Engineering Experiment Station, Department of Medical Science, School of Management.

University of Alaska, Juneau: School of Fisheries and Science.

University of Alaska, Anchorage: College of Arts and Sciences.

University of Alaska, Community Colleges, Rural Education and Extension: Fishery Industrial Technology Center.

Alaska Sea Grant has made significant contributions to fishery development in a number of areas:

Adult Education Through the Marine Advisory Program and the Fishery Industrial Technology Center, workshops are conducted at the university's geographically far-flung facilities. Trawl handling, vessel stability, fisheries rules and regulations, sea survival, and business management are typical workshop topics.

Aquaculture By funding economic studies, providing an aquaculture specialist, and supporting research on salmon genetics and habitat evaluation, Alaska Sea Grant was instrumental in developing the private non-profit hatcheries. These now form the base of North America's largest and most successful ocean salmon ranching program. Egg takes have increased ten-fold over the past 10 years, returns by more than that. This effort is now redirected, concentrating on pen-rearing salmon and trout in Alaskan waters.

In 1985-86, Alaska Sea Grant funded a visiting staff position for Junzo Abe, well-known Japanese aquaculture specialist. While in Alaska, Abe is conducting demonstration culture projects for scallops and seaweeds and advising the Office of the Governor on cold-water aquaculture. He is also lecturing in 10 communities.

Marine Safety The Alaska Marine Advisory Program is recognized throughout the National Sea Grant College Program as a leader in safety education. Since 1975, the marine safety project has increased fishermen's use of basic vessel safety equipment and marine survival techniques. The races developed to familiarize people with survival suits at local festivals and fairs are now staple attractions in coastal communities. Safety specialists spearheaded formation of AMSEA, the Alaska Marine Safety Education Association, a statewide organization of safety professionals. AMSEA is developing formal education programs in marine safety and survival for Alaskan waters. A four-episode marine survival videotape series developed by MAP has won 12 national awards and been widely used by government and industry.

Science Networking Alaska Sea Grant has become a leading organizer of multi-disciplinary scientific conferences. These meetings usually center on a particular marine problem, connecting top scientists and managers from different fields and various countries, people working on the same species who ordinarily would not meet. Conference workshops that outline needed research often become standard planning documents in the field. Recent conferences have discussed king and Dungeness crab biology and management; the options for managing Alaska's offshore fisheries, particularly halibut; rockfish; and seafood quality.

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Alaska Sea Grant's Long-Term Multi-disciplinary Approach Forms Base for Growing Tanner Crab Fishery

Commercial fisheries are shaped not only by the market, but by biology, politics, and ecology. The Alaska Sea Grant College Program applies the university's academic strength to today's complex multi-disciplinary fisheries problems.

One example of Sea Grant's approach is in Alaska's tanner crab fishery, which now has an ex-vessel value of $50 million. Between 1973 and 1985, as this fishery developed, Alaska Sea Grant funded:

* **Biological studies** covering tanner crab biology as it relates to harvesting.
* A major meeting of scientists working on this species, focusing on current biological and management problems.
* **Economic analysis** of the market and of by-catch avoidance in the Bering Sea groundfish trawl fishery.
* **Applied crab research** in which ration studies for the manufacture of livestock feed increased the value of fish processing by-products.

Biological Studies

Beginning in 1973, Alaska Sea Grant funded three tanner crab biology studies. This work provided most of the knowledge now available on this species in Alaska.

Data gathered under the first biological study (1973-1976) was used by the Alaska Department of Fish and Game (ADF&G) to establish the initial management programs. The graduate student supported by the project was hired by ADF&G and eventually managed the major tanner crab fishing region.

Results from the second study (1979-1982), on reproductive biology, are now used by management agencies to determine allowable catch for the fishery.

The third study (1983-1984) focused on tanner crab molting frequency. Scientists used encrusting barnacles as inexpensive natural tags for estimating molting frequency. Unlike man-made tags, these natural tags do not have to be implanted, do not inhibit the growth of the specimen, and sampling can be done at dockside when the catch is delivered to a processor.

In 1982, the Alaska Sea Grant Public Information Office organized a scientific conference on *Chionoecetes* attracting scientists from Canada, Japan and the U.S. Conferees presented papers on current management, research, and fisheries. The meeting culminated in a workshop on research needs and a published proceedings. This 750 page document was distributed to more than 300 researchers and managers.

Economic Analysis

Just after the Magnuson Fishery Conservation and Management Act was passed, Alaska Sea Grant funded economic analysis of the international market for tanner crab. Japan dominated the market, and fished largely off Alaska. Economists traveled to Japan to discuss how Americanization of the fishery would change the market.

The resulting study showed that Americanization would not cause major economic dislocation in the producing countries and would result in long-term net benefits to the Alaskan fishing industry, developing an export market. The study was used by the North Pacific Fishery Management Council as part of the groundwork for policies that ended foreign tanner crab fishing off Alaska.

Recently, the Alaska Sea Grant Program funded a study on by-catch in the developing domestic trawl fishery for groundfish.

While this groundfishery is growing almost exponentially, the trawl gear incidentally captures other highly-valued commercial species, particularly halibut and king and tanner crab. In this study economists will attempt to value the incidental catch against suggested modifications for avoiding these species. The study is expected to be useful for managers weighing the consequences of various management plans for this fishery.

Applied Crab Research

By 1983, Alaska Sea Grant studies had proved that meal made from shellfish particulate reclaimed from processing waste water could be used as a protein supplement in swine and lactating dairy cattle feed. This created a market for reclaimed crab waste in Alaska and gave processors a way to turn a profit on equipment required by the EPA to clean waste water before dumping.

Development of the feed meal market in Alaska is calculated to have saved processors millions in compliance costs. All of the meal manufactured in Alaska has been sold to local farmers, who previously imported soybean meal for protein supplements at substantial cost.

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The California Sea Grant College Program— A Leader in Addressing Marine Problems and Opportunities

The California Sea Grant College Program—largest of the state programs in the national network—addresses marine-related problems and opportunities in a state whose coast stretches for over 1100 miles. Its research, advisory, and educational activities have national and international benefits as well.

Since its inception in 1968, California Sea Grant has funded over 300 projects at 49 colleges and universities within, and 7 cooperating institutions outside, the state. Research by the Program's principal investigators, their staff, and their graduate trainees has resulted in the publication of over 700 articles in refereed journals, plus another 500 publications of other kinds. Over the years, the Program has supported more than 500 graduate student trainees, who are today making major contributions in science, business, education, and government.

Among the program's recent achievements are the following.

- California Sea Grant is a leader in marine biotechnology and the development of new marine products. Its Marine Chemistry and Pharmacology Program has collected and tested the biological activity of over 800 compounds from marine organisms. Of these, approximately 17 are viewed as being novel and pharmacologically potent enough to warrant patent application. One such compound, pseudopterosin, derived from a Caribbean soft coral, not only is an effective anti-inflammatory drug, but also is a potent pain-reliever.
- Work by another Sea Grant-sponsored researcher has shown that modern biochemical and genetic engineering techniques can be used to improve the production of abalone and other commercially valuable shellfish. He and his colleagues have developed simple and commercially useful chemical procedures for accelerating the abalone's development and, using DNA technology, are deciphering the sequence of genes that regulate abalone insulin production. One exciting and unexpected discovery was that certain marine algae and bacteria produce peptides that mimic a neurotransmitter (called GABA) found in the mammalian brain and that may prove useful in medical diagnosis and treatment.
- Sturgeon are presently of great interest to commercial aquaculture operations in various parts of the nation. Research funded by California Sea Grant plus the work of its Marine Advisory Program have been instrumental in developing a new sturgeon aquaculture industry in California. A research project funded by Sea Grant has provided important information on maturation and spawning techniques, larval-rearing procedures, and diet formulations. A hatchery manual prepared by the Program's aquaculture specialist is presently being used by the U.S. Fish and Wildlife Service as well as commercial growers.
- Research funded by California Sea Grant has characterized the major challenges to governments and the public posed by the accelerated pace of oil and gas development now taking place off California's south-central coast. The Program's marine advisors have been helping local citizens predict the potential impacts of such dramatic production increases on ocean resources and marine-related industries, and working to improve communications between the oil and fishing industries as well as local, state, and federal agencies. Advisory personnel have been instrumental in establishing vessel traffic-lane agreements to help oil-industry support vessels avoid nearshore shellfish traps and gillnet fishing areas. They also participated in a research project on the effects of seismic surveys on fish dispersal and an interindustry economic impact study. Distribution of their "Oil and Gas Project Newsletter for Fishermen and Offshore Operators" has risen to 825.
- Upgrading the quality of seafood products affects both consumer acceptance and our nation's ability to compete with burgeoning imports. One study by California Sea Grant's Marine Advisory Program evaluated liquid-chilling systems for holding salmon on commercial vessels and led to guidelines for improved handling and storage, which have been widely adopted by the fishing industry.
- In California, coho and chinook salmon and steelhead trout are reared in hatcheries to enhance their propagation. Though hatchery rearing significantly improves the survival of young fish, the ocean catch and adult returns do not reflect this initial advantage, possibly because current practices may inadvertently contribute to poor survival and growth in the ocean. For example, large losses may occur when hatchery-reared salmon are released at an improper stage of smoltification. Research funded by California Sea Grant has demonstrated the environmental (especially lunar) and hormonal influences on adaptations of young salmon to saltwater. The findings have significantly affected hatchery practices and excited state, national, and international interest.

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CALIFORNIA SEA GRANT

Biochemical and Genetic Engineering Improve Abalone Production

Modern biochemical and genetic techniques are being used to improve control over biological processes that limit the production of commercially valuable shellfish, such as abalone. These processes include several stages of reproduction, larval development and metamorphosis, and survival of the cultivated animals.

Experiments conducted by Dr. Daniel E. Morse, Marine Science Institute, University of California, Santa Barbara, with funding provided by California Sea Grant, have concentrated on the Red Abalone, a major commercial resource in California.

Morse and his research associates initially sought to improve control over reproduction. They found that they could induce abalones to spawn by adding a small amount of the hormone prostaglandin to the surrounding seawater. A search for a less expensive procedure led to the discovery that hydrogen peroxide stimulates production of prostaglandins, and thus also induces spawning.

A second research problem arose from the fact that the larvae that hatch from fertilized abalone eggs frequently exhibit high mortality—a problem that had been plaguing efforts at industrial cultivation for years. Morse found that the swimming larvae are normally induced to settle and undergo metamorphosis to their juvenile form at the surfaces of specific red algae.

In subsequent work, Morse was able to isolate the substances in these algae that are responsible for the induction of settlement and metamorphosis. Of these, the most potent and least expensive proved to be a simple amino acid known as GABA (for gamma-amino-butyric acid). Use of this chemical provides a safe and inexpensive method for inducing rapid metamorphosis with high efficiency and survival. Most exciting perhaps is the potential application of GABA to human medicine, since the amino acid is known to be a potent neurotransmitter that controls nearly one-half of the cells in the human brain. New compounds have been discovered by this research group in marine algae and bacteria that mimic the action of GABA; these are now being explored for their usefulness as diagnostic and therapeutic agents.

One of the major problems remaining in the commercial production of abalone is the animal's relatively slow growth. To attack this problem, Morse has begun to clone and amplify the genes that code for growth-accelerating hormones, thereby applying the techniques of genetic engineering to mariculture. Using DNA technology, his group has been deciphering the structure of the abalone-specific insulin. Once they know the DNA sequence of the genes that regulate insulin production, the hormone can be manufactured in sufficient quantities and at low cost.

By far the greatest application of Morse's work has been in the area of marine aquaculture. The methods developed are simple, inexpensive, reliable, and applicable to a large number of species.

Industrial and research users of Morse's methods have applied the results of this project to improve the economic efficiency and reliability of production of more than 15 different abalone species and hybrids, and more than 20 different commercially valuable species of oysters, scallops, mussels, clams, and snails under cultivation in the United States and abroad.

Direct use of these methods and findings has been made by a number of commercial and governmental shellfish operations in California, other states, and abroad and by other Sea Grant-supported research programs on related aspects of shellfish production in California, Washington, Oregon, Delaware, Maryland, Florida, Massachusetts, Hawaii, Palau, and Guam; Academia Sinica Institute of Oceanology, China; Ministry of Agriculture and Fisheries, New Zealand.

Morse has discussed applications of his work at the invitation of several U.S. biotechnology and aquaculture firms. He has collaborated with scientists from the Oyster Research Institute in Japan, the Institute of Oceanology in the People's Republic of China, and the Central Marine Fisheries Research Institute in India. He has also shared his research at the Sea Grant-sponsored International Symposium on Recent Advances in Cultivation of Pacific Molluscs and co-edited the symposium proceedings. He has given lectures and demonstrations of his team's research findings at universities and fisheries in Japan, the People's Republic of China, Thailand, India, New Zealand, Fiji, and the Cook Islands, and he has consulted with researchers in the Philippines, Chile, Mexico, and Australia.

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SEA GRANT'S HELPING MAKE THE U.S. #1 IN THE OCEANS . . .

And the USC Sea Grant Program is a part of that effort!!

Since the early 1900s, the University of Southern California has been involved in the areas of marine science, ocean engineering and marine policy.

The USC Sea Grant Program, a part of the university's Institute for Marine and Coastal Studies (IMCS), is helping to carry on that tradition by linking university research with industry and user groups, which put research results into practice.

Virtually the entire population of Southern California is affected by the use and management of the ocean — for jobs, for goods and services, and for recreation. Therefore, the intelligent use and management of the ocean's scarce resources are of vital concern to all Southern Californians.

USC Sea Grant was established in 1969 and, since that time, has maintained its commitment to applying the expertise of specialists to solve special marine and coastal problems of the region through:

Research that spans coastal and marine resources, environmental problems, coastal management and ocean engineering.

Marine Education for elementary, secondary and adult classes.

Advisory Services for recreational activities, government agencies and private industry.

Recent accomplishments in these areas have included:

- Three major national conferences on seaport management and related issues.
- Development of a new and inexpensive assay for the toxins that cause paralytic shellfish poisoning.
- Coordination with the National Weather Service and volunteer radio operators in establishing a Mariner's Reporting Program (MAREP) for ocean weather forecasts.
- Analysis of effluent plumes from major urban outfalls
- Tests on the stress resistance of engineering welds in sea water.
- Shallow-water diving accidents at beaches.
- Six marine education curriculum guides for K-7 teachers.
- New systems for using x-ray fluorescence on marine minerals.

Further information on USC Sea Grant's services and programs is available by contacting:

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Institute for Marine and Coastal Studies
University of Southern California
University Park
Los Angeles, CA 90089-0341

Phone: (213) 743-6068

USC SEA GRANT RESEARCH INVESTIGATES SURVIVAL RATE OF MOLLUSK LARVAE

The oyster industry on the U.S. West Coast depends on hatcheries for new seed because the Pacific oyster, *Crassostrea gigas*, does not generally reproduce successfully in these waters.

To improve the survival rates of oyster and other mollusk larvae reared artificially, information is needed on (1) their nutritional requirements and (2) how hatchery-induced changes in the chemistry of seawater can affect the survival of larvae.

Both questions are addressed in research being sponsored by the University of Southern California Sea Grant Program.

SEA GRANT RESPONSE

The successful aquaculture of edible mollusks, such as oysters and abalone, has been hampered by the lack of information on dietary requirements. Such information is especially important for the early stages of development (embryos and larvae) because there is about a 90% mortality rate of cultured animals in commercial hatchery systems.

Dr. Donal T. Manahan, who is conducting the USC Sea Grant research, is among the first to employ recent advances in bacteria-free animal culture techniques and analytical chemistry to obtain precise measurements of the uptake of dissolved organic materials by larvae under bacteria-free conditions.

To test the hypothesis that dissolved nutrients are important to larval nutrition, Dr. Manahan is culturing oyster larvae under bacteria-free conditions, measuring rates of amino acid uptake by larvae using a combination of high-performance liquid chromatography and isotope techniques, and determining the contribution of amino acid uptake to nutrition by comparing the caloric input of nutrient uptake to the total energy requirements of larvae.

PRELIMINARY RESULTS

- Oyster larvae can absorb 16 common amino acids directly from seawater.
- Larvae of the red abalone *(Haliotis rufenscens)* have a pattern of amino acid uptake similar to that determined for oyster larvae.
- Oyster and abalone larvae release the amino acid taurine into seawater, whether or not amino acids are present in the seawater. This taurine loss also occurs in oyster larvae reared under the not-bacteria-free conditions in commercial hatcheries.
- Oyster larvae often are capable of de novo synthesis of the four amino acids methionine, phenylalanine, isoleucine and leucine. This finding is contrary to the widely held view that these compounds are "essential" and must be supplied in the diet.
- Abalone larvae gain significant weight (up to 600%) between day 0 and day 2. This increase occurred despite the fact that the larvae lack a digestive system and had been presumed to be "non-feeding."

In summary, the USC Sea Grant research is showing that organic nutrients dissolved in seawater do constitute a potential source of nutrition for mollusk larvae. The importance of these substances to overall larval metabolism and energetics now needs to be assessed. This, and the animals' changing amino acid requirements during development, are the subject of continuing research in the USC Sea Grant laboratory by Dr. Manahan. The work, for which the industry has donated all oysters and abalone, complements current studies at Oregon State University and the University of California.

Further information on research sponsored by USC Sea Grant is available by contacting:

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THE CONNECTICUT SEA GRANT PROGRAM

The Connecticut Sea Grant Program is a partnership between the National Sea Grant College Program and the University of Connecticut, drawing on federal and state resources and talent to meet the challenges presented by Connecticut's marine environment. Through scientific and engineering research, education, extension services, publications, and forums, Connecticut Sea Grant and its Marine Advisory Program are aiding the thousands of Connecticut residents who earn their living from the sea, and millions — both in Connecticut and elsewhere — who look to the sea for scientific knowledge, economic benefits, responsible development, and enjoyment.

Connecticut Sea Grant and NOAA's National Undersea Research Program (NURP) are both located at the University of Connecticut Avery Point campus, where they are major elements of the University's growing Marine Sciences Institute. The campus is also home to the Coast Guard's Research and Development Center and Project Oceanology. Sea Grant also has close ties to the Naval Underwater Systems Center and Submarine Base, the Coast Guard Academy, the National Marine Fisheries Laboratory, the Connecticut Department of Environmental Protection, and other branches of the federal and state governments, as well as business and community leaders.

The Connecticut Sea Grant Program supports research in a number of areas, ranging from the regional to the international in scope:

- Shellfish, aquaculture, and gear technology.
- Finfish, including new products and processing techniques that can increase the yield, quality, and market appeal of indigenous species.
- Oceanographic and atmospheric research, in conjunction with the Naval Underwater Systems Center.
- Port and harbor development, including dredging problems, sediments, and estuarine studies, in conjunction with the Corps of Engineers, NURP, and other groups.
- Marine economic and fiscal policy and financial management; this involves close work with the Internal Revenue Service and the State Tax Service.
- Remote sensing of coastal waters.
- Coastal planning and land use, including impact studies on tourism, recreation, and charter boats.

Several research projects are being conducted through the Sea Grant Program, all of which have a direct impact on one or more of these areas. The program is currently involved in:

- A study of how materials resulting from harbor dredging behave when dumped, with the aim of building less expensive, more stable mounds. This may ultimately affect dredged materials disposal practices everywhere.
- The first identification of the hormone controlling crustacean development and reproductive cycles, opening possibilities for advanced aquaculture, selective breeding, and control of marine pests.
- Research in conjunction with State University of New York (Stony Brook) into the use of fast-growing brown seaweed to produce energy.
- The development of a method for mass propogation of a parasite *A. ocellatum*, which is a bane of aquaculturists and aquarium hobbyists. This will make it possible to test the efficacy of various chemicals against the parasite.
- A study which will aid in the growth to maturity of juvenile oysters by investigating the relationship between juveniles and other benthic species.

The Connecticut Sea Grant Program also includes the Marine Advisory Program, an arm of the Cooperative Extension Service that works to make the maritime community aware of the practical benefits of research conducted in Connecticut and elsewhere. Some of the important activities of the Marine Advisory Program include the annual Marine Fisheries Forum; the introduction of the hydraulic clam rake into the State; aid in developing shellfish management plans for ten towns; training programs in seafood handling, marketing, and preparation techniques for industry workers, home economists, and consumers; a quarterly newsletter, *Connecticut Currents*; and providing tax aid and updates on gear technology and fishing techniques for more than 1,000 commercial fishermen.

In sum, the Sea Grant Program is dedicated to the productive use of Connecticut's coastal resources, while enhancing and protecting these natural resources, which are of inestimable value to the state's people and economy. For more information, a detailed description of current projects, a newsletter subscription, and/or an annual report, please contact Dr. Edward C. Monahan, Director, Connecticut Sea Grant Program.

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CONNECTICUT SEA GRANT PROGRAM REVITALIZES LOCAL SHELLFISHING INDUSTRY

Connecticut's shellfishing industry, historically great, fell upon hard times in recent decades. Through the 1960s and well into the '70s, approximately 90 percent of Connecticut's tidal inshore shellfish areas were closed to direct harvesting. The cause was bacterial contamination, which worsened water quality to the point where it fell below the direct harvesting standards established by the National Shellfish Sanitation Program.

These shellfish grow-out and harvesting grounds, once internationally famous centers of oyster production which produced enough shellfish to provide for a hungry domestic population and still allow for export, were almost completely fallow and thought by many to be worthless.

But Connecticut Sea Grant Marine Advisory Program staff believed that, with proper management, the shellfish beds could provide substantial relays into certified waters for natural cleansing, or depuration. Management plans might also allow for the restoration of recreational and some commercial shellfishing activities.

Unfortunately, such plans did not exist. Beginning in 1983, however, a cooperative effort among several shoreline towns and the Marine Advisory Program began to develop them. At the same time, Marine Advisory Program staff developed and presented a variety of programs on the advantages of sound shellfish management and the possibilities for the future of the Connecticut shellfish industry.

The presentations included workshops on harvesting gear, technology, help for shellfishermen, municipal shellfish commissioners and other officials; workshops on shellfish management for shellfish researchers, fishermen, officials, and municipal sanitarians; more than 50 slide/lecture presentations on shellfish management and plan development for officials; and a program for high school students in local shellfish commission internships.

The results were, quick, real, and identifiable:

- Seven Connecticut municipalities have since developed comprehensive shellfish management plans, all of which have been reviewed and approved by the Aquaculture Division of the Connecticut Department of Agriculture.
- Five municipalities created new shellfish divisions.
- Three local shellfish commissions approved habitat restorations projects.
- Four internship programs surveyed the shellfish industry possibilities and assessed local resources.

As a direct result of the Connecticut Sea Grant Marine Advisory Program management plans, small but significant recreational and/or commercial shellfisheries have been re-established in seven towns to date. The state has already benefited from these indigenous businesses and the jobs they've created, and the new shellfish industry has already harvested product with a dockside value of close to $1 million.

Though the establishment of these programs is impressive, the potential — in employment, local business, and appropriate use of a natural resource — is enormous. And, quite possibly in the not-too-distant future, the Connecticut shoreline will once again be filled with a string of famous shellfish-producing towns.

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University of Delaware Sea Grant College Program

Now in its nineteenth year in Delaware, Sea Grant continues as a partnership in which the University, the government, and the private sector pool intellectual and financial resources to address coastal and marine issues.

Current emphasis in the Delaware Program is in marine biotechnology, estuarine and coastal environmental assessments, geological and coastal dynamics, and marine programs outreach.

Research

- To define new methods of preventing biofouling on marine vessels and other artificial substrates, Sea Grant scientists are studying how marine organisms such as corals and sponges have developed mechanisms to prevent the early attachment of barnacles and other biofoulers. Laboratory experiments have resulted in localizing and identifying natural antifouling components in specific chemical fractions and show that many of these naturally produced antifouling compounds are rapidly degraded.
- Chitin, the cellulose-like structure found in the shell of crab, shrimp, and other marine animals, has been a major component of Sea Grant research. Although crab shells have been considered a waste produced by seafood processsors, our scientists have developed methods to extract chitin and have produced surgical sutures, high value food additives, and specialty chemicals.
- Salt-tolerant plant research has developed a grain, vegetable, and several forages from wild halophytes. Sea Grant researchers reached a major biotechnological landmark by successfully regenerating a tissue portion of the forage *Distichlis spicata* to a full-grown plant.
- The Delaware Estuary is a major source of commerical and recreational growth for the mid-Atlantic region. At University of Delaware Sea Grant, researchers are continuing a major study of the bay to define how the estuarine system functions and to assess its health. Results of the study are being used by resource managers and the private sector to make decisions on future development on and around Delaware Bay.
- Certain that sea level is rising, Sea Grant geologists and coastal engineers are working to predict future shoreline changes as well as determine which coastal erosion structures will be most effective in areas along the Delaware coast. Preliminary results suggest that sea level is rising at triple the rate of 50 to 75 years ago.

Marine Advisory Service

Marine Advisory Service activities encompass a wide range of projects designed to educate the users of our marine resources through knowledge gained by research. During our nineteenth year as a Sea Grant College, the Marine Advisory Service collaborated with 20 local, state, and federal agencies; 27 academic institutions; 43 trade associations and businesses, and 68 public schools and universities. Specialists provide technology transfer in the areas of fisheries development, seafood quality, marine education, and marine business management.

The following projects help demonstrate the many ways the Marine Advisory Service works to enhance the lives of Delawareans:

- The Mariner Reports (MAREP) program continues to provide boaters as well as the National Oceanic and Atmospheric Administration's National Weather Service with updated weather reports to protect mariners' lives, vessels, and catch. Through MAREP, mariners report timely sea and weather observations to personnel at the University of Delaware in Lewes, who relay the information to the National Weather Service to update and improve its marine forecasts. Revised forecasts transmitted to Lewes are then available to mariners at sea.
- The MAS recently undertook a cooperative project with the Department of Natural Resources and Environmental Control (DNREC) to evaluate the feasibility of applying remote setting technology to enhance oyster populations in Delaware. Together these organizations are raising oysters in captivity, inducing their spawning, and then setting the spat on shell in local riverbeds where the survival and growth of the oysters will be monitored.
- To assist the charter/headboat industry in the state, the MAS sponsored a business workshop in conjunction with the Delaware Small Business Development Center. The captains received information on financial planning and management, methods of improving marketing and advertising, and research results on the biology and basic fishery science of important Delaware Bay sport fish.
- The MAS conducted a workshop for the state's seafood retailers, providing them with timely information on the storage, handling, and preparation of seafood, as well as guidelines to market it successfully.

Education

Since its designation as a Sea Grant College Program in 1976, the University of Delaware has had, and continues to have, a strong commitment to the education of students pursuing marine studies. Many of these students have gone on to successful marine-related careers in industry, state and federal government, and academia. During the past year, 23 students received Sea Grant support.

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University of Delaware Sea Grant College Program
Research Benefits Fact Sheet

Marine Biofouling

In marine biotechnology–the application of the principles of engineering and technology to the marine sciences–University of Delaware researchers are studying how marine organisms such as corals and sponges have developed mechanisms to control or prevent the early attachment of barnacles and other biofoulers. By understanding how natural chemical defenses deter fouling, our scientists hope to gain insight into new and better methods of preventing biofouling on marine vessels and other artificial substrates. Laboratory experiments have resulted in localizing and identifying natural antifouling components in specific chemical fractions and have indicated that many of these naturally produced antifouling compounds are rapidly degraded. The researchers' next goal is to understand how bioactive chemicals act at the organism/water surface.

Fouling–the encrusting of barnacles and other foreign matter on marine vessels and other objects–is an ever-present problem. In the marine environment, where hard substrate is at a premium, biofouling has caused major cost problems. It weakens wooden boat hulk and dock pilings, reduces vessel speeds and thus increases transportation costs, and causes an endless flow of surface preparation and coatings applications. A significant industry problem results from biofoulers clogging water intake lines and interfering with the function of underwater equipment. In the U.S. alone, the annual cost of reducing marine biofouling is more than $1 billion. Scientists have conducted several studies on various aspects of biofouling on artificial substrates, mechanisms of attachment by fouling organisms, and succession in the fouling community. However, University of Delaware researchers are addressing the problem of inhibiting and preventing biofouling by understanding how marine organisms chemically defend against fouling.

Submerged organisms contend with biofouling. In these organisms the detrimental effects of biofouling include feeding and respiratory obstruction, increased drag and sedimentation, and shading. In the marine environment there are several organisms which, although attached or slow-moving, remain free from biofouling. In many of these organisms there is evidence that suggests that the antifouling mechanism involves both chemical and biological interactions. Researchers at Delaware are studying how these mechanisms work in the subclass of corals known as octocorals–a species found most abundant in the tropical western Atlantic. Of octocorals, Delaware scientists have chosen gorgonian because this particular species is most obvious on shallow tropical reefs and is readily accessible. Octocorals have also been found to have activity of potential ecological significance. Several octocoral extracts and compounds have antibacterial properties and have shown to be powerful inhibitors of algal growth. Because dead octocorals show lush bacterial and microalgal growth, Delaware researchers reason that it is not the substrate itself, but some mechanical or chemical defense characteristic of the living colonies, which prevents biofouling. By determining the organisms' organic chemical composition, scientists have already characterized several antifouling properties in laboratory tests. Once more is understood about natural antifouling mechanisms, adaptation can lead to use on artificial substrates.

Because of the potential impact in savings to the marine industry resulting from this work, the Office of Naval Research is providing one-half of the funds necessary to carry out the research.

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FLORIDA SEA GRANT COLLEGE

Florida A&M University • Florida Atlantic University • Florida Institute of Technology
Florida International University • Florida State University • University of Central Florida
University of Florida • University of Miami • University of North Florida
University of South Florida • University of West Florida

LIVING MARINE RESOURCES

Florida's marine resources support major commercial and recreational fisheries. The 430 seafood processing and wholesaling plants process well over $500 million in wholesale products, placing Florida sixth in the nation in catch value. Well over five million anglers participate in Florida sportfishing annually making it a major state industry. However, the state's fisheries are threatened by multiple use conflicts, overfishing, and coastline development which contributes to habitat loss.

To assist the fisheries, Florida Sea Grant has:

□ Determined nursery habitats required by early juvenile snook to demonstrate a cause of the decline of the snook population and suggested measures to restore this prominent fishery.

□ Determined that a proposed 30 percent federal import duty on shrimp would have raised import price by 37 percent, vessel price by 9 percent, and decreased quantity imported by 8 percent.

□ Stimulated the development of a soft crab fishery in Florida. The number of soft crab shedding operations jumped from 6 to 30 in just four years, providing approximately $3 million of new products since 1978--a return of $500 for each Sea Grant dollar invested.

□ Established new golden crab fishery in the Gulf of Mexico potentially valued at $3 million annually. New biological research will help determine the level of investment and fishing effort required to maintain a productive fishery.

□ Examined offshore alternative commercial fisheries to reduce the conflict with recreational fishermen who fish mostly coastal waters.

□ Conducted a major program in effectively utilizing artificial reefs and in how to properly site and permit them.

COASTAL PROCESSES AND DEVELOPMENT

Florida is the nation's second fastest growing state and by the year 2000 is expected to be the third largest. Eighty percent of this population lives in coastal counties. Productive wetlands are threatened. Shoreline construction has both created hazards and is threatened by them. Structures built along the coast frequently contribute to erosion of the beaches and are themselves subject to corrosion of the reinforced steel concrete used in building. Florida Sea Grant has been effective in helping to solve many of the problems by:

□ Coordinating research on the behavior of materials in the marine environment using structural engineering, chemistry, biology, and acoustic detection of corrosion. This information has nationwide implication and has been used widely by offshore oil interests and incorporated into the American Petroleum Institute's recommended practice design of fixed offshore structures. One study indicates work on the use of fiber and polymer modified concrete for use in marine structures will save millions of dollars over a 10 year period.

□ Supporting long term research efforts in the Apalachicola Bay, a major estuarine and fisheries production area, which have resulted in changes in pesticide use by agriculture, in timber clear-cutting practices, and in seafood processing techniques.

□ Developing model flood plain and hurricane zoning ordinances and a model ordinance to effectively manage stormwater runoff in the coastal zone.

□ Defining geologic processes on the non-barrier shoreline of Florida's Gulf coast. Planners and citizens can now better utilize the coast knowing the rates of shoreline change, geologic hazards and environmentally sensitive lands.

MARINE INDUSTRIES

About 550,000 vessels are registered in Florida--one for every 210 persons or one for each eight households. There are 1500 marinas. Other marine industries include shipbuilding and repair, naval architecture and yacht design, marine engineering and surveying. Some Sea Grant work has:

□ Determined the legal aspects of recreational marina siting and operations in Florida to avoid or minimize potential liability.

□ Devloped the first ever economic profile of the major recreational marine industries in Florida. This included sales and labor market trends in pleasure boat manufacturing and retailing, financial performance of marinas and boatyards, economic characteristics of boat and trailer manufacturing, marine equipment manufacturing, marinas and boatyards, marine trade and marine services. These results have been used in the international promotion of Florida's marine industry.

□ Determined the strength and cost effectiveness of new light weight, high strength materials using finite element analysis for small boat manufacturers.

MARINE EDUCATION

Every Florida Sea Grant project nvolves education. Research projects train graduate and undergraduate assistants, Sea Grant extension programs educate statewide groups and individuals, and the communication efforts of Sea Grant disseminate material through various media. Following are some of the more significant accomplishments:

□ Developed a 4-H Marine Program which has involved over time 50,000 youths and 10,000 adult leaders in marine education projects and activities in over two-thirds of Florida counties.

□ Assisted in starting a ship and yacht design course utilizing computer graphics aids in the design of both power and sail yachts.

□ More than 300 students have participated as assistants in Sea Grant research projects at state and private institutions.

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FLORIDA SEA GRANT COLLEGE

SEAWATER CORROSION OF REINFORCING METALS IN CONCRETE

BACKGROUND

Cracking and spalling of concrete due to corrosion of embedded steel is a major engineering problem in maintaining numerous structural systems not only in Florida, but all across the nation. Although environmental conditions related to saltwater is a problem in all coastal states, other locations where salt is used to alleviate winter weather conditions experience similar stress and corrosion fatigue of concrete structures also. The damages occur in bridge and highway structures as well as buildings and marinas. As a result, the problems associated with the corrosion of embedded steel in concrete and the resulting deterioration, is of national significance. It has been estimated that one-third of the nation's bridge decks suffer seriously from corrosion of the reinforcing steel and prestressed tendons with resulting damages being estimated at approximately $7 billion dollars annually in the United States alone.

SEA GRANT RESPONSE

Beginning in 1973 and continuing to date, Florida Sea Grant, aware of the need for study in this area, has funded a comprehensive program which has addressed the problems associated with the behavior of materials in the marine environment and has provided information applicable to the wider geographical range mentioned above. These projects have looked at the problems in new ways, stimulating outside participation and encouraging new funding sources. Because the problems are multi-disciplinary in nature, the investigators approached the research in a like manner taking into consideration:

- marine materials
- structural engineering
- chemistry
- biology, and
- acoustics.

Researchers at Florida Atlantic University (FAU), initiated the first project entitled, "Environmental Cracking and Corrosion Fatigue in Sea Water." The objective of this early work was to investigate the importance of cyclic frequency, or rate of stress reversal, upon the sea water corrosion fatigue response of steel. The researchers' determinations included frequency dependence of corrosion fatigue, such as stress vs. cycles, to failure; the influence of frequency of corrosion fatigue crack initiation time and crack growth rate; and the importance of frequency to the potential dependence of corrosion fatigue processes as applicable to cathodic protection criteria.

This project generated information crucial to the engineering of coastal structures such as bridges, piers, seawalls, breakwaters, and offshore ocean structures and stimulated major research initiatives by the American Petroleum Institute Committee on Offshore Safety and Antipollution Research.

In the intervening years, other engineering projects related to sea water corrosion followed including, "Seawater Corrosion of Reinforcing Metals and Concrete Cracking," "Cathodic Protection Against Sea Water Corrosion," and "Fatigue of Welded Structural Steel in Sea Water."

Another project was designed to develop fatigue data for welded steel under conditions approaching those of actual wave loadings (low cycle stress rate and variable amplitude loading). Results of this research have been incorporated into the American Petroleum Institute Recommended Practice RP-2A, "Design of Fixed Offshore Structures."

Sea Grant investigators have also researched methods by which corrosion related structural damage occurring in reinforced and prestressed concrete can be identified using sound, and have developed the ability to monitor and characterize the cracking process caused by reinforcing bar corrosion using acoustic emission (AE), a passive, non-destructive technique. This includes detecting and locating even very small cracking at the micro crack level and is useful in identifying early structural damage in concrete specimens. The AE method will provide the ability to relate the potential for structural deterioration to an ongoing corrosion process buried within these concrete structures. As a result, a new ultrasonic pulse technique for sensing corrosion has been developed and is being refined.

Since permeability of concrete is the most important characteristic determining the long-term durability of concrete exposed to seawater, researchers, in a first of its kind study, have investigated the strength of concrete when modified with a combination of fiber and polymer. Fibers used included steel, glass, and kevlar. Results have shown the value of using latex additives in concrete in reducing permeability and identified kevlar as the most suitable additive for durability.

RESULTS

Through the development of this comprehensive program, Florida Sea Grant has provided leadership in an area of vital concern. In addition to the results mentioned above, project researchers have produced educational materials on their findings for public and professional bodies. Recognized as experts, individual researchers served on the governor's independent review panel on the Skyway Bridge Project. Stimulated by Sea Grant research which totalled $100,000 over a period of four years, industry responded with approximately $200,000 per year over a ten-year span. The results have been used widely by offshore oil interests. A cost evaluation by the State of Florida Department of Transportation indicated that one project could save the state $12 million over the next ten years. Furthermore, the information generated by these projects addressed a need identified by the federal government for action related to the rehabilitation and maintenance of transportation systems in the United States.

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Georgia Sea Grant College Program

The National Sea Grant College Program was already five years old when Georgia's participation began in 1971 at the Coherent Grant level. Georgia was granted Institutional status within the National Program in 1974, and the top level of recognition, Sea Grant College status, was awarded in 1980.

Marshalling University Resources to Benefit Coastal Industries

Through the Georgia Sea Grant College Program, the extensive multi-disciplinary resources of the state's university system have been marshalled and carefully coordinated to address problems of coastal industries ranging from fisheries development and seafood processing to marine mining and coastal tourism and recreation.

Although strongly focused on the needs of Georgia's coastal and marine communities, the Georgia Sea Grant College Program has the potential for wider impact through a network of more than 30 Sea Grant universities bordering the oceans and the Great Lakes. These institutions make up a coordinated system which generates and disseminates information and technology to address the significant marine resources problems and opportunities which confront the United States today.

Helping Fishermen and Processors

A few examples of Sea Grant projects with significance and application beyond Georgia's boundaries include the following:

- **Alternative Fisheries**
  In the late 1970s, Georgia Sea Grant began a program to lessen the dependence of southeastern fishermen on shrimp. Shrimpers were encouraged and trained to diversify their operations by harvesting offshore finfish. From 1969 to 1975, annual landings of offshore finfish in Georgia averaged 76,000 pounds, with an ex vessel value of $38,000. In 1984 and 1985, however, the annual catch has averaged 553,000 pounds and provided fishermen with $660,000. With a 2.5 multiplier effect, the increased impact on the coastal economy in Georgia alone may have amounted to over $1.5 million in each of the last two years.
- **Quality Control of Seafood**
  Georgia Sea Grant's Analytical Services Laboratory helps not only individuals but also the seafood processing industry as a whole. After several instances where processed seafood products were rejected because of high bacterial counts, the industry faced indefinite suspension in the marketplace. The laboratory director went into plants and devised methods to monitor the internal temperatures of crabs scattered throughout the cooking tank to determine evenness of cooking. As a result, the position of steam inlets in the retorts was changed resulting in a more evenly cooked product which improved overall quality and safety.
- **Softshell Crab Industry**
  The introduction of softshell crab technology has resulted in the establishment of a small industry that promises to grow. In Georgia, crabs are sold normally for about $0.05 each to crabmeat plants. A crab that is ready to molt (peeler) is worth about $0.30 to the crab shedder, and a softshell crab is sold for about $1.00 to retailers and restaurants.
  Sea Grant trained crab fishermen to detect peelers and trained crab shedders to build and maintain circulating and recirculating seawater systems to hold peelers for molting. In 1984, approximately 90,000 softshell crabs were produced to set a record for Georgia. The number of softshell crab producers has increased from one in 1980 to 12 in 1984.

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Georgia Sea Grant Stimulates Development of Offshore Finfishery

In the late 1970s, Georgia Sea Grant began a program to lessen the dependence of fishermen in the southeastern United States on shrimp. Fishermen were encouraged and trained to diversify their operations by harvesting offshore finfish, such as snapper, grouper, and tile fish, which had been virtually unexploited.

The impact of this program can be measured in part by landings figures. From 1969 to 1975, annual landings of offshore finfish in Georgia averaged 76,000 pounds, with an ex vessel value of $38,000. In 1984 and 1985, however, the annual catch has averaged 553,000 pounds and provided fishermen with $660,000. With a 2.5 multiplier effect, the increased impact on Georgia's coastal economy alone may have amounted to over $1.5 million in each of the last two years.

Averting Economic Crisis

Sea Grant's program for diversification began in a time of economic crisis for shrimp fishermen. The fishery had been pushed to maximum production capacity due to a dramatic increase in the number of shrimp boats in Georgia after Mexico's adoption of a 200-mile limit. High fuel costs, which also affect the cost of other items such as ice and fiberglass, already were lowering the margin of profit. Then came three disastrous years (1977, 1978 and 1981) when shrimp were killed off by cold weather. Many fishermen were forced to take advantage of loans from the Small Business Administration to keep afloat. With added debt, many felt it out of the question to tie up their boats for the five months off-season, yet the option of traveling to the Gulf of Mexico had become increasingly marginal.

Examining Alternative Fishing Methods

Refitting shrimp boats for multi-purpose fishing appeared to be a practical solution to extending the working season for shrimpers. The Georgia Sea Grant Program set about demonstrating the feasibility of this option with the use of the *R/V Georgia Bulldog*.

A former drug boat abandoned by smugglers, the 73-foot trawler had been acquired by Georgia Sea Grant through the National Sea Grant Program Office. The conventional wooden hull trawler was converted into a multi-purpose fishing vessel, and a study was begun to determine if a shrimp boat can harvest finfish economically and efficiently. Various types of gear and equipment were tested. Fishing methods were evaluated, including surface longlining, trap fishing, handlining, bottom longlining, and bottom trawling. During this study, 130 square miles of productive bottom areas were located and charted.

Training In New Technologies

Georgia Sea Grant developed a program to teach shrimp fishermen how to use the electronic fishfinding and navigational systems needed to work 40 to 80 miles offshore. The *Bulldog*'s sleeping quarters for eight made it possible to take fishermen out to experience offshore operational techniques.

A Winning Combination

The Georgia finfish project reflects many of Sea Grant's distinguishing characteristics. It was interdisciplinary; it combined education and training with research; and it was designed to meet a well-defined need. Today, offshore fishing has become profitable business for many. As a result of this growing fishery, the first Georgia dock devoted fulltime to packing and marketing finfish is now the largest within 300 miles.

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Hawaii

The University of Hawaii Sea Grant College Program responds to national and state problems related to the wise use of coastal environments and ocean resources by facilitating the timely application of the university's capability through research, education, and extension programs.

RESEARCH

In aquaculture

The knowledge gained by researchers in the culture of prawns will be applied in the refinement of production technology for farming marine shrimp. A second species—mahimahi—which has been successfully reared to the fingerling stage from eggs, shows good growth potential.

In tourism and recreation

Researchers are now planning an underwater park on Hawaii to enhance the island's attractiveness to both tourists and residents. Sea Grant research on the marine recreation industry indicates that these small businesses contribute substantially to Hawaii's gross state product. Research on risk management practices of coastal jurisdictions in the United States will provide basic data on customary safety practices of public agencies managing coastal sites and recreational facilities and characteristics of high risk sites.

In biotechnology

A fast simple test for ciguatoxin has been developed by researchers at the University of Hawaii with funding provided by state and federal agencies and Sea Grant. The test, currently being evaluated by the Food and Drug Administration, holds promise for safely marketing underutilized toxin-prone species.

In fisheries

Sea Grant research on enhancement of fish aggregation devices discovered that yellowfin tunas, the most important species associated with such devices, almost exclusively consume deepwater shrimp, a previously unknown resource. This leads researchers to believe that fish aggregation devices may trigger new trophic relationships.

In international law

A Sea Grant-sponsored workshop on potential conflicts related to the rejection of the Law of the Sea Convention by the United States resulted in a book entitled, *Consensus and Confrontation: The United States and the Law of the Sea Convention*. This book is the most definitive work on implications of the U.S. position on the Law of the Sea Convention.

EDUCATION

Graduate education

In the 1983-85 biennium, Sea Grant funds provided support for 154 graduate students. During this same period, 42 Sea Grant-supported students earned graduate degrees: 14 Masters, 15 Juris Doctors, and 13 doctorates.

EXTENSION SERVICES

The establishment of The Ocean Recreation Council of Hawaii, a statewide organization of small businesses engaged in the rental and instruction of ocean recreation equipment, was one of the results of a conference and trade exposition organized by Sea Grant Extension agents. These businesses represent the cutting edge of new development in the tourism industry in Hawaii.

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Breath-Hold Diving Research Results Have Medical Applications

Although engineered systems have advanced dramatically in their capability to withstand the crushing pressure of the ocean depths, knowledge of human performance is still largely a trial and error procedure. Research in human performance in hyperbaric environments has produced valuable data which are now being used in medical treatment.

University of Hawaii Sea Grant researchers have gained national recognition for their meticulous study of breath-hold diving research which involves head-out water immersion, apnea, submergence, pressure and cold exposure, and underwater exercise. The results of the apnea and water immersion studies are now used in clinical practice; for example, apnea is used as a treatment for supraventricular tachycardia.

Conversely, the knowledge of the hazards of induced apnea in laryngoscopy, braonchoscopy, applications of aerosols, and tracheal cleaning of patients on ventilators has been advanced by this Sea Grant project. Other applications include, advances in treating near-drowning cases, understanding apnea and sleep disorders, and the use of immersion as a procedure for redistributing blood flow to various internal organs and elimination of excess body fluids when patients can not tolerate diuretics.

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The Illinois-Indiana Sea Grant Program

Well over 8 million people inhabiting the southern Lake Michigan regions of Illinois and Indiana create a tremendous pressure on the Lake's relatively short 105 mile shoreline in the two states.

Not only does Lake Michigan supply drinking water for the millions of citizens who live near its shores, but it also offers excellent fishing, swimming, boating and other recreational opportunities. This water resource is also a great tourist attraction because of its beautiful beaches, abundant state and local lakeside parks, and interesting historical sites.

The Illinois-Indiana Sea Grant Program, based at the University of Illinois at Urbana-Champaign and Purdue University, will focus this year's efforts on:

- Water usage
- Coastal policy
- Tourism
- Recreational/Cultural resources
- Fisheries
- Economic growth
- Aquaculture

The Marine Extension Program

The Fish Contamination Controversy

A series of water quality articles have been produced in *The HELM*, IL-IN Sea Grant's quarterly newsletter, to inform the public about human health impacts and other fish contamination issues in the Great Lakes.

Rising Lake Levels and Shoreline Erosion

Shoreline homeowners in several communities have been provided with erosion protection advice. Erosion prevention workshops will help property appraisers be better prepared to help shoreline property owners make well-informed property use decisions.

Tourism Industry's Potential for Increasing Region's Economic Stability

Several hospitality training workshops have been conducted for recreation and tourism enterprises. Three workshops on "Bed & Breakfast" opportunities have also been presented to provide current and future proprietors with skills to attract more tourists to their area. The influx of tourists means more dollars brought into the region which brings increased economic stability to this depressed industrial region.

An annual workshop, a quarterly newsletter, and individual contacts provide business management, fisheries, and other information to 300 charterboat operators who are a major tourist attraction and a multi-million dollar segment of the recreation industry.

Boating Safety Hazards in Inclement Weather

Ten charterboat operators have been recruited to report timely marine weather data which will result in more accurate weather forecasting and increased boating safety; this Mariner Reporting Program (MAREP) is being sponsored by Sea Grant, NOAA, and the U.S. Weather Service.

Waterfront Development Issues

Information has been provided to the Lake Michigan Marina Development Commission (LMMDC) on boat-related taxes in Indiana's neighboring states. This data helped the Commission determine if northwest Indiana's slip rental fees were competitive in the region. The LMMDC plans to apply for a mini-grant from IL-IN Sea Grant to do impact studies on marina development in northwest Indiana.

Emerging Aquaculture Industry

The Program's coordinator is a member of the Illinois Aquaculture Advisory Committee which is providing input to the "Illinois Aquaculture Feasibility Study." If the study receives favorable legislative reaction, an Illinois aquaculture plan will be prepared, followed by a detailed aquaculture marketing plan.

Water Quality Improvement

Aquatic weed management training sessions have been given to area homeowners and municipal and park managers. The aquatic weed control section of the Illinois Pesticide Applicator Training Manual has been updated by the Marine Extension Adviser.

The Research Program

Food Habits of Salmonids in Southern Lake Michigan

This is part of a Great Lakes-wide investigation of salmon and trout food habits. By monitoring salmonid diets, it is hoped that changes in diet due to changes in the forage base can be detected. The information gained should be useful in helping fish managers determine whether salmonid stocking should be increased or decreased and which species are best to manipulate.

Analyses of the Behavioral Bases for Changes in Salmonid Diets

If realistic judgements are to be made on salmonid stocking to ensure a good harvest by sportsfishermen, it is important to understand what limits the shift to alternate prey species. By video-recording and visually observing foraging behaviors of coho salmon, chinook salmon and lake trout, researchers will try to determine why Lake Michigan salmonids continue to forage heavily on alewives which are declining, while alternate prey populations are increasing.

Development of Gene Transfer Technology for Aquaculture

This research will contribute to the development of technologies for genetic engineering in fish. Its focus will be on fish of commercial importance such as walleye and yellow perch, that have not yet been exploited for gene transfer experiments. Theoretically, gene transfer technology could be used to produce new and useful fish strains.

Factors Affecting Participation in Indiana-Based Recreation on Southern Lake Michigan

This project will develop an information base about recreation site use to help decisionmakers formulate policy about Indiana's role in water-based recreation on the Lake. 3,000 residents from the Chicago metropolitan area, northwest Indiana and southwest Michigan filled out questionnaires which asked about their use of recreation sites, attributes that made the choice attractive, and background data.

Production, Identification and Characterization of Multiple Toxins Responsible for Ciguatera in the Caribbean and South Atlantic

The objective of this study is to reduce or eliminate the danger of poisoning that can occur when eating certain tropical and subtropical fish. Research results should provide a starting point for developing practical marketplace tests that will safeguard individuals against this ciguatera poisoning.

In Summary

Through its research and marine Extension activities, the small staff of the IL-IN Sea Grant Program is working continually to address problems important to the millions of people living near the Lake Michigan shore. While not all of its achievements can be measured in dollars, the IL-IN Sea Grant Program has made a significant contribution to the economic benefits of the two states and the Great Lakes region.

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Illinois-Indiana Sea Grant Helps to Enhance Tourism Industry, Improves Economic Stability in Southern Lake Michigan Region

Through the efforts of the Illinois-Indiana Sea Grant Program, an increasing number of tourists have been attracted to the southern Lake Michigan region, bringing more dollars into the area, thereby increasing the region's economic stability. This was accomplished by providing information and serving in an advisory role to key tourism industry personnel in northwest Indiana and the Chicago metropolitan area.

Northwest Indiana is an economically depressed region because the demand for its main industry, steel manufacturing, has declined sharply in recent years. Therefore, key agencies and officials in northwest Indiana have been taking a hard look at tourism as an additional economic base. They feel that Lake Michigan's attributes, along with the 13,000 acre Indiana Dunes National Lakeshore, create the potential to draw large numbers of tourists to the area.

Illinois-Indiana Sea Grant has assisted with the promotion of tourism in many ways:

- Co-sponsored a tourism workshop in Merrillville, IN which brought together public officials, planners, government tourism boards, recreation boards, chamber of commerce officials, motel operators, managers of cultural institutions, entertainment promotors, and the general public. They learned about plans underway to promote tourism in northwest Indiana and the anticipated economic impact of those efforts.

- Assisted in coordinating a waterfront revitalization conference in Gary, IN. Some of the topics discussed in this workshop included waterfront development on the waters of northwest Indiana, including plans for marina development in Gary and Michigan City, IN and on the Grand Calumet River.

- Provided funding for three key tourism leaders to attend a Great Lakes Sea Grant Network tourism workshop in Traverse City, Michigan.

- Co-sponsored a hospitality training workshop at the Calumet campus of Purdue University. Attendees representing local businesses and government agencies were provided information on meeting and greeting people, giving directions and supplying information about their community.

- Coordinated and co-sponsored Bed & Breakfast (B & B) workshops in Illinois and Indiana. These provided prospective B & B proprietors with the necessary information to begin such a business and current B & B owners with new information and ideas they could apply to their ongoing businesses.

- Conducted training workshops for charterboat operators. The Lake Michigan charterboat business for sportfishing is an important dollar-generating tourism industry in northern Illinois and Indiana. These workshops have helped the charterboat operators improve their business management techniques.

- Produced "Charterlines," a quarterly newsletter for charterboat captains from Illinois and Indiana aimed at keeping them abreast of new publications, workshops, legislative updates, and other information that will help them in their business activities.

- Provided input to the economic impact study of the North Point Marina in Illinois; supplied the Lake County Economic Development Commission with tourism and charterboat statistics for this study.

- Produced *State and Federal Regulations Related to Boating on Lake Michigan* and distributed it to local chambers of commerce, mayors, park districts and recreation departments, marinas, charterboat operators, planning commissions, port authorities, and other interested persons.

- Cooperated in the printing and distribution of *Indiana's Shoreline – A Recreation Guide*. Copies were distributed to Indiana's tourism offices, which found them to be very popular among their visitors.

Impacts Resulting From Illinois-Indiana Sea Grant's Tourism Promotion Activities

- A new tourism office was founded in Porter County, Indiana in 1985. This office along with two young tourism offices in Lake and LaPorte Counties have increased their staff to such a size as to create a need for new locations.

- In 1985, the state of Indiana allocated $2 million over two years to form a Marina Development Commission which is studying the possibility of building or expanding five marina developments in five Indiana cities bordering Lake Michigan. This Commission plans to apply for a mini-grant from the IL-IN Sea Grant Program to do impact studies on marina development in northwest Indiana.

- The impact of our educational efforts related to tourism in Illinois has not been as great as that in Indiana. The Chicago metropolitan area has a more developed tourism industry, however we will continue to offer assistance to those sectors of the Illinois tourism industry which can benefit from our workshops, publications, and other information.

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LOUISIANA SEA GRANT COLLEGE PROGRAM

Based at Louisiana State University's Center for Wetland Resources, the Louisiana Sea Grant College Program is committed to research, education, and advisory projects that lead to practical solutions for the problems of marine resources management and use in the state of Louisiana. The great size, biological productivity, and mineral wealth of Louisiana's coastal zone make the region important to both the state and national economies; its management has been Louisiana Sea Grant's dominant concern, for without effective management, vital long-term economic and social benefits will undoubtedly be lost.

The following represent recently completed or ongoing Sea Grant projects in research and advisory services that benefit both the state of Louisiana and the nation and are in keeping with the goals of the National Sea Grant College Program.

- Present methods of removing or reducing toxic wastes from waterways are often inadequate and expensive, sometimes creating new combinations of chemicals that are more dangerous than the original toxicants. Using genetic manipulation, Sea Grant researchers have developed strains of bacteria that can destroy hazardous wastes--the first microorganisms tailor-made to feed on such toxicants as PCB, PCP, PAH, and creosote in brackish and saltwater environments as well as in fresh water. The microbial waste treatment process has been approved by the EPA for use in cleaning up several major waste disposal sites in Louisiana. The technology will soon become widely available as the result of an agreement between LSU and the Manville Service Corporation in which the microbes will be produced in large numbers in a pilot plant and marketed to industries throughout the country.

- Sea Grant aquaculture research virtually established and developed a thriving crawfish farming industry in Louisiana from what had once been just a traditional wild harvest. This industry has had an annual economic impact on the state of $70 million. In other Sea Grant-supported aquaculture research, the development of the closed recirculating water system revitalized the faltering soft-shelled blue crab industry in Louisiana, where deteriorating coastal water quality had made it difficult and unprofitable for fishermen to hold hard crabs for shedding in natural water systems. Closed-cycle water systems have also proved successful in producing soft-shelled crawfish, thus giving crawfish farmers a new, marketable product, and in purifying oysters from contaminated water sources, providing Louisiana oyster processors with the solution to a serious problem.

- The dynamic forces fostering the growth of the evolving Atchafalaya delta and their extensive impacts on surrounding wetlands have affected many important coastal activities--commercial fishing, trapping, hunting, shell dredging, flood control, oil and gas production, and navigation. Louisiana Sea Grant's research program here has provided important information for government and industry in coastal management planning and resource development projects.

- Louisiana's coastal marshes, which sustain the nation's most valuable commercial and recreational fisheries, are yielding to saltwater intrusion and erosion. Sea Grant research has been in the vanguard of state efforts to measure the rate of wetland loss, study the fundamental processes that control wetland growth and decline, and recommend methods to mitigate existing damage and minimize further losses. The results of Sea Grant research are also used by federal agencies like the U.S. Fish and Wildlife Service, the U.S. Corps of Engineers, and the National Marine Fisheries Service.

- Louisiana Sea Grant's Marine Advisory Program supports 20 marine advisory agents and specialists who live and work throughout coastal Louisiana, providing information and assistance to their communities on a variety of topics such as aquaculture, seafood marketing, fisheries technology, mariculture, marine engineering and economics. Sea Grant marine agents and specialists have been instrumental in the continuing development of Louisiana's seafood industry. Marine agents have worked to educate fishermen about valuable but underexploited fisheries and have helped them to develop new kinds of gear or gear modifications for exploring new enterprises.

Through industry-wide workshops and conferences, Sea Grant specialists have taught processors and retailers how to increase their business--and profits--through effective merchandising, greater product diversity, and efficient quality control. They have aided the crawfish processing industry to expand by providing liaison with restaurant industry buyers nationwide; by arranging financing for plant expansion and inventory; by developing industry standard practices for cooking, packaging, storage, and quality control; and by counseling processors in business management. Sea Grant agents and specialists have assisted the oyster industry in the development of depuration plants for the production of safe, bacteria-free oysters and have aided seafood processors of all kinds in achieving FDA standards for plant sanitation.

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LOUISIANA SEA GRANT COLLEGE PROGRAM

Louisiana's coastal waters are famed for their rich harvests of seafood, and fishing is a way of life in many communities along the coast. But Louisiana's commercial fishermen have always concentrated primarily on shrimp, leaving many other stocks of edible seafood virtually untouched, and the coastal seafood processing industry has traditionally distributed only the products that were needed for local markets--fresh, headless shrimp; sack oysters; live and boiled crabs; and fresh fish.

Thus, over the years, large quantities of seafood have been trucked directly from Louisiana's docks to other states for end-product processing and packaging--passing through Louisiana without contributing in any significant way to the state's economy.

Harvesting nontraditional fisheries and capturing the "value-added" economic benefits associated with the processing and marketing of seafood are, therefore, major challenges for Louisiana--a state historically dependent on the declining oil and gas industry for revenues and employment but now in need of new areas for economic development. To accomplish this, the Louisiana processing industry needs to modernize, to intensify marketing efforts, and, most importantly, to maintain exacting standards of freshness and wholesomeness for all the products it produces.

In a Sea Grant-supported advisory project, Michael Moody, seafood technology specialist, and Gail Moertle, research associate in food science, have been working with the seafood production industry to solve some of its most pressing problems from sanitation to marketing. Blending university research with education, the two have formed a unique trouble-shooting team for Louisiana seafood producers--who have not been slow to ask for help.

Dr. Moody and Ms. Moertle educate plant operators regarding the practical problems they encounter in the commercial processing of seafood, especially those involving sanitation and seafood quality. In the laboratory they develop scientific methodology that can be applied in an industry setting to diagnose problems and produce better products.

Crabmeat, for example, is especially vulnerable to microbial contamination, as crabs are handled extensively during processing. In making intensive sanitation surveys of crab plants, Moody and Moertle were able to determine the kinds and sources of contamination and recommend practical measures to eliminate the problem. As a result of their work, important procedural changes have been made statewide in Louisiana crab processing plants, assuring safer products for the consumer and saving plant operators from expensive FDA fines.

But sanitation is not the only requirement for maintaining high seafood quality, and Moody and Moertle's research also includes the development of optimum procedures for insuring excellence in taste, texture, and color. Such guidelines are especially needed by Louisiana's crawfish industry, which has now moved from local markets to national ones but lacks standards for cooking, peeling, and packaging its products. Experimenting in the laboratory with various cooking and freezing procedures, and testing the results through the use of taste panels, instrumentation, and bacterial analysis, Moody and Moertle have solved several critical processing problems for the crawfish industry.

- They developed a method for preventing discoloration in crawfish meat so that the cooked meat now retains a uniform pink and white appearance, especially important in bulk restaurant sales.
- Another important problem solved by the team was that of cooking time. The action of enzymes in crawfish meat and differences in plant equipment made it difficult to judge cooking times, but Moody and Moertle devised a standard test so that each processor can calculate accurately the proper cooking time for insuring optimum taste and texture.
- For frozen crawfish, there were no regulations regarding the amount of fat to be included with the meat, and no statistics available on the average amount of fat usually found with a pound of packaged crawfish meat. As the result of a study done by Moody and Moertle, however, an average was determined and state regulatory agencies were thus provided with a base figure to use in setting regulations for additional substances.
- In a current major study, Moody and Moertle are evaluating freezing methods for crawfish meat that will yield both firm texture and maximum moisture content.

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University of Maine
University of New Hampshire
Sea Grant College Program

SEA GRANT COLLEGE PROGRAM UNIVERSITY OF MAINE

Making waves in northern New England, the Sea Grant College Program at the University of Maine is a cooperative program with the University of New Hampshire.

A SEA BESIDE A SEA

As part of the national Sea Grant College Program created by Congress in 1966, the University of Maine Sea Grant College Program is a statewide cooperative effort in **marine research, education,** and **advisory** service activities which focus on the coastal and marine opportunities of the Gulf of Maine: *a sea beside a sea.*

A body of water 70 percent enclosed by New England and Canadian land masses, the **Gulf of Maine** is truly a sea beside a sea. Encompassing 36,000 square miles from Cape Cod to Nova Scotia, the gulf is home for one of the most complex and productive fisheries in the world.

The Sea Grant program in Maine is recognized as a regional leader in research on Fisheries Management and Development, Changes in the Coastal Environment, and Industrial and Commercial Development:

- A Sea Grant economist at the University of Maine quietly helped launch a revolution in fish marketing over a decade ago. The idea he proposed—the **first "display" auction in North America**—became the rallying point for the $22 million fish pier in Portland, Maine.

  Recently completed, the Portland Fish Exchange facility held its first auction this spring, and it is already changing the way the fishing industry does business. With its emphasis on high quality product, this display auction puts all transactions out into the open, allows dealers to buy only as much fish as they need, clears the market quickly, and gives fishermen an immediate knowledge of prices.

- Co-sponsored by Sea Grant, the Maine Department of Marine Resources, and the university's Cooperative Extension Service, a **Maine Shellfish Conference** brought together shellfish harvesters, dealers, municipal shellfish committees, and specialists to explore the latest information on marketing, leasing, pollution, and shellfish research.

- Current Sea Grant-sponsored **studies on bottom-feeding flatfishes** in conjunction with the Maine Department of Marine Resources and the National Underwater Research Program (NURP) will help lay the groundwork for new, multispecies fisheries management strategies in the Gulf of Maine.

- While fishermen and yachtsmen all know that it can often be "rough going" in the Gulf of Maine, civil engineers at the University of Maine can tell you just how rough. These Sea Grant researchers are studying the wave climate of the Gulf of Maine and associated coastal regions by the **prediction of maximum wave heights** through a computer model.

  This work will enable us to more fully understand coastal processes and establish design criteria for offshore oil rigs or shorefront structures. Prior to this project there were almost no wave data on the Gulf of Maine.

- In the wake of winter storms in 1978 which caused over $47 million in property damage on the Maine coast, the public began to listen to a Sea Grant oceanographer who had initiated a series of profiles to determine rates of change along Maine's 37 miles of sandy beaches. Alarmed by rapid commercial and residential development in these fragile ecosystems and alerted to the possible harmful effects of documented sea level rise, the researcher began a campaign to preserve Maine's beaches in their natural state. This ten-year effort to inform the public has led to the **enactment of a tough Sand Dune Law** in Maine which now severely limits new construction on the dunes or reconstruction of storm-damaged sites.

- To help reduce severe economic losses for Maine's highest value fishery, Sea Grant researchers worked for over a decade on the bacterial disease, ***Gaffkemia,*** which often causes **high mortalities among lobsters** held in pounds in Maine and in the Canadian Maritime Provinces. This effort has resulted in the first Federal Drug Administration (FDA)-approved drug for any crustacean species. Development of medicated diets with Terramycin for lobsters to control ***Gaffkemia*** will save more than one million dollars a year for lobster dealers and fishermen in the Gulf of Maine region.

- To accomplish results such as these has taken time as well as the dedication and cooperation of innumerable individuals and institutions working together to understand and protect the complexity of the resources of the Gulf of Maine.

Better knowledge of the Gulf of Maine, all agree, is the key to protecting it against shortsighted decisions. Although the Gulf is still one of the most productive marine environments in the world, threats do exist to its near-pristine quality: the growing population along its various coasts; degradation by heavy metal, organic, and airborne pollutants; the threat of oil spills; and overharvesting of its fishery resources.

The partnership of Sea Grant's university-based researchers, educators, and marine advisory cooperators with industry, government, and the citizens and organizations in the state, has made a vital contribution to the long range development and management of Maine's marine and coastal resources.

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MAINE AQUACULTURE: SHELLFISH AS A CASH CROP

The cold, clean waters of Maine's 3500-mile coastline provide an ideal setting for the development of aquaculture. And in Maine, Sea Grant is practically synonymous with shellfish aquaculture, since it is precisely this venture that first brought the Sea Grant presence to the state in 1971.

- Fifteen years and many successful research projects later, aquaculture is a thriving, new industry in Maine with millions of dollars invested in commercial hatcheries and grow-out facilities and hundreds of people employed in a variety of activities ranging from seed procurement to market development.

SEA GRANT HATCHES NEW INDUSTRY

Through its first Sea Grant-funded coherent project, "The Culture of Resources in a Cold Water Environment," the University of Maine introduced shellfish aquaculture to Maine. The initial efforts were undertaken at the flowing seawater facility located at the Ira C. Darling Marine Research Center. There researchers documented the faster growth and diminished predation of shellfish suspended in the water column. Early work concentrated on the European oyster (*Ostrea edulis*) because of its high market value and easy adaptability to Maine waters.

- The initial growth studies sparked such immediate interest that several firms were started near the Darling Center to put into practice what the researchers were still testing in the lab. This enthusiasm in grow-out techniques led to problems in seed procurement because at that time only two hatcheries in the U.S. could supply European oyster seed, and importation of this seed into Maine was not always feasible due to biological problems.

- Thus, the stage was set for the next phase of the Sea Grant work: development of an in-state supply of seed. In a spirit of cooperation which today continues to characterize the interaction between the University and the aquaculture industry, the Darling Center hatchery began producing seed and making it available to the new growers. They, in turn, kept detailed records to aid the research efforts. This is how most Maine oyster culturists got their start in the business.

- By 1984, just a little over a decade after Sea Grant's first appearance in Maine, there were four commercial shellfish hatcheries in the state with an investment in plant and equipment close to $700,000. These hatcheries were the major source of seed for a number of in-state grow-out facilities with close to $1,000,000 invested in plant and equipment. (Figures from Maine Aquaculture Association survey conducted in February, 1984.)

- Today, there are two commercial hatcheries still operating in Maine. Their primary focus now is production of American oyster and hard-shelled clam seed due to changing market demands, although European oysters and bay scallops are still supplied. The Darling Center hatchery continues to produce a variety of seed for experimental purposes.

SEA GRANT BUILDS MUSSEL POWER

While the oyster culture industry was making a rather dramatic debut in Maine thanks to Sea Grant research, the slower-growing mussel culture industry was also getting its start at the Darling Center under the aegis of Sea Grant's five-year long "Cooperative Blue Mussel Project," which began in 1975. This cooperative effort involved the University of Maine, the University of New Hampshire, the Maine Department of Marine Resources, and, joining them after the first year, Abandoned Farms, Inc., the only commercial mussel culture firm in the U.S. at that time.

- Although the blue mussel (*Mytilus edulis*) had enjoyed a long history of use on the American continent, it had fallen into disfavor after peak production during World War II when it was used as a source of high protein for the military. By 1947, it was apparent that the mussel fishery in Maine was in trouble, and the loss of market was probably due to the availability of other protein sources considered more desirable coupled with a lack of good quality mussels.

- It was this issue of quality that led the research team to the idea of culturing mussels which, they believed, could produce a better mussel than those harvested from natural stocks. Research at the Darling Center shed light on biological aspects of mussels from both natural and experimentally cultured populations. Results indicated that culturing mussels lessened the incidence of pearls and also provided a marketable-size mussel in eighteen months to two years, a substantial decrease in time that a wild mussel takes to reach the same size.

- With substantial capital investment in the late 1970's, the slow-to-begin mussel culture industry started to supply an increasing demand. Through stepped-up marketing efforts and the switch to on-bottom culture techniques, the culturing of mussels gained a permanent place in Maine's aquaculture picture. Today about 100 people actively participate in mussel culture which supplies one-third of Maine's $5 million mussel production.

AQUACULTURE RESEARCH— A CONTINUING PRIORITY

The aquaculture industry in Maine continues to be challenged by questions which the Sea Grant College Program at the University of Maine seeks to answer. By cooperating with the many individuals and organizations devoted to Maine aquaculture, we plan to continue to make a positive difference in the development of this industry.

- To receive further information about current aquaculture projects, a publication catalog, or the recent biennial report of the Maine/New Hampshire Sea Grant College Program, please contact:

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MARYLAND SEA GRANT ON THE CHESAPEAKE

Historically the nation's largest and richest estuary, the Chesapeake Bay has been a great provider of food and an important boost to the region's economy. In recent years, the commercial harvests of the Chesapeake, especially oysters and striped bass, have been dwindling. Because explanations for these declines are not always clear, the Maryland Sea Grant College has underway integrated programs in fisheries and water quality research. Their goal: a more precise understanding of the biological and estuarine processes that affect the Bay's major commercial fisheries.

In fisheries research, Sea Grant support emphasizes factors crucial to growth and survival:

- reproduction and recruitment — the processes by which Bay species replenish themselves in the estuary
- population dynamics — the mechanisms that determine how those species thrive in the estuary, how they feed, how they migrate, how they respond to disease or other threats to their well-being
- man's use — the ways we harvest, prepare and sell seafood

Within these areas, we have worked to develop the knowledge that can also be applied directly to the enhancement of natural fisheries and the development of aquaculture.

RECENT PROJECTS

■ Sea Grant researchers have discovered a new bacterium that plays an essential role in the setting and metamorphosis of oyster larvae. Aquaculturists on the west coast are conducting production tests of the bacterium in hatcheries, while in Maryland state resource managers are supporting an ambitious applied research program to determine the effectiveness of the bacterium and its metabolites in growing seed oysters.

■ A Sea Grant Extension project has helped design demonstration plots for oyster aquaculturists and is helping to show how best to prepare the bottom, plant oyster spat and monitor for disease and parasites. An important aspect of this project is an assessment of remote setting, a technique in which planters could reduce operational costs by growing their own oyster spat.

■ Sea Grant researchers are charting new territory in biotechnology Through analyses of genetic material, for example, researchers can now better plot the lineage and migration of striped bass, an important step toward understanding population dynamics and the survival of this important game and food fish. Another biotechnology project could improve the growth rate of fish in aquaculture.

■ Sea Grant-supported researchers are studying processes of nitrification in the Bay and mechanisms of anoxia — the loss of life-sustaining oxygen, especially in overenriched bottom waters. By bringing together scientists from a number of different fields, this project is the first major attempt to develop comprehensive pictures of the related physical, biological and microbiological factors behind oxygen depletion.

■ Maryland Sea Grant also supports research into the ways seafood can best be processed, prepared and stored. One project, for example, has provided new knowledge on the pasteurizing of oysters in flexible plastic pouches, a technique that can extend the shelf life of freshly shucked oysters from two weeks to several months. Another project has developed improved methods for composting processing wastes — they add up to 20 million pounds a year in Maryland — from blue crab processing plants.

COMMUNICATIONS

■ To inform resource managers, aquaculturists and others about current research results and extension capabilities, Maryland Sea Grant produces a series of books, newsletters, fact sheets, radio programs, films and videos. *Chesapeake: The Twilight Estuary*, for example, is an award-winning film about the disappearance of seagrasses throughout the Chesapeake Bay estuary; it has been seen by hundreds of civic organizations, public interest groups, and school children and has been broadcast on public and commercial television in the United States and abroad. *Concepts in Marine Pollution Measurements* examines techniques for measuring marine pollution and its effects on the environment; with reviews in scientific journals and international distribution, it is now in a second printing. *Troubled Waters*, one of the issues of *Maryland Sea Grant* magazine synthesizes complex issues of water quality and has been in great demand for a variety of educational purposes. At the Governor's request, Sea Grant prepared *Maryland's Chesapeake Bay Program*, the annual report that explains the state's progress in programs dedicated to reversing declines in the Bay's water quality and commercial fisheries.

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MARYLAND SEA GRANT AND THE FUTURE OF AQUACULTURE

Problem

People have always turned to the sea for food and other resources, but we have found that the sea is not inexhaustible. Especially in heavily fished estuaries like the Chesapeake Bay, a combination of natural cycles and man's exploitation can cause serious depletion of fish and shellfish stocks. Conservation and harvesting restrictions, essentially negative responses to the problem, are not enough.

Solution

In order to boost survival and production of desirable species, Maryland Sea Grant conducts research and extension programs in aquaculture. From practical approaches for engineering aquaculture systems to sophisticated marine biotechnology studies, the aim of Sea Grant's programs is to improve the productivity of commercially important marine species.

Examples

Here are several examples of Sea Grant's research and extension efforts in aquaculture:

- *Improvement of closed-system shedding tanks for soft crabs.* Blue crabs bring a higher price when sold as soft shells, but many crabs die during molting in closed systems, where water quality can deteriorate quickly. Sea Grant Extension specialists have been devising better systems and better means for monitoring water quality. Through workshops and demonstration projects, specialists and agents have reached a growing number of fishermen with news about improved methods for increasing yields of soft shell crabs.

- *Demonstration of oyster culture techniques.* Maryland has traditionally relied on its wild oyster crop to sustain a valuable oyster industry. But with Bay-area population growing and natural populations of oysters dwindling, a new emphasis is being placed on oyster aquaculture. Sea Grant Extension agents and Sea Grant-supported researchers are working with oyster planters to help them turn barren bottom into productive growing grounds and to help them understand problems caused by disease, parasites and environmental changes.

- *Genetic improvements for fish.* For centuries plants and animals have been manipulated and improved through crossbreeding and hybridization. But such changes can lead to a lack of viability of offspring and the decline of the altered species. New advances in genetic engineering are enabling Sea Grant-supported scientists to develop means for transferring highly desirable traits between species without adverse effects. One study in particular is examining ways to improve the growth of fish in culture.

- *Aquaculture of striped bass.* A popular game fish and important food fish, the striped bass is facing a major decline. Sea Grant researchers are investigating the nutritional and environmental requirements of striped bass, including those of striped bass hybrids. Extension agents are working with demonstration projects to explore the practicality and profitability of growing striped bass and their hybrids in closed ponds for consumption and profit.

For more information about aquaculture and marine biotechnology, contact:

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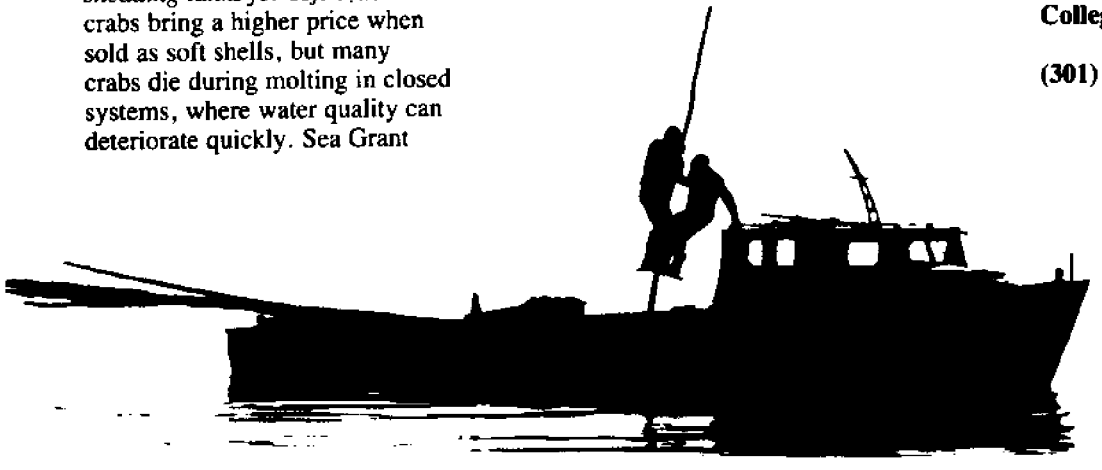

MIT Sea Grant, a Leader in Ocean Engineering

For more than a century the Massachusetts Institute of Technology has been a world leader in ocean engineering and technology development, with such diverse accomplishments as patenting the catamaran in 1877 and building a phenomenal 115-foot Cape Cod Canal model in 1935. It was not unusual then for MIT in 1971 to join in an innovative and ambitious new marine initiative – the National Sea Grant Program. Since then Sea Grant has become a principal focus of the Institute's marine research. Tapping the outstanding talent of students and faculty, MIT Sea Grant has made vital contributions to creating technologies for ocean energy production, fishing safety and efficiency, undersea vehicle design, and coastal zone management.

• **MIT Sea Grant has been a leader in addressing the problem of selective fishing gear.** An alarming decrease in fish stocks has placed the Northeast fishing industry in peril. Fisheries managers and fishermen see selective fishing gear as a way to stem the decline, both as a regulatory tool and a method to prevent the taking of juvenile fish and wasteful bycatch. Using the sophisticated gear testing facilities at the Naval Ship Research and Development Center (NSRDC) in Maryland, MIT Sea Grant has helped to develop tests which net manufacturers and fishermen have used to improve net design for greater selectivity and efficiency.

• **MIT Sea Grant substantially advanced the ability to predict when shipboard ropes become dangerously weak.** Ropes breaking during use are a serious threat to life and limb and can be the cause of navigational hazards. Several years ago when its tow line snapped, an oil barge went aground at Woods Hole, Massachusetts, spilling its cargo and polluting coastal waters. In 1985 New England's Hurricane Gloria caused millions of dollars of damage to boats whose mooring lines snapped in the storm. Through painstaking laboratory and field analysis Sea Grant researchers have developed mathematical models and theories of rope behavior to help sailors predict breakage and avert resulting danger.

• **MIT Sea Grant facilitated the start-up of a new industry** based on the public health benefits of fish oil consumption. Years of research have identified components of fish oil that dramatically reduce the levels of blood fats associated with heart disease. Sea Grant research into the characteristics of oil in locally-available fish species provided the impetus for the Foster Miller Company to develop a process for oil extraction from fish. The company plans to license the process and sell it to industries interested in extracting and selling fish oil as a food additive and dietary supplement.

• **MIT Sea Grant was responsible for the start-up of a biotechnology company.** The program's expertise in the diverse application of chitin, a substance found in the shells of molluscs, spawned The Chitin Company, a Massachusetts firm formed with venture capital to exploit the commercial potential of Sea Grant chitin research. The Chitin Company acquired options on patents to Sea Grant-developed processed chitin and is introducing the product to European cosmetic companies and American food and drug companies.

• **MIT Sea Grant constructed mathematical models of water circulation and particulate dispersion** to determine the fate of pollutants and the effects of change in coastal waters. Consulting firms active in the environmental analysis of coastal waters have been using the models to minimize damage from municipal and industrial waste disposal, sediment transport, hurricane surge locally, nationally and worldwide.

• **MIT Sea Grant pioneered the development of undersea robotics technology.** Last year, a student invented a totally different approach to building manipulators for underwater vehicles. He based his design on the bone-tendon-muscle structure of a human arm, clustering the motors at the base of the manipulator. The result is a working device for underwater or factory use that is strong enough to carry 500 to 600 pounds but agile enough to do welding, cleaning, and inspection.

• **MIT Sea Grant reduced the cost of offshore oil exploration and production.** The offshore industry has spent millions of dollars at a test site in Louisiana trying to predict the capacity of foundation piles to support structures on the ocean floor. MIT Sea Grant researchers not only have provided geotechnical engineers with more reliable interpretations of test results and have identified the important properties to measure and/or control during pile load tests. The result is safer, less expensive offshore structures.

• **MIT Sea Grant transferred laboratory research directly to industry.** Through the Marine Research Center, in 1985 the offshore industry matched Sea Grant funding with $195,000 to ready mature offshore research for commercial application. As a result of these industry funds, research on riser and mooring dynamics, piles for tension leg platforms, and computer codes for simulating wave kinematics has moved from the academic laboratory to private industry.

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MIT Sea Grant improves instruments and techniques to make design of offshore structures less costly, more reliable

The Problem

According to government and industry forecasts, U.S. oil demand will rise one-half to one percent annually through year 2000, and dependence on imported oil will jump from 29 percent in 1984 to 43 percent in 2000. To supply this ever-increasing demand and loosen the country's dependence on precarious foreign supplies, oil companies have been looking offshore for additional resources.

The combined, hostile forces of wind, waves, and weather make working in the deep ocean not only tremendously difficult, but extremely dangerous as well. This translates into expensive oil retrieval. For a company to begin operating in a new offshore oil field can take up to ten years – from discovery to production. And just to build a typical offshore rig costs more than $200 million. Even in favorable economic climates producers must keep costs down to make U.S. oil prices competitive. And when economic conditions drive the industry into a slump – as they have recently – the oil industry is hard pressed to continue developing expensive offshore resources which the country will require in the near future.

One factor that drives up costs is the need to overdesign oil and gas production facilities. Lacking experience with subsea soils and the push-pull effect of waves and winds, engineers cannot predict precisely how much structural strength is required to keep a platform from failing. So to be safe, they "over-engineer", relying on redundancy to ensure safety.

In the case of bottom founded platforms – those that sit on piles or are held by anchoring systems – soil strength is a critical engineering concern. Driving huge metal or concrete members into the ocean floor requires tremendous force, distorts the subsea soil, and substantially modifies its strength.

The Solution/Industry-University-Government Cooperation

To develop procedures for predicting soil strength several oil companies have spent heavily on geotechnical tests to get reliable field data at a site in Empire, Louisiana. The site was chosen for its similarity to soil conditions in the Gulf of Mexico, where most of U.S. offshore drilling takes place. The tests, costing millions of dollars, are ongoing. Three years ago the oil company consortium turned to Sea Grant researchers in MIT's Department of Civil Engineering. Their need was a solid theoretical basis which would cut costs considerably and would produce more accurate predictions.

For almost a decade the government through MIT Sea Grant had sponsored a major research program to develop a solid theoretical basis for predicting offshore pile load capacity. The result – an approach to pile load prediction known simply as the "MIT approach". The approach has two parts – instruments for data gathering, and an analytic method for interpreting geotechnical data.

The essence of the analysis is the Strain Path Method, which, after years of refinement, provides an integrated, systematic framework to predict pile foundation capacity, interpret in situ tests, assess sampling disturbance affects, and in general, approach offshore geotechnical problems in a consistent and rational manner. Results of the Strain Path Method are now widely used in industry.

To get to this method, the research team first had to develop technology to gather data in situ. They adapted and improved a piezocone commonly used in Europe; their version has since become a standard instrument for geotechnical engineers worldwide.

The researchers also designed an extremely sensitive piezo-lateral stress (PLS) cell, which provides simultaneous measurements of the complex stresses acting on piles as they are driven deep into the clay. Repeatedly, the PLS cell has provided reliable measurements; it has significantly enhanced engineers' understanding of the behavior of piles in clay.

Using the newly-identified procedures, the MIT group increased the standard industry estimate of pile capacity, which has resulted in significant construction savings and will help to make the structures stronger and safer.

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The Woods Hole Oceanographic Institution Sea Grant Program

The Woods Hole Oceanographic Institution Sea Grant Program is an institutional program that focuses most of its effort on research. Over the last several years emphasis has been on marine resources and related marine policy issues. Representative studies are:

- Paralytic shellfish poisoning (commonly known as red tide) in the New England Region, including its introduction to embayments and possible methods for its control.
- Stabilization of the bay scallop population in Massachusetts through relocation of natural seed or placement of cultured animals to compensate for natural losses of juveniles, and through improved management of the fishery.
- The biogeochemistry, dispersion and impact of PCB pollutants in the Buzzards Bay area, surrounding New Bedford, Massachusetts
- Sediment bypassing of tidal inlets, in general, and sediment transport on Cape Cod and inshore waters.
- Polymetallic sulfide research concerning policy and economic issues of this potential marine metals resource.
- Assessment of algal candidate species for commercial scale production of marine polysaccarides, substances finding wide use in every day applications such as gelling and thickening additives for food, use in paint and potential pharmaceutical applications. Using the fermentation industry as a model, this research aims at determining economic and biological optimum yields for selected marine algae.
- Continuation of our International Marine Science Program that has worked with selected South American countries (Columbia, Ecuador and Brazil) to assist them in the development of their marine resources and other marine opportunities. Through this program and other efforts potential opportunities now exist in the Carribean and the Middle East.

Our Marine Assistance Service fosters interactions with the public at large as well as with state and national agencies and private industry in the marine sector.

A joint doctoral program in oceanographic exists between the Woods Hole Oceanographic Institution and the Massachusetts Institute of Technology: several of the students have been supported by Sea Grant.

The **National Sea Grant Program** plays a major role in the development of a responsive marine research effort for the United States by promoting the understanding, assessment, development, utilization and conservation of our Nation's ocean and coastal resources. The **Woods Hole Oceanographic Institution Sea Grant Program** joins with our colleagues around the nation, bringing the resources and momentum of our Institution to bear on this Sea Grant ideal.

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Some Benefits from Woods Hole Oceanographic Institution Sea Grant Supported Projects

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Savings and Solutions Through Coastal Engineering

Coastal engineers using results of a Woods Hole Oceanographic Institution Sea Grant study on the coast of Nantucket Sound saved $250,000 in a beach nourishment project. As a result of this same study, a navigational improvement project in Popponessett Bay has been modified and is underway again after 14 years of inactivity.

Cost Effective Sewage Treatment

The Town of Orleans, Massachusetts, saved $3 million as a result of a Woods Hole Oceanographic Institution Sea Grant supported study that suggested a proposed sewer system would divert only a fraction of nutrients naturally entering a valued estuary. Instead of the sewer system the Town opted for a less expensive septage treatment facility.

Predicting PSP Outbreaks

Research on "red tide", the cause of potentially fatal paralytic shellfish poisoning (PSP) in humans consuming affected seafood, has provided a basis for predicting where and when outbreaks are likely. Public health personnel in four northeast states have received training in identification of cysts of the microbe responsible for the ailment.

A Drift Buoy for Monitoring Coastal Waters

A freely drifting buoy for use in measuring coastal currents, and tracking oil spills or other drifting objects was developed through Woods Hole Oceanographic Institution Sea Grant funding and is expected to be produced commercially. The buoy which automatically transmits its position to shore-based stations was designed around conventional electronic navigation equipment.

Extending Harvests Of Bay Scallops

Research indicating rapid growth of bay scallops in the late fall resulted in government agencies changing the opening day of the scallop season from October 1 to November 1. This results in a larger harvest of this heavily fished species.

Assessing PCBs Within The Marine Environment

Research on the distribution, resuspension and dispersion of PCBs (polychlorinated biphenyls) in New Bedford Harbor and Buzzards Bay is providing a framework for government agencies to plan cleanup of this pollutant and management of living resources of the area. Research defining the impact of PCBs on marine animals, including commercially valuable species, has provided a means for assessing the impact of PCBs on a coastal environment.

Michigan Sea Grant Provides Benefits to Michigan, the Great Lakes Region and the Nation

Ship Propulsion — Sea Grant research has resulted in significant advancements in engineers' ability to analyze and improve the design of marine stern bearings. This removes a serious limitation on propulsion efficiency of large lake carriers and ocean-going ships.

Ship Hull Design — Sea Grant research has developed a graphics package to improve computer-aided design of ship hulls. This software is used in university, industry, and armed forces research.

Offshore Research — Sea Grant research on the response of offshore structures, such as oil drilling platforms, to waves and other stresses is at the forefront of international research and has been recognized by off-shore companies for its potential usefulness. A Sea Grant-established consortium of University of Michigan marine engineering researchers and industry representatives is facilitating the transfer of university research to industry.

Fish Analysis — Sea Grant research has produced advanced techniques to analyze Great Lakes fish for toxic contaminants. These techniques are also useful for determining the freshness of caught fish and the number of times fish flesh has been frozen and thawed.

PCBs and Toxaphene — Sea Grant research has resulted in improved methods for identifying and quantifying harmful PCBs and toxaphene in the Great Lakes. This improves the ability to reduce the dangers these substances pose to humans.

Underwater Preserves — Sea Grant marketing research and extension efforts inspired the legislation providing for underwater preserves in Michigan. Continued Sea Grant efforts have resulted in the establishment of four preserves, the only ones in the U.S. waters of the Great Lakes. The preserves protect shipwrecks and interesting natural features.

The underwater preserves have resulted in remarkable economic impacts for preserve communities, all in rural areas. In the small town of Munising, home of the Alger Bottomland Preserve, 1985 diver expenditures totalled over $2 million, up from $600,000 in 1980. Gross revenue to the county, calculating the multiplier effect, was $4,746,000 in 1985.

Hyperbaric Chamber — Michigan Sea Grant acquired a $27,000 grant from the National Undersea Research Program (NOAA) to reactivate a hyperbaric chamber in Alpena General Hospital. The chamber, used to treat bends and other illnesses caused by diving accidents, is within a few miles of a popular underwater preserve and is the closest chamber for three other heavily used diving areas. Within a month of installation, the chamber saved a diving accident victim from potentially crippling disabilities.

Diver Evacuation and First Aid — Sea Grant agents have orchestrated diver evacuation plans and provided diving first aid training in underwater preserve areas. To date they have trained 210 people. Fifty "first responders" have subsequently upgraded their organizations' accident response strategy.

Rescue vs. Recovery — Michigan Sea Grant's cold water near-drowning rescue techniques are continuing to save lives worldwide. Law enforcement *body-recovery* teams are now *rescue* teams, and must be capable of rapid deployment and safe practices. Sea Grant leadership has resulted in law enforcement departments in Michigan and across the nation upgrading equipment, training and funding for their rescue teams, thus increasing the potential for saving lives.

Fish Biology — Studies of yellow perch, whitefish, pink salmon, lake herring, and coho and chinook salmon are providing information on population dynamics, migration patterns, diets and abundance. The results are being used by the Michigan Department of Natural Resources to maintain healthy fish populations.

Maps — Sea Grant has developed maps of Great Lakes fishing grounds to save commercial fishermen time and money in getting to fishing areas.

Purse Seine Research — The Michigan Department of Natural Resources is conducting research to determine whether the purse seine (a commercial fishing net) can be used to harvest whitefish without killing sport fish. They are using a fishing vessel outfitted by Michigan Sea Grant.

Underwater Pump — Sea Grant fisheries researchers developed an inexpensive, compact, and portable underwater pump for collecting aquatic organisms. The pump inflicts minimal damage to fragile organisms. Previous pumps were operated from on-board ship, and were expensive and difficult to implement and use.

Salmon Disease — Sea Grant has developed a technique for identifying gas bubble disease, which has had a devastating effect on Michigan's hatchery-grown salmonids. Large numbers of healthy fish are essential to maintain the multi-million dollar Great Lakes salmonid sport fishery.

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Michigan Sea Grant Provides Savings to Shoreline Property Owners

THE PROBLEM

The Great Lakes are at record high levels. All lakes are several inches to more than a foot above previous record levels, with no relief in sight. Consequently, property owners along 1,000 miles of Michigan's 3,200 miles of shoreline are facing severe shoreline erosion problems. Land, houses, docks, marina facilities, and other structures are being damaged or destroyed. Based on losses experienced during previous high-water periods, over $180 million (1985 dollars) in damages will be suffered. At least another $120 million will be spent for protection measures, for a total minimum economic loss of $300 million.

Unfortunately, experience has shown that many of the shoreline protection structures that will be built will be ineffective. A newly revised Michigan Sea Grant publication based on the program's erosion and shore protection research offers information that is helping shoreline owners avoid investing in ineffective protection measures.

SEA GRANT ASSISTANCE

The booklet, *Shoreline Erosion: Questions and Answers,* describes proven erosion control structures, common problems associated with many structures, non-structural control methods, such as vegetation and relocation of buildings, and what to look for when buying shoreline property. It lists additional sources of information, including other Michigan Sea Grant erosion control publications. In the first six months after its revision in December 1985, 3,500 copies of the booklet were distributed to individual property owners and to government agencies that are conducting erosion control workshops.

Michigan Sea Grant Extension Agents are assisting property owners through meetings, site visits, individual contacts, newspaper articles, and radio interviews. For example, one owner planned to spend $10-20,000 on erosion control measures. After an agent demonstrated that his plan would be ineffective, he did not make the investment.

Another agent developed a computer model for coastal erosion management that projects property losses for specific plots and provides owners with a choice of solutions. The agents have used this model around the state. For example, in the Upper Peninsula the Hiawatha National Forest Campground is incorporating appropriate options indicated by the model to reduce their yearly loss of $15,000 worth of real estate. The model is applicable to the other Great Lakes states and to ocean coasts. The Great Lakes Sea Grant programs have established a Great Lakes Network Lake Level/Erosion committee to coordinate activities to help shoreline property owners around the Great Lakes.

Using a Sea Grant investment model one agent met with county assessors to discuss the value of eroding property. Subsequently, assessors reduced the valuation of approximately 100 parcels of property by a total of $500,000, thus providing tax relief to owners. Assessors in other counties are considering this approach also.

Coastal flooding, particularly during storms, is another problem caused by high lake levels. To help residents contend with flooding, a Sea Grant agent and an Extension home economist have prepared a handbook of tips on flooding, survival, and home cleanup. Topics covered include preparing to evacuate, salvaging furniture and books, restoring electrical service, and information on flood insurance and home relocation. Sources of additional information are listed. The Corps of Engineers estimates that a single December 1985 storm caused $12-14 million worth of flood and erosion damages to five southern Michigan counties on Lake Michigan. This handbook was designed to reduce such damages during spring and fall storms as well as to alleviate human suffering.

SAVINGS

Michigan Sea Grant studies have shown that shoreline property owners invest such large amounts of money in erosion protection that, on the average, they essentially re-buy their house and land every 20 years. One survey made during the high-water period of the mid-70s showed that 150 property owners had lost $2.5 million in damage and investment in ineffective measures. Michigan Sea Grant research, publications and outreach will reduce this needless expenditure by millions of dollars. This is a many-fold return on the original federal investment of $200,000 for research and publications.

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SEA GRANT BENEFITS MINNESOTA

Sea Grant is a national program established in 1966 to promote the wise use of the oceans and Great Lakes. Minnesota Sea Grant works on issues of importance to Lake Superior, the North Shore region, and the state.

Sea Grant's Approach

Research

Faculty at the University of Minnesota and William Mitchell College of Law investigate a variety of water-related problems including: water quality, fisheries and aquaculture, water policy and law, biotechnology, economics, and hypothermia.

Extension

Agents explain research results to the public and to organizations that can benefit from Sea Grant's work. They also conduct educational programs and workshops thoughout Minnesota.

Results

Contaminants in the Great Lakes

Minnesota Sea Grant researchers were among the world's first scientists to study the bottom of Lake Superior. Using a submersible, they are studying a layer of water and sediment near the lake bottom that contains large amounts of contaminants, such as PCBs. Their findings will help determine what types of contaminants are present in the lake, where they come from, and how they move throughout the lake. They are also studying how contaminants travel though the lake's food chain.

High Lake Levels

Although erosion from high lake levels is a problem on Lake Superior, the bigger crisis comes from flooding, especially since most people do not have flood insurance. Sea Grant extension sponsored workshops for lenders, insurance agents, and property owners on the federal government's flood insurance program. Sea Grant has also provided workshops and on-site advice for property owners on how to slow erosion from high water.

Economic Development

Sea Grant research was instrumental in new commercial developments in northern Minnesota. Research detailing the area's tourism potential, what tourists enjoy doing, and the major markets for increasing tourism resulted in construction of a large restaurant/lodging complex. Developers received private financing for the project as a result of Sea Grant's report. The report is also being used by other regional businesses to market and advertise their services.

Fish-Hatchery Benefits

Fish hatcheries are raising more of the Great Lakes best sportfish without increasing costs, using techniques developed by Minnesota Sea Grant. Researchers developed a semen extender to increase fertilization rates in muskies, rainbow trout, and lake trout. The extender results in higher rates of fertilization, allowing Minnesota hatcheries to increase production of some species by up to 20 percent. The extender is also used to facilitate cross breeding of lake trout for stocking in the Great Lakes.

Creating Safer Herbicides

The longer chemical herbicides are used, the greater the problem of plant resistance and environmental hazard. Sea Grant is working to create safer herbicides from naturally occuring lake algae. Researchers have already isolated a chemical from blue-green algae and terrestrial weeds. The new products developed from the chemical could help solve resistance problems and would be plant specific, killing only the intended plants while leaving fish and other plants unharmed.

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June 1986

SEA GRANT CONTAMINANTS RESEARCH IS USEFUL NATIONWIDE

Contaminants are a major problem throughout the Great Lakes.

PCBs, toxaphene, dieldrin, and dioxins are present in varying amounts in all the lakes, affecting fisheries, harbor dredging for shipping and water quality.

Minnesota Sea Grant's research has provided valuable information on the sources, behavior, and movement of contaminants in large lakes. Sea Grant's basic and applied research on Lake Superior is valuable for management of the entire Great Lakes drainage basin, the oceans, and other inland lakes across the country.

Submersible Research

Minnesota Sea Grant researchers are among the world's first scientists to study the bottom of Lake Superior. Using a submersible, they are studying a layer of water and sediment near the lake bottom that contains large amounts of contaminants, such as PCBs. Their findings will help determine what types of contaminants are present in the lake, where they come from, and how they move throughout the lake. They are also studying how contaminants travel through the lake's food chain.

Tracking the Movement of Wastes

When wastes are dumped into lakes and oceans, no one is sure how far those wastes will move. Sea Grant researchers created the first computer model to predict how underwater currents transport wastes. The model can predict rates of movement and where the wastes will ultimately settle at any dump site under varying conditions. As proposals to dispose of wastes in the oceans and Great Lakes continue, this information will help determine the feasibility and stability of underwater waste disposal sites.

Better Ways to Dispose of Dredge Spoils

Disposal of dredge spoils is a controversial issue, since most spoils are contaminated with organic pollutants and industrial wastes. As on-land storage areas fill up, disposal of spoils in deep holes in harbors has been proposed. Sea Grant results show that deep hole disposal is a good option to onland disposal. Contaminated sediments can be safely contained in holes sealed with a clay top. This option may be better environmentally than onland disposal since spoils can contaminate soil and groundwater.

Cleanup

As research continues, scientists are discovering a broader range of contaminants in the Great Lakes. Minnesota Sea Grant supports the development of innovative tools for cleaning up polluted water and sediment.

New Bacteria May Clean Up PCBs

More than 90,000 metric tons of PCBs contaminate the environment, but there is no efficient method of removing PCBs from water. Researchers are trying to create a new strain of bacteria capable of degrading PCBs by recombining the genes of bacteria that degrade other substances. The new bacteria could be used to clean contaminated soil and water.

Low-Cost Water Purification

Removing chemical impurities from water generally requires expensive filtration processes. As a lower cost alternative, researchers are testing the use of temperature-sensitive gels. The gels absorb water but leave behind concentrated impurities. The gels then collapse and release clean water when the temperature is increased. The gels can be reused at least 100 times.

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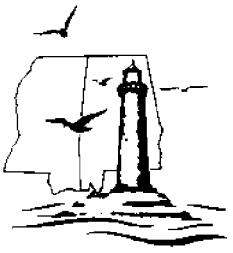

Mississippi-Alabama Sea Grant Consortium: Problem-solving research reaches beyond state borders

A consortium of nine universities and research institutions, the Mississippi-Alabama Sea Grant Consortium (MASGC) brings together the scientific expertise of two states to discover in marine resources new solutions to old problems as well as new opportunities for a changing world. In recent years, MASGC projects designed to solve regional problems have taken on international scope.

Engineering

A project that has produced a cost-cutting fuel and refrigeration system for commercial fishing vessels, for example, began as a search for uses of methane gas associated with Alabama's coal deposits. At the same time, the domestic shrimp fishery was hit by rising operating costs on one hand and the influx of foreign maricultured shrimp on the other.

MASGC research united governmental, university and international industrial resources and produced a system that converts marine diesel engines for use of low cost liquefied natural gas (LNG) and diesel. The LNG also reduces maintenance costs and serves as a refrigerant, eliminating the cost of purchasing and transporting ice. Annual savings can range up to 45 percent, and a vessel now under construction will test the system in actual shrimping operations. Representatives of other fisheries have expressed interest in the system.

Biotechnology

An MASGC study of unique crystal growth inhibitors found in selected marine organisms also promises benefits for industries beyond the borders of Mississippi and Alabama. Crystallization of calcium carbonate and other minerals on the inner surfaces of pipes, boilers and cooling towers is a continuous industrial problem in spite of costly maintenance and the use of preventive water treatment chemicals.

Through the Sea Grant study, patents have been awarded and negotiations are under way for commercial development of new non-toxic, biodegradable compounds that increase the effectiveness of traditional water treatment measures. Future applications include preventatives for plaque on teeth and for harmful crystallization on artificial heart valves and other prosthetic devices.

With 70,000 acres of catfish ponds in Mississippi alone, catfish farming is big business in the south. A new algicide to combat the blue-green algae that plague catfish farmers had its beginnings in Sea Grant more than a decade ago. MASGC provided a three-year start-up for investigating why ponds containing certain species of water plants never experienced algal bloom.

Researchers have since identified compounds active against blue-green algae; patents have been granted; and a chemical manufacturing company is now preparing to market the new product. Tests also continue on the product's effectiveness in other aquaculture environments including the brackish water required by some marine species.

Estuarine processes

The movement of sediments, either through natural processes or through man's dredging activities, is characteristic of the estuaries that border Mississippi and Alabama. With such movement affecting fisheries, pollutant transport and navigation, MASGC has directed coordinated studies toward sedimentation and related estuarine processes.

An outgrowth of that concern was sponsorship of the Third International Symposium on River Sedimentation with an emphasis on coastal and estuarine processes. The 1986 conference drew more than 240 scholars, scientists and engineers from 31 countries to Jackson, Mississippi, where they shared the latest in sedimentation research and technology.

Fisheries

Now in it's fourth year, a Sea Grant study on survival of early life stages of red drum, also called red fish, is supplying data on factors affecting recruitment to the fishery. The study comes at a good time.

Meager scientific evidence has been available about redfish; and the booming popularity of the cajun dish blackened redfish has led to plans for emergency regulations in the federal waters of the Gulf of Mexico to avoid overfishing the resource, especially spawning stocks.

Through extensive sampling in federal and state waters off Alabama, Mississippi and Louisiana coasts, the Sea Grant project has documented heavy larval concentrations likely to indicate red drum spawning areas. Researchers are studying the effects that unexpected water patterns have on survival of larvae, and analysis of prey selection should provide valuable information for red drum mariculture operations.

More than 15 new soft-shelled crab producers are now operating in Alabama as a result of cooperative Sea Grant research that has tested and streamlined closed recirculating artificial seawater systems for shedding blue crabs. Current MASGC research includes experimentation with hormones to induce pre-molt in crabs and is directed toward the need for steady sources of pre-molt crabs in many Gulf regions.

MASGC researchers have discovered physiological signs of maturation in post-molt crabs that will allow large-scale producers to select crabs appropriate for hormone dosage. Researchers are also testing the use of low-calcium seawater to inhibit hardening of soft-shells and to increase the size that crabs attain in artificial seawater systems. Research results are expected to yield benefits for aquaculture efforts involving other crustacean species.

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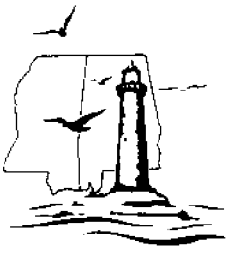

Controlling crystallization: Sea Grant project mines rich vein of applications

Crystallization is everywhere. It gives us healthy bones, coral reefs and shells for oysters. It also gives us plaque on teeth, barnacles on boats and costly mineral scaling on industrial surfaces.

Developing technology to control the process is equivalent to building a better mousetrap, and Mississippi-Alabama Sea Grant Consortium research is on the way to developing that technology.

Dr. Steven Sikes, University of South Alabama biologist, has been awarded three patents and has a fourth pending on new non-toxic, biodegradable water treatment chemicals.

The new compounds increase the effectiveness of phosphonates traditionally used to combat calcium carbonate crystallization on the inner surfaces of industrial pipes, boilers and recirculating water cooling systems. Negotiation for commercial development is under way.

Patents are also expected for new polymers that attack other mineral-scaling problems for which there are presently no effective water treatment measures.

Natural inhibitors

An earlier discovery led to the current development of crystalline inhibitors. Sikes and a collaborating researcher found that organic material termed "matrix" in oyster shells inhibits growth of calcium carbonate crystals. Natural inhibitors have since been discovered in materials from algae, sea urchins and other marine species. Synthetic analogs of natural inhibitors have also been found effective.

Water treatment chemicals are only the first of beneficial uses. Preventatives for harmful crystallization on artificial heart valves and other prosthetic devices, for plaque on teeth and for barnacles on boats and other marine structures are among applications for future study.

How and why

As research progresses on practical applications, Sikes has been experimenting with ideas on how and why the inhibitors work so well. He believes he has the answer and is setting out to prove it. The better mousetrap is on the way.

While Sikes' work represents innovative Sea Grant research that spans the spectrum from basic knowledge to application, it is also an example of other Sea Grant strengths.

A year of his scientific training came with Sea Grant support as he worked toward a Ph. D. at the University of Wisconsin. Now, as a Sea Grant researcher, he is collaborating with another scientist—one who has received support from the South Carolina Sea Grant program – on research of far reaching benefit.

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New Hampshire

University of New Hampshire
University of Maine
Sea Grant College Program

The Sea Grant College Program at the University of New Hampshire — a joint program with the University of Maine — works cooperatively with marine industries, state and federal agencies, organizations, and individuals to identify and solve problems associated with the development and conservation of northern New England's marine resources. Through its marine information, education and advisory programs, the UNH Sea Grant program increases public awareness of important marine and coastal resource issues.

FISHERIES MANAGEMENT AND DEVELOPMENT

- Discovery that acid rain in New England rivers may be interfering with the Atlantic salmon's ability to return to its homestream to spawn, thus jeopardizing attempts to restore this prized species to New England.
- Study of the mortality rates for undersized commercial fish species which are discarded at sea. This information is necessary to effectively manage fish stocks.
- Discovery of the presence of the sex steroid hormone, testosterone, in seven salmon commercial diets. This hormone has been linked to diminished fitness of hatchery reared salmon and may reduce potential of survival to adulthood.

CHANGES IN THE COASTAL ENVIRONMENT

- Development of a technique to solidify/stabilize inorganic hazardous waste in a cement mixture. Ocean disposal may prove feasible as leaching rates for these solidified blocks may be significantly slower in the ocean than on land.
- Development of a new technology, which has subsequently been adopted by the EPA, to measure leaching rates of toxic substances from soil.
- Discovery that raindrops produce vortex rings which can penetrate the water column to 40 centimeters. These rings can resuspend a significant amount of fine-grained sediment in a shallow estuary.
- Examination of the legal aspects of providing and controlling access to New Hampshire's coastal resources.

INDUSTRIAL AND COMMERCIAL DEVELOPMENT

- Design of a hinged, collision-tolerant navigation aid which could save the Coast Guard millions of dollars per year in piling replacement costs.
- Study of a fiber optic system to transmit real-time color images from a tethered submersible.
- Development of a model for planners to use to predict and compare the economic outcomes of alternative tourism product mixes on coastal lands.

EXTENSION AND EDUCATION

- Assistance to the State of New Hampshire in determining the effectiveness of marketing and promotion strategies in bringing tourists to the coastal zone.
- Development of a coastal issues curriculum for use by high school teachers and students studying problems facing the seacoast.
- Coordination of a volunteer marine docent program which delivers marine education programs to more than 10,000 students, educators and members of the public each year.
- Assistance to New Hampshire seafood wholesalers and retailers in developing more effective marketing and display techniques.

For further information on these and other Sea Grant contributions to the State of New Hampshire and northern New England, contact:

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University of New Hampshire
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Sea Grant College Program

MONITORING ANIMAL BEHAVIOR: A NEW RESEARCH TOOL

Sea Grant researchers at the University of New Hampshire have developed a sophisticated, yet inexpensive, research technique for monitoring animal behavior.

One of the most difficult challenges encountered when investigating animal behavior is developing a way to express data in a quantitative manner. In recent years, behavioral analysis of reactions to environmental or toxicological manipulation has become much more quantitative, due in large part to technological advances in remote monitoring and manipulation of data by computers. Several commercially-available systems now provide researchers with the ability to track both aquatic and terrestrial creatures and determine behavioral parameters such as distance travelled, time spent in particular areas, and even the number of social interactions.

These modern laboratory tools have enabled investigators to analyze and manipulate behavioral data in increasingly more effective and efficient ways and thus perform experiments that would have previously been too tedious or complex to undertake.

However, these systems have three major disadvantages for the average investigator. First, they are expensive, costing on the order of $10,000–80,000. Second, the investigator is often separated from the raw data. Many subtle, but important, behavioral responses might go unnoticed by the computer. Finally, sophisticated systems are often not flexible enough to allow for widespread applications. This includes field work where the area in which the behaviors are being monitored are either non-standardized or contain varied backgrounds which would confound most automated tracking systems. What was needed was an inexpensive and flexible, yet sophisticated, technique that allows for close investigator interaction, from the raw data stage to plotting the final results.

Sea Grant researchers at the University of New Hampshire have developed just such a system to determine the response of salmonids to certain olfactory stimulants. Called ITS for Interactive computer/video Tracking System, the system consists of a 128K Apple IIe computer with software, a video camera and VCR, and a special effects generator. Experiments are videotaped and then during playback of these tapes, the special effects generator is used to simultaneously display the video image and the graphics output of the computer on a monitor. The user simply tracks the animal of interest using an electronic pen, and the position of that animal in the test chamber, in the form of X-Y coordinates, is determined by the computer at user-defined time intervals. When the tracking is complete, a plot of the track of the animal is printed out within the outline of the test chamber. Animal velocity, distance from a predetermined point in the chamber (for example, olfactory stimulant source), and time spent in a given area can all be calculated over a given time period or for the entire experiment.

ITS has numerous advantages over commercially available devices that perform similar tasks. First, it is relatively inexpensive, especially if one already owns video equipment and a computer. Second, it can analyze many types of experiments that can be stored on videotape, including work in the field. Third, the fact that it is not automated makes it easy to track multiple objects, even if their tracks cross and are not easily located against a low-contrast background. Finally, because whole images do not have to be digitized, and data collection intervals can be adjusted by the user, it is possible to analyze very long experiments with a microcomputer.

For further information on this and other Sea Grant contributions to the State of New Hampshire and northern New England, contact:

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New Jersey

The New Jersey Sea Grant Institutional Program is managed by the New Jersey Marine Sciences Consortium, an alliance of 28 educational institutions, a number of businesses and private entrepreneurial organizations, and individuals interested in the state's marine affairs. New Jersey Sea Grant has recently entered its eleventh year of activity in coastal and marine concerns.

Sea Grant has grown steadily in value to New Jersey by directing attention to the challenges and opportunities presented by the state's extensive and invaluable marine resources. Emphasis on critical problems dealing in fisheries, coastal processes and pollution continue to be at the forefront of Sea Grant activities under the New Jersey program. Additionally, the program's focus has expanded to include exciting new projects based on the state's needs in the areas of marine research technology and development and the socioeconomic impacts within the commercial and recreational fishing communities.

These activities, while highly sophisticated in scientific and academic terms, nevertheless include a pragmatic interest in the economy of the state. Despite its small size, New Jersey is bounded by more than 1700 miles of coastline, which accounts for 17% of its land mass. Tourism is the state's second largest industry, accounting for over 5 billion dollars annually, most of it attracted by marine recreational activities. The state perennially ranks among the top ten in the nation in commercial fishing landings with the fishing industry alone generating almost 1 billion dollars each year.

Following are some of the results of the diversified research projects conducted under the Consortium's Sea Grant program. Each of these has been beneficial in providing knowledge essential to making decisions regarding the best possible use and preservation of our marine and coastal resources:

- A comprehensive, multi-institutional project on the identification of bivalve larvae was completed in 1986. Sixteen academic, federal, and private institutions participated in the program which will culminate in the publication of a comprehensive manual/scientific monograph for the identification of bivalve larvae and early postlarvae in the marine and estuarine waters of the North Atlantic. The project holds the promise of international importance in its ability to provide bivalve researchers and managers with essential information and reference resources.
- A New Jersey Sea Grant funded project examining the viral content and filtration rates of the hard clam at a commercial depuration facility could ultimately lead to a revitalization of the state's declining hard clam industry. Analysis of, and recommended improvements in the depuration process (placing clams from marginally condemned waters into running sterilized water for 48 hours to eliminate microbial contaminants) will help determine new harvesting sources.
- The condition of the state's inlets, barrier beaches, and other coastal features is crucially important, both economically and culturally. The Sea Grant Coastal Systems Program, in full cooperation with the NJ Department of Environmental Protection, has successfully identified barrier island hazard areas, analyzed the success of beach nourishment projects and tested new techniques for maintaining inlet channels. These findings will enable New Jersey Sea Grant to contribute significantly to coastal zone management in the state.
- Turning to the sea as a source of biomedicinals, New Jersey Sea Grant projects have yielded valuable information that have far reaching implications in the field of medical science. A search for actinomycetes in the marine environment has resulted in new findings regarding these antibiotic-producing bacteria. A major pharmaceutical house in New Jersey has expressed interest in the project, and its participation could contribute to the creation of a new product utilizing marine antibiotics.
- The pursuit of a simplified technique for determining cobalamins in marine waters led Sea Grant researchers to a startling discovery. *Limulus polyphemus* (horseshoe crab) blood and cells, obtained as a plentiful waste-product of the lysate industry, turned out to be unusually rich in vitamin B-12 binding proteins. The discovery led not only to the development of the simplified testing method for cobalamins, but significant application of the findings in the medical and diagnostic field.
- Originally provided by the NJ Sea Grant Extension Service, sea surface temperature charts and weather and wave conditions forecasts were successfully turned over to a private industry. Recent surveys indicate both services continue to benefit the commercial fishing industry by contributing toward fuel conservation, reduced transit time and improved catches.

From Sandy Hook to Cape May, and into the shallows of the Delaware Bay, New Jerseyans are, in ever-increasing numbers, associating themselves with the Consortium's leadership in the preservation and conservation of their marine resources.

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New Jersey Sea Grant Makes Significant Strides In The Areas of Coastal Processes and Fisheries Management

COASTAL SYSTEMS PROGRAM

New Jersey's Atlantic Coastline is a series of barrier islands punctuated by stabilized and unstabilized inlets. Some sections of the outer coastline have some degree of man-made protection from the Atlantic Ocean; others are protected by dunes. The struggle to maintain an acceptable degree of stability along one of the most highly developed shorelines of the nation is constant. Scientists and engineers return year after year in pursuit of better technology and education to protect what man has built from the essentially ephemeral nature of a barrier island coastline.

Sediment sources, transport mechanisms, "natural" system dynamics, and the effects of such human activities as dredging and spoil disposal need to be well defined and better understood. New Jersey Sea Grant's Coastal Systems Program is striving to achieve a combination of understanding these processes with the ability to predict changes under various assumptions. If profound changes occur in the back barrier areas, there will be equally profound impacts on the productive wetlands and their associated ecosystems, the intense human uses of the areas for tourism, commercial fishing, and increased building on the barrier islands.

New Jersey Sea Grant has introduced and supported a fully integrated Coastal Systems Program, involving a number of mutually supportive projects, directed to the critical state and national problem of the filling and narrowing of waters between barrier islands and headlands. This filling in of back islands and headlands has serious implications. As waters become more shallow and shoal filled, both the navagability and general utility of these areas are diminished. Second, the environments evolve from subtidal to intertidal and finally to salt marshes with narrow channels.

The economic benefit of one of the first projects in the Coastal Systems Program was realized almost immediately. A study of "Littoral Sediment Dispersal of Materials Dredged from Barnegat Inlet Used as Beach Nourishment on the Northern End of Long Beach Island, NJ," revealed that littoral drift in the Barnegat inlet area differed in direction from what was previously thought by the U.S. Army Corps of Engineers. The Corps had spent $4,300,000 to dredge the inlet and used the dredged material to nourish nearby beaches. The researchers estimated a longevity of three years for the nourished materials. The findings indicated that nourishment should have been done further south in an area, where the longshore current was determined to be in a southerly direction. Because the beach nourishment was affected in the area of northerly flow of the current, the sand migrated to and over the jetty and ultimately back into the inlet from which it had initially been dredged. The project provided data that is invaluable in making decisions regarding multimillion dollar beach nourishment projects.

The full impact of the economic benefits provided by the Coastal Systems Program has yet to be realized. With the full cooperation of the NJ Department of Environmental Protection, and benefits already derived from consultation with the Corps of Engineers in selecting a model to provide a core program element, the initial successes are evident. Long-range implications indicate that the data and models provided by the Coastal Systems Program will significantly aid and alter the course of coastal management and development in the state.

FISHERIES MANAGEMENT

The importance of the state's fisheries has been stressed since the New Jersey Sea Grant Program's inception. With over 400 companies in the industry and payroll in excess of 100 million dollars, helping to improve this important sector remains a high priority.

An ambitious and productive project, five years in the making, could ultimately result in providing an authoritative resource that will aid fisheries management, on an international level.

Aside from its scientific significance the "Identification of Bivalve Larvae: a Multi-Institutional Approach" exemplifies the merits of cooperative effort. Sixteen institutions (academic, federal and private industrial) in both North America and Europe contributed to the project, which culminated with the publication of a comprehensive manual/scientific monograph for the identification of bivalve larvae and early postlarvae in estuarine and marine waters of the North Atlantic.

Prior to the completion of this project, existing keys for bivalve identification were extremely limited and it was almost impossible to unambiguously identify the larvae of many species, particularly at an early stage. Those limitations long hampered both applied (aquaculture, fisheries management, environmental monitoring, etc.) and basic (ecological, biogeographical, etc.) research efforts in estuarine and marine waters. The results of this project eliminated many of those obstacles and the resulting publication provided a definitive resource and research tool for researchers and management alike. The potential economic benefits to bivalve research and fisheries management could conceivably have global implications and far surpass the program's original goals and expectations.

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Sea Grant Programs Match Diversity of New York State's Great Coastlines

New York Sea Grant has developed many unique projects in response to the challenges and opportunities presented by the diversity of its coastline, which includes the Atlantic Ocean and two of the Great Lakes. A few examples of these projects:

- In the summer of 1985, a mysterious "bloom" of algae spread across the waters of eastern Long Island, killing the $1.3 million scallop crop.

The high degree of responsiveness of New York Sea Grant allowed research into the causes and effects of the bloom to be launched immediately.

With Sea Grant funding, Dr. Scott Siddall, of the Marine Sciences Research Center at the State University of New York at Stony Brook, began investigating how water salinity and weather conditions affect the algae involved, and how the algae affect scallop larvae.

While the mystery of the brown algae bloom has not yet been solved, the reappearance of the condition in 1986 reinforces the urgency of ongoing Sea Grant research in this matter.

- Consumption of seafoods reached a record 14.5 pounds per American in 1985.

To meet the increased demand, seafood industries must adopt new technologies to enable them to package and distribute high quality fish to retailers on a regular basis.

In recognition of this, Sea Grant has funded the work of Dr. Joe Regenstein and other seafood technologists at Cornell University.

Dr. Regenstein has worked closely with industry in his investigation of methods to extend the shelf-life of fresh and frozen fish. For example, he brought to the attention of U.S. industry a new, sophisticated method of evaluating fish quality, developed in Scotland.

His work may also help minimize the loss of valuable food. He is studying ways to extract, store and use the flesh that clings to the bones of filleted fish. Tons of this fish meat, high in iron content, are being wasted each year.

- The once great lake trout population of Lake Ontario went into an alarming tailspin in the 1950s, due to such factors as over-fishing, predation, and pollution.

In the 1970s, the United States, New York State, and Canada jointly began stocking this international lake with one-year-old lake trout.

Finally, in 1986, thanks in part to the Sea-Grant-funded work of Dr. Charles Krueger of Cornell University, the first positive evidence was produced that lake trout may be making a comeback: 75 baby trout, or "fry," were found in the Henderson Harbor area of Lake Ontario.

Dr. Krueger has been conducting breeding studies to help reestablish lake trout in the Great Lakes, by making it easier to discover which strains are reproducing naturally.

Successful fry collection is just one step in a restoration program that may take 20 years to complete.

But for the Great Lakes sportfishing industry, including the 300 charter boat businesses on Lake Ontario, it's a step in the right direction.

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In New York, Sea Grant Writes the Book on Revitalizing a Marine Industry

The New York Sea Grant Extension program, nationally recognized for excellence, has helped bring about a major revitalization of the tuna-fishing industry on Long Island.

Sea Grant Extension agents noticed that tuna caught by Long Island fishers frequently were rejected by the Japanese buyers who made up the most important segment of the fresh-tuna market.

The agents set up meetings with the buyers, to find out why.

It turned out that the Japanese have very strict standards as to how tuna should be handled once they are brought onto the boats—and that the Long Island fishers were unaware of those standards.

As a result, the opportunity for millions of dollars in tuna sales was being lost, and many hours of work wasted.

In addition, Sea Grant agents discovered that human illness was occurring due to mishandling of the tuna. A chemical formed in poorly handled tuna causes cramps and other symptoms in consumers.

To remedy this situation, Sea Grant developed a pamphlet detailing the proper methods for maintaining the tuna in the most desirable condition during the trip to the dock.

Sea Grant distributed it both to individual fishers and at large group meetings. Local and regional newspapers soon wrote stories about its availability. Within 80 days after its publication, more than 500 copies had been requested.

In addition to obvious benefits to human health, Sea Grant's success in this matter also had an enormous impact on the economy of Long Island, our state, and the nation as a whole.

At $5 a pound dockside, a single 800-pound bluefin tuna is worth about $4,000.

By making these fish usable in the important Japanese sushi and sashimi market, Sea Grant helped effect an increase in sales of over 32,000 pounds of fresh tuna in one season alone.

This translates into a hike of more than $250,000 in annual regional economic activity.

Tuna sales soared to nearly $2 million in 1985, compared to less than $300,000 in 1982.

The effect of this development on the U.S. balance of trade is exactly the kind of impact that is needed for the national economy right now.

The Sea Grant Extension Program is just what the doctor ordered for the physical health of consumers; it has also proven beneficial for the economic health of the Long Island tuna-fishing industry, and those who depend upon it for their way of life.

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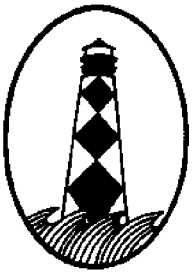
North Carolina



Sea Grant is teamwork. It's an orchestra of scientists—biologists, engineers, sociologists and geologists—creating harmony from the dissonance of coastal problems...

Upstream

Coastal residents know it as river scum. It looks bad, smells bad and makes the drinking water taste different. And it puts a halt to boating and swimming.

Sea Grant scientists know it as a bloom of blue-green algae that has an altering effect on the ecosystem.

They found that the blooms decrease the efficiency of the river's food chain and spur the growth of estuarine algal blooms downstream.

Sea Grant findings have been used to tackle blue-green algae problems all along the East Coast.

In the estuary

Eastern North Carolina's fertile lowland must be drained to be farmed. Fresh water from the fields is funneled into the estuary. But fishermen worry that the influx into brackish estuaries affects fisheries production.

To solve the dilemma, Sea Grant scientists studied how fresh water affected estuarine hydrology, salinity and fisheries production. And they examined alternative drainage methods.

Consequently, the state changed its water quality standards regarding freshwater input and funded further research.

The beach and beyond

When it comes to beachfront development and offshore use, it pays to look down the road.

Sea Grant assessed the effects of major storms on a homeowner's first line of defense—the dunes. Using these findings, homeowners can take storms into account before the waves start crashing.

Sea Grant trained tomorrow's resource managers and planners in a program that examined important coastal legal and policy issues—beach access, public trust rights and offshore oil development.

After several years of research and refinement, the alternative septic systems designed by Sea Grant scientists have passed the test. Even in the shallow sandy soils of the barrier islands, the systems succeeded in treating sewage without threat to nearby waters.

Offshore, scientists mapped underwater mesas. The mesas are prime fishing spots and a potential source for tomorrow's minerals.

Fish and fishermen

Sea Grant provides state and federal management agencies with the biological and sociological facts needed to manage fishery stocks.

Sea Grant scientists have:

- examined the biology and harvest of hard clams. The findings were used to establish regulations that prevent overharvest.
- developed computer models for managing the state's scallop and shrimp fisheries. The models will add more money to fishermen's pockets.
- devised important tests for detecting hepatitis A in shellfish.
- studied how fishermen transfer information among themselves about innovations and regulations.

Farming fish

Sea Grant scientists believe that tomorrow's seafood plate should have a cultivated flavor. They are perfecting the commercial culture of hybrid striped bass.

Through genetic manipulation, researchers are growing a hardier, faster growing hybrid. And they are working out the diet and disease problems that often plague aquaculture operations.

Seafood technology

Surimi. It's a bland protein fish paste. But add coloring and flavoring, and it can be formed into a pseudo crab leg or lobster tail.

Americans ate 150 million pounds of surimi-based products in 1985, doubling the previous year's consumption. But most surimi is imported from Japan.

Sea Grant scientists experimented with a cheap, abundant fish, the menhaden, which could give American processors an opportunity to enter the expanding market.

They refined the menhaden into a high quality surimi and solved some unique processing problems. Now the National Marine Fisheries Service is building a pilot plant for menhaden surimi production.

Reaching out

People turn to Sea Grant with problems you won't believe. They want to know how to rig a net, stop beach erosion or shed a crab.

Through workshops and publications, one Sea Grant extension agent sold the state's fishermen on crab shedding. His efforts increased gross sales of soft crabs by $2 million.

Another agent's knowledge of beach processes paid off. He saved the state over $20,000 by repairing damaged dunes with Christmas trees.

And last year, Sea Grant received over 60,000 requests for written information. And the program reached more than 24,000 people each month with its newsletter, *Coastwatch*.

By 1990—in four years—75 percent of all Americans will live within 50 miles of a coastline. If Sea Grant represents money well spent in 1986, then future dollars are even more important to the commonweal.

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An alternative septic system designed by Sea Grant researchers has improved water quality on the coast and helped to create a building boom nationwide.

The normally fragile ecology of North Carolina's coastal region was in trouble in 1977.

The migration of Americans toward sun and sand had begun to create unbearable pressures on the land.

New residents meant new housing, and that meant sewage disposal in an area where municipal disposal systems were almost nonexistent.

So septic tanks by the thousands were being installed. Soil scientists would discover later that 70 to 90 percent of them were installed in soils unsuitable for private sewage disposal.

The results:

- One county had stopped all construction for two years, and others were considering a similar ban.
- A serious health problem in one community was blamed on widespread water pollution.
- Pollution from human waste was cited as one factor in the loss of thousands of acres of shellfishing.
- Coastal communities badly in need of an economic boost faced stagnation because of ecological restraints on development.

Desperate for a solution, health department sanitarians in the 20-county region turned to the state for help.

The state, through its Department of Natural Resources and Community Development, turned to Sea Grant.

"I went to the Soil Science Department at N.C. State University," says Sea Grant Director B. J. Copeland.

Researchers there had been experimenting with an alternative septic system to accommodate high growth in the state's fast-growing Piedmont section.

If it worked in the Piedmont soils, Copeland reasoned, it ought to work at the coast. Copeland gambled a modest research grant that he was right.

The gamble was a good one.

The low-pressure pipe system of waste disposal developed by Sea Grant research has become the standard waste treatment system in some counties, the mandatory system in others, and an economic alternative nationwide.

The LPP system opened the way for construction on land once classified as unsuitable for development, creating a boom in construction.

The increase in development has added jobs and money to the economy.

The LPP system begins with a septic tank, just like a conventional system. But then the effluent flows into a second tank which contains a low-pressure pump.

Sea Grant researchers Dennis Osborne and Bobby Carlile found that these pumps could evenly "dose" the flow of effluent into a greater area of soil for treatment.

The LPP system costs about twice as much as a conventional system, but it's worth it, Osborne says.

In business for themselves now, Osborne and Carlile can attest to the LPP's success.

Osborne says that in Wake County alone, "there's been a half to a billion dollars in direct construction costs that would not have occurred without the low pressure pipe system."

He estimates that by the end of 1987 his company will install LPP systems for 1,000 Wake County houses—houses that cost an average of $95,000 apiece.

"1,000 houses times $95,000 is a bunch of money," Osborne says. "And that's just the houses themselves. The cost of construction adds up to even more money flowing through the economy. That's just in one county in one year.

Other states are finding the LPP works there, too. Virginia, Delaware, South Carolina, Texas and Louisiana are just a few of the states that are rewriting their waste disposal codes to require the LPP design in some cases. Some states even reference the Sea Grant publication that explains the LPP system.

In the West, the LPP system is treating sewage on land that is high-priced and densely-developed. "Building too close together on land makes it impossible to use conventional systems," Osborne says.

"I look at it (the LPP) as the difference between being able to use a lot or not," Osborne says.

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Ohio Sea Grant Program: The First Ten Years

Ohio Sea Grant Program, now in its tenth year, strives to answer the critical resource and development problems and issues of the nation's coastal resources, especially Ohio's Lake Erie, for society and industry. Well-developed cooperative marine research, advisory services, and education programs have been strengthened with the involvement of influential and energetic citizens coordinating and directing the capabilities and expertise of the private and public sectors.

Ohio Sea Grant, housed within the College of Biological Sciences at The Ohio State University, is funded by the federal government, the state legislature, participating universities, and businesses.

Ohio Sea Grant has concentrated its efforts on biological resources, water quality and lake processes, coastal and offshore engineering, aquaculture, biotechnology, and resource economics and marketing.

A few specific accomplishments are explained here.

Predation on Bloom Species

Aphanizomenon flos-aquae and *Microcystis aeru ginosa* are two of the most potent fresh water toxin producers and are public health concerns in eutrophic lakes. A microbial predatory system against these cyanobacterial, blue-green algal, blooms is being tested to control the problem blooms.

Biological Removal of Mercury

Toxic and potentially hazardous heavy metals are found in wastewater from many industrial sources. Mercury is one of the most toxic and notorious examples of heavy metal pollution. The biological detoxification method changes the mercury to a form which can be condensed and recovered in the elemental form. This method will eliminate the need to dispose of the mercury-laden waste in an approved toxic waste landfill.

Dynamics of Bioavailable Phosphorus

Special consideration has been given to the role of phosphorus in freshwater systems since a relationship between eutrophication and phosphorus concentrations was established. Dispersion models, applicable throughout the Great Lakes basin, are being designed to evaluate and prioritize remedial actions needed to reduce non-point source impacts. Sea Grant researchers are providing valuable information on the transport of sediment laded with phosphorous and other contaminants/nutrients from tributaries to the near shore zone and ultimately to the open lake.

Pesticides Runoff to Wetlands

The transport and fate of currently used pesticides in large agricultural watersheds are matters of increasing concern in marshes and wetlands. The impact of these pesticides is currently being analyzed to present the impact of changes in tilling and fertilizing techniques to the agricultural industry.

Economic Valuation and Impact

Ohio Sea Grant researchers provide estimates of the economic value and impact of the Lake Erie sport fishery, charter fishery, and marina industry to policy and decision makers dealing with the management and development of our most valuable natural resource—Lake Erie.

Design Method Underwater Welding

Underwater "wet" welds, welds made without any mechanical shielding from the water, are plagued by the rapid quenching effect of the surrounding water and by a susceptibility to hydrogen embrittlement. With the current expansion in ocean engineering activities, there has been an overwhelming demand to improve the quality and strength of joining techniques. Ohio Sea Grant researchers are working cooperatively with private industry to meet this demand.

Artificial Reefs

Artificial reefs have the potential to greatly enhance the Lake Erie fishery and the economy of the local communities where the reefs are placed. In Ohio, the economy of north central and northeast Ohio will be improved. Research is underway to evaluate reef design to insure that the reefs are constructed in the most beneficial fashion.

Under-Utilized Fish Species

On Lake Erie, 80 to 90% of all fish impinged at power plant intakes are gizzard shad. Shad, in the power plant discharges, have only a slight chance of surviving the winter. In addition to being the most abundant fish in the lake, their harvest during the winter does little to deplete spring forage stocks. The shad have been made into chum blocks for testing, in cooperation with the Florida Sea Grant Extension Agents, in the saltwater sport and commercial fishing industry. It is anticipated that this will result in a new market for the commercial fishery, cost savings to power plants, increased economic impact, and the use of a previously non-used resource. Other efforts to develop markets for gizzard shad in Louisiana as crayfish bait have produced the spinoff of a crayfish market and commercial harvest in Ohio.

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The Biological Removal of Mercury from Contaminated Waste Investigated by Ohio Sea Grant Researchers

The Problem

Mercury pollution in Lake Erie was such a serious problem during the early 1970s that sport and commercial fishing were banned. The lake has been cleaned up substantially since then, but there are still areas where the waters and sediments contain unacceptably high concentrations of metals such as mercury, zinc, arsenic, nickel, and chromium.

Mercury is one of the most toxic of the heavy metals. And methylmercury, naturally formed in aquatic and terrestrial environments from elemental (Hg^2) and mercuric (Hg+2) mercury, is one of the most toxic forms of mercury. Industrial releases of inorganic mercury have been shown to considerably increase the amount of methylmercury in the environment.

Mercury is currently removed from industrial waste waters by chemical precipitation with sulfide or reduction with sodium borohydride followed by filtration. This leaves mercury-contaminated precipitate which must be safely disposed of at a great cost to the industry. Alternative biological removal processes also result in mercury-containing waste. Consideration should be given to the concept of complete removal and recovery for re-use rather than safe disposal.

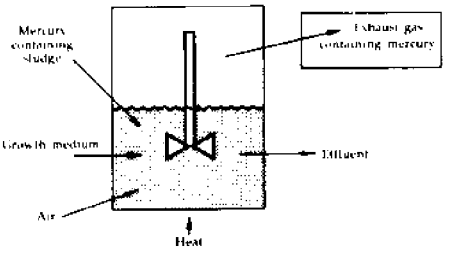
Two Ohio Sea Grant Program researchers, Drs. Olli Tuovinen and Conly Hansen, are able to give more than consideration to the problem. Their biological approach could replace present methods of detoxifying industrial sludges contaminated with mercury. Dr. Olli Tuovinen is with the Department of Microbiology, field of bioengineering, at The Ohio State University and Dr. Conly Hansen is with the Food Nutrition and Science Department at Utah State University. Hansen was previously with the Agricultural Engineering Department at The Ohio State University.

This biological detoxification process has several distinct advantages over the chemical and other biological methods currently being investigated or applied to the mercury problem.

The Research

The Ohio Sea Grant Program has sponsored the three year research project of Drs. Tuovinen and Hansen since September, 1984.

They proposed to convert mercury, using a bioreactor and mercury resistant bacteria, into a form which can be condensed and recovered for re-use. Mercury polluted sludge was mixed in a small scale bioreactor with an energy source and the mercury resistant bacteria. The bacteria survived, grew, and multiplied, the mercury changed into the usable form of elemental mercury, and the resulting effluent sludge was mercury-free. The bacteria were genetically engineered in The Ohio State University laboratories.



The biological process has been applied to industrial sludge from a chlor-alkali factory in northern Ohio. This sample of a filtrate "mud" from the electrolysis cells was mainly composed of potassium salts, insoluble metal hydroxides, and 100- 150 ppm mercuric hydroxide. This sludge is currently being disposed of at great expense in approved toxic waste landfills. Making only slight modifications, the mercury was completely removed using Hg-resistant bacteria in a continuous process. These results indicate the feasibility of the biological approach to the control of industrial mercury pollution.

The Benefits

It was found that raw sewage is sufficient to maintain the bacterial culture. The culture is therefore self-sustaining, and reduces mercuric ion (Hg+2) to volatile mercury (Hg^2) in an aerobic process which requires no pre-sterilization procedures. Thus, continuous mercury removal under non-sterile conditions has proven feasible in the bench top bioreactor - essential if the process is to have large scale industrial applications.

The research now being conducted will have a significant effect on the application of biotechnology to hazardous industrial waste management. Such an advancement could benefit the entire world community.

The results from this study will also lay the groundwork for further biotechnological studies to remove and/or detoxify other toxic metals found in wastewater and sludges. Several other metals have already been shown to be transformed to less objectionable forms by various resistant microorganisms.

Another important aspect of this work is the attempt to use an industrial, food processing waste as a nutrient and carbon source for biological, hazardous waste detoxification. Various methods have been investigated for upgrading and utilizing food waste and by-products as animal feed or human food. However, there is a great need to find non-food uses for agricultural waste by-products. The proposed research is an innovative approach for using industrial food processing waste as a microbiological nutrient source in a biotechnology related application.

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Oregon Sea Grant

Established in 1968 as the Oregon State University Sea Grant College Program, Oregon Sea Grant is dedicated to the maintenance, conservation, and wise use of the ocean and coastal zone of Oregon, the Northwest and the nation. The program integrates research, education and advisory services.

Several academic institutions in addition to Oregon State University contribute to the program: University of Oregon, Lewis and Clark College, University of Washington, Washington State University, and North Dakota State University.

Sea Grant work is also carried out onboard ocean vessels such as the R/V *Wecoma* and at several satellite facilities, including the Oregon State University Seafoods Laboratory in Astoria and the Mark O. Hatfield Marine Science Center in Newport.

The program is only as good as its people, and fortunately many outstanding individuals are involved. One hundred faculty members work at the institutions listed above on Sea Grant-sponsored projects. More than 325 Sea Grant-supported students have received advanced degrees since the program began.

• • •

Sea Grant-sponsored projects address many marine areas and issues. Some examples of recent significant activities:

• The United States is virtually completely dependent on South Africa and the Soviet Union for its supply of chromium, an essential metal used in many industrial applications. But the beaches of the Oregon coast and those submerged areas of the continental shelf which were once beaches are believed to contain considerable quantities of chromite, the mineral source of chromium. A Sea Grant study conducted from 1983 to 1985 identified how these mineral deposits are formed on the modern beaches. Following up on this research, mining companies have indicated an interest in exploring for deposits on the continental shelf off Oregon in the near future. If chromite mining were to result, local coastal economies, currently depressed, might benefit significantly.

• The great variety of deepwater fish known collectively as groundfish are America's highest volume fishery and have substantial economic importance. While maintaining sustainable groundfish populations is clearly desirable, groundfish management has been very difficult, largely because the fishery is complex and notoriously hard to study. An ambitious, pioneering research effort begun in 1985 has gained the cooperation of both management agencies and commercial fishermen. Already it is producing new, reliable data from onship samplings off the Oregon coast about what quantities of groundfish are caught, where, and with what gear. A better understanding of the web of relationships between management decisions, fishing strategies and fish populations is the expected outcome of this project. Improved groundfish management may result.

• The Columbia-Snake River System figures prominently in the inland economy of the Pacific Northwest. As it flows through six states and two Canadian provinces, the Columbia has a profound effect on maritime shipping, hydroelectric power generation, irrigation and fishing. More than a half-dozen current Sea Grant research and extension efforts address a variety of the issues and opportunities associated with the increasingly intensive use of the river. These projects include training for port managers, public education efforts on critical environmental issues, such as riparian management and waste burial at the Hanford nuclear reservation, and biological research to enhance salmon production at Columbia Basin hatcheries. The Columbia effort demonstrates the value of the multistate, multi-institutional Oregon Sea Grant network.

• Waterfront districts represent a community asset to port towns and cities, but in many communities this asset has fallen into disuse. To promote the revitalization of waterfronts, Oregon Sea Grant organized two major workshops in 1985 and 1986 that were attended by more than 150 city planners, administrators and interested members of the private sector from Oregon and Washington port towns. Officials from the towns of Reedsport and Astoria, Oregon, are among those who acknowledge these workshops as a catalyst in their own planning activities. Technical assistance responding to the specific needs of individual communities is now being provided by Sea Grant in the next phase of the revitalization effort.

• Erosion of beach property is a common problem at coastal locations; where the often rough Pacific hits the Oregon coast it can be a severe problem. But seawalls, which some property owners construct to protect their beachfronts, may not be a good idea, a current Sea Grant project is discovering. In the first phase of the project, controlled laboratory experiments done in a wavetank have found that waves remove much sand from beaches adjacent to seawalls and can also eat into property behind them. In the next phase of research, new and existing seawall construction sites at the coast will be evaluated and a computer model developed that will allow the effects of seawall construction in a particular site to be predicted before construction.

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The Promise of Useful Drugs from the Sea

Historically, most drugs used in human medicines have been derived from plants and animals that live on land. The ocean, as a vastly different environment, would seem likely to offer a whole new pharmacopeia, but until recently the ocean has scarcely been explored for this purpose. An ongoing Oregon Sea Grant research project addresses this opportunity. Results to date include the isolation of several new compounds whose chemical activity could make them beneficial in new drugs.

While research into potential marine biomedicinals is not altogether new (Oregon Sea Grant itself supported a number of research projects in the early 1970s), today's research is able to go farther with the new understandings and new tools of biochemistry developed in the 1970s. For his research, for example, 31-year-old Bill Gerwick uses Oregon State University's recently acquired magnetic resonance spectrometer and mass spectrometer, highly sophisticated instruments whose analytical abilities were not available to the researchers of a decade ago. Just the same, Gerwick, a natural products chemist in the OSU College of Pharmacy, collects his samples in the traditional way—he goes to the beach in his rubber boots and gathers his seaweed samples into a bucket.

In testing 44 species of common seaweeds found along the Oregon coast, Gerwick has isolated 21 new chemical compounds that have displayed some level of antimicrobial activity.

Three compounds that Gerwick has discovered are of particular interest. One is a very potent antibacterial compound which, in laboratory tests, has successfully killed *Pseudomonas aeruginosa,* a bacteria that causes almost certain death because it has a strain resistant to all known antibacterial agents.

Another compound derived from seaweed extract, which Gerwick calls "exciting," is related to a newly discovered group of human hormones known as leukotrienes. These hormones are associated with asthma attacks, contraction of smooth muscle and cases of hives. The fact that a seaweed can produce a similar compound could lead to the development of drug analogs to the hormone, made from the seaweed.

The greatest promise of any of Gerwick's discoveries to date comes from a seaweed he discovered while diving off the coast of Puerto Rico and which he continued to analyze once he had moved from the University of Puerto Rico to Oregon State. From this blue-green alga, Gerwick derived a novel carbon compound which he calls hormothamnione. In lab experiments the chemical shows itself "an exceptionally potent toxin to cancer cells," Gerwick notes. Hormothamnione is actively being investigated by a pharmaceutical drug company, and the National Cancer Institute is considering a proposal from Gerwick for additional study of the substance's action. Gerwick's other natural compounds will also be tested by pharmaceutical companies.

While Gerwick is quick to point out that it often takes years to develop drugs for human uses, still he is encouraged by his results to date. "What we are finding in the ocean is a chemistry that is unique from what is found in terrestrial environments," he says. "It is totally new."

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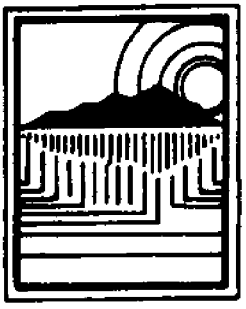

UNIVERSITY OF PUERTO RICO SEA GRANT PROGRAM

PUERTO RICO SEA GRANT: GATEWAY TO THE CARIBBEAN

WITH SEA GRANT IN PUERTO RICO, the National Sea Grant College Program (NSGCP) extends its services and influence to the Caribbean and Latin America.

SEA GRANT IS OF GREAT VALUE FOR PUERTO RICO AND THE CARIBBEAN BASIN COUNTRIES.

UPRSGP has provided:

- incentives and funds for needed tropical research...
- information and guidance for new income and employment in marine resources...
- improved decision making capabilities and enhanced technology in marine affairs...
- broad dissemination of research results deriving from the NSGCP network...
- UPR SEA GRANT in only five years, has undertaken important projects such as:
- Studies of ciguatera fish poisoning which causes severe regional health problems and results in a $10,000,000 annual loss to U.S. fisheries. UPRSGP is undertaking the development of a simple dock-side test for infected fish.
- Management guidelines for local grouper fishery by investigating reproductive potential and sources of juvenile recruitment.
- New compounds extracted from seaweeds show promise as anticancer drugs, antibiotics and pesticides. These are now being tested by pharmaceutical and agriculture companies.
- Studies of microbial contamination of shellfish by sewage show higher antibacterial inactivation rates than in temperate waters, and question the use of "standard" coliform counts as indicators of fecal pollution in the tropics.
- Spawning aggregations of commercially valuable groupers are targets for intense fishing. Project results are essential for fishery resource management and development.
- A study of population dynamics of tropical mangrove oysters suggests that oyster harvests and their economic value can be increased by transplanting additional spat to growing areas. This work has applications for resource management and mariculture ventures.
- MAS promotion of underutilized resources such as shark and fresh tuna has produced an additional $70,000 annual income for local fishermen.
- Aquaculture training workshops lectures, TV and radio programs reached 150 potential aquaculturalists and more than half a million people.
- Health officials, restauranteurs and CES agents receive MAS training in improved seafood handling and quality control.
- Tourism grosses $600,000,000 annually. MAS is endeavoring to increase the marine and coastal recreation share of this important industry.
- URPSGP education efforts improve public awareness of the sea, its resources and socio-economic benefits.
- Highly motivated Puerto Rican teachers trained by UPRSGP have established AMPEM, a voluntary association to promote marine education.
- Sea Grant Communications project is the only available source of marine-oriented applied information in Puerto Rico and the Virgin Islands. The demand for this information increases around 20% every year. Some of our publications are now bilingual in order to service the U.S. Virgin Islands and stateside constituents.
- Two thousand newsletters are distributed in twelve Latin American countries, Israel, Spain, Africa and the Caribbean; 25,000 additional publications are circulated annually; 34,000 requests for information are processed.
- Our publications provide needed local marine information for the school system; 475 public and private libraries are serviced through our Marine Education and Information Resources Center (MEIRC).
- UPRSG specifically encourages research that addresses problems of management, development conservation and utilization of marine and coastal resources in three programmatic areas: Fisheries-Aquaculture, Marine Pharmacology and Natural Products, and Coastal Environmental Processes.

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UNIVERSITY OF PUERTO RICO
SEA GRANT PROGRAM

CIGUATERA: A PUBLIC HEALTH AND ECONOMIC PROBLEM

CIGUATERA FISH POISONING- A PUBLIC HEALTH AND ECONOMIC PROBLEM

Ciguatera Impact

Ciguatera fish poisoning is a human health problem that can affect all persons living near tropical seas. In addition to a toll of 10 deaths per year, the highest annual morbidity rates in the United States are found in Puerto Rico and the U.S. Virgin Islands where diagnosed cases range from 10 to 27 persons per thousand per year. Increased exports of tropical reef fish also have resulted in ciguatera out-breaks in the temperate U.S., Canada, United Kingdom and France. In addition to the public health aspects, an estimated $10,000,000 per year is lost to the Florida, Caribbean and Hawaiian fishing industries, as a result of quarantined sales of species which are frequently toxic, and to adverse publicity. In addition to significant losses in work time, medical expenses resulting from ciguatera fish poisoning in the U.S. average $1,300 per case.

The Problem

Public health and economic implications of ciguatoxic fish are of such regional magnitude that an intensive research effort was called for. The UPRSGP investigation team has faced two problems: (1) little was known about the origin and chemical nature of the ciguatera poison; and (2) there was no simple way to determine if a fish was toxic or edible. Solution of the first problem is basic to public health information needs; the second addresses the problem of economic and protein losses.

Sea Grant Response

Supported initially by a "seed money" grant and subsequent project funding by UPRSGP, Drs. T.R. Tosteson, D.L. Ballantine and H.D. Durst have made significant progress. Using systematic collections of locally caught barracuda, a carnivorous fish which frequently is ciguatoxic, and microscopic dinoflagellates from nearby coral reefs, the researchers determined a seasonal toxicity peak during January-March. In addition, researchers identified specific anatomical areas of concentrated poison in barracuda. By extracting ciguatoxic fish tissue and concentrating reactive compounds from dinoflagellates which are associated with reef algae, the research team has isolated reactive components termed collectively as ciguatoxins (CTX), and is further defining their chemical nature and complex origin. In addition to a dinoflagellate source of CTX, results also indicate a bacterial role in ciguatoxic formation. The research team is now undertaking to develop a simple and effective dock-side test to detect infected fish.

Results

- a system for accumulating toxin(s) responsible for ciguatera fish poisoning has been established and significantly increased the supply of crude toxin.
- barracuda toxicity is apparently seasonal, with peak ciguateric activity seen during late winter and early spring months.
- two potential dinoflagellate vectors of ciguatera have been located and identified. Dynamics of natural populations of each species has been characterized over a two year period.
- cultured dinoflagellates and readily accessible wild populations have significantly increased available crude microalgae toxin.
- bacterial flora associated with dinoflagellates also appear to contribute to ciguatoxin formation.
- ciguatoxicity is shown to alter the color response of fish scales (melanophore cells) in the presence of adrenalin.
- melanophore response is being further investigated as the basis for a simple yet adequate dock-side test for ciguateric fish.
- two publications have been accepted in peer-review journals; three additional papers are in preparation.

Gambierdiscus toxicus

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Rhode Island's Sea Grant Works at Home, Abroad

The University of Rhode Island's Sea Grant College Program was one of four original Sea Grant programs created in 1966. But URI was a Sea Grant institution long before the bill was signed into law.

The University has always been committed not only to research but to educating and advising the community. Because Rhode Island is the smallest state in the country, URI's Sea Grant Program is able to serve not just the state but a broader audience which crosses regional, national, and international borders. The program has been involved in efforts such as estuary studies in different regions of the United States, coastal management in developing countries, as well as studies of pollution in Rhode Island's Narragansett Bay.

Liability Bill. Commercial fishing is one of the nation's most hazardous occupations. Skyrocketing insurance rates reflect a situation aggravated by vessel losses and an increase in the number and size of personal injury settlements.

A URI researcher provided Congress with a study suggesting alternatives to the current system of personal injury compensation. Portions of the study, funded by Sea Grant, were incorporated into legislation, House Bill 4415, and a companion Senate bill, S2546.

The bills limit the liability of the vessel owner unless a crew member is permanently disabled. If a crew member is injured, he is eligible to recover medical expenses and up to 80% of lost wages. This replaces a situation where there is no limit on the recovery of damages.

The bills also require that vessels carry additional safety equipment such as a black box which emits homing signals on emergency frequencies, survival suits, life rafts, as well as a radio and flares. The bills limit the amount of liability that a vessel owner and insurance companies must face. That, coupled with increased safety, should encourage insurance rates to drop.

Surimi. Surimi is a tasty imposter of big-ticket shellfish items; lobster, crab and shrimp. The product, made from white fish and flavored with shellfish juices, is inexpensive and nutritious.

While extremely popular in Japan, surimi does not enjoy such widespread acceptance or marketability in the United States. A URI food scientist, with funding by Sea Grant, investigated ways of making the domestic market competitive with Japan's surimi market by streamlining the processing techniques and altering the texture of surimi.

Improvement in the processing techniques include the use of locally caught fish. And scientists are experimenting with additions to surimi paste to alter its texture to resemble not only shellfish but meat, snack foods, as well as cheese.

Aquaculture. Sea Grant has funded aquaculture research with an emphasis on increasing the profit and marketability of rearing Atlantic salmon. These two-year projects include economic studies of rearing fish and biological manipulation of young salmon.

Based on aquaculture industry research, a researcher analyzed how fish farmers can target salmon markets on a regional basis. The study also profiles the national and international aquaculture markets.

Other researchers are trying to determine when smolitification, or the many changes fish make when moving from fresh to salt water, occurs in fish. If scientists can pin down that moment, they may be able to control the release of hatchery-grown fish into the sea. Staggering the release of fish would control their return appointments to their birth place, producing a better sales market.

Upper Narragansett Bay. Pollution in Narragansett Bay, the state's major estuary, is a serious problem. Sea Grant funded a multifaceted study in upper Narragansett Bay which attempted to identify what constitutes pollution for portions of the Bay and ways to treat urban waste economically.

Scientists studied the Bay by measuring salinity, temperature, and currents to create flow models of the Bay and the Providence River. A companion project considered the effectiveness of water quality policies on the Bay and how efficiently those regulations are managed.

Scientists also identified the amount of pollution the estuary is able to assimilate by measuring the oxygen levels in the water and determining how frequently the Bay is flushed by ocean and river water.

Marina Executive Program. Marinas stay afloat not only with secure docking facilities but with strong business practices.

To help marina owners understand the business of boating, Sea Grant has funded several projects including marina executive management programs for marina managers and owners.

The programs focus on developing skills to improve profits and services and tailoring a business to local coastal environments. The five-day program featured speakers from industry and academia as well as visits to marinas and boatyards. A spinoff seminar will be offered through a new non-profit marina management organization.

Before the creation of the National Marine Financial Data Bank, a two-year study sponsored by Sea Grant, there was no official source for financial information on marinas, boatyards, and other related businesses. Researchers also created a data bank that collected information about marine-related businesses on a national basis which was broken down into regions. Sea Grant advisory specialists also facilitated the first national survey of boating facilities which identified more than 10,000 marinas and boatyards throughout the country.

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Protecting a Precious Estuary: Rhode Island's Narragansett Bay

Narragansett Bay, more than 100 square miles of coastline and water, splits Rhode Island into two jagged pieces. The Bay is home for sailors, fishermen, beach lovers, and offers a deep-water port for shipping.

The upper Bay however, which ends at the capital city of Providence, is a repository for sewage treatment plants, runoff, and other pollutants. Management of this portion of the polluted Bay is highly politicized.

URI scientists conducted a multidisciplinary study of the polluted upper Bay, focusing primarily on the management of this urban area (which includes the Providence and Seekonk Rivers). Because researchers had previously conducted a similar multidisciplinary effort involving the state's saltwater ponds that was very successful, they felt confident that they could apply the same techniques to the Bay and provide direction for management needs.

Research projects ranged from the description of more than 200 years of pollution history with sediment cores to the measurement of oxygen levels in the rivers and estuary.

Hydrodynamic Modeling. Salinity, temperature, and currents made up the data base which described the pollutant flow, or transport dynamics, in the Providence River. The data also verified tidal and non-tidal computer hydrodynamic flow models of the Bay. Combined with estimates of runoff and effluent discharges, the model can be used to make quantitative predictions about water quality.

Oxygen Levels. How much pollution can the upper Bay and Providence River assimilate? Scientists studied the relationship between natural recycling and nutrient loading in the estuary by measuring oxygen levels biweekly. Studies included measurements of oxygen released from phytoplankton through photosynthesis, the amount of dissolved oxygen and nutrients contributed from sewage treatment plants, and the oxygen uptake by the benthic community. The study revealed the residence time of fresh water in the river and provided information on how quickly the ocean flushes the river.

Resource Economics. An economics project evaluated the costs and benefits of controlling pollution inputs through alternative strategies. Scientists constructed a data base for recreational uses of the upper Bay and pointed out the effects of water quality on adjacent residential property. The study also produced an inventory of pollution point sources, urban runoff, and the effects of a hazardous pollution spill.

Management Strategies. A companion project, conducted by the Coastal Resources Center, concentrated on the effectiveness of water pollution policies and how successfully the policies are administered. The CRC looked at adopted water quality goals, existing information, and the progress of pollution abatement. Researchers set up simple and easy-to-use sewer system and pollutant transport models. This study was particularly timely because of speculation as to whether the 1972 Clean Water Act addresses specific trouble spots such as urban estuaries.

Heavy Metals. Estuaries are considered watery nurseries for young finfish and shellfish. Scientists studied the impacts of pollution on young winter flounder and quahogs in order to provide basic information on the effect of pollution on living resources.

Other Studies. Additional studies included charting manmade and natural physical changes to the shoreline of the Providence River through dredging, landfill, and natural causes. Another project involved studying sediment cores, which resulted in a historical construction of pollution reaching back to the 1700s.

The comprehensive research project accomplished several goals. It gave researchers a chance to study the complex problems of an ecosystem, Narragansett Bay, which has been severely impacted by pollution and remains difficult to manage as one large body of water. While it was difficult, as in any multidisciplinary project, to reach an agreement between the many agencies concerned with the Bay, new policies for the Providence River were adopted by the Coastal Resources Management Council.

With the information gained from Narragansett Bay, researchers have begun a study that compares the management strategies for six estuaries around the country, from San Francisco Bay to Delaware Bay. The study will provide researchers with an understanding of how various management plans have evolved and man's success in dealing with a natural environment.

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South Carolina Sea Grant Consortium
Exploring the coast today for a better tomorrow.

Like many sunbelt states, South Carolina has grown as more people are drawn to warm temperatures, golden beaches, and vast natural resources. In the ten years between 1970 and 1980 the coastal counties have increased in population over 24%. Along the state's 187 mile coast, pressures from commercial, recreational, industrial and preservation interests continue to increase. A cynosure for these pressures, the state's abundant coastal and marine resources are among her greatest assets.

Recognizing the needs and opportunities presented by South Carolina's vast coastal and ocean resources, the State Legislature formed the South Carolina Sea Grant Consortium. The Consortium is designed to supply the knowledge and technology needed to develop and manage these resources. To that end, the Consortium draws upon the talents and physical resources of its seven member institutions: Clemson University, the College of Charleston, the Medical University of South Carolina, South Carolina State College, South Carolina Wildlife and Marine Resources Department, The Citadel and the University of South Carolina. This consortial partnership encourages cooperative research, extension and education efforts in a variety of disciplines: it also offers access to a wide variety of facilities, including 30 laboratories and the new James M. Waddell, Jr. Mariculture Research and Development Center.

One research project being conducted at the Waddell Mariculture Center is investigating the commercial aquaculture of striped bass/white bass hybrids. The striped bass ranks as one of America's most desirable game and food fish. Similarly, the striped bass/white bass hybrid has received widespread acceptance as a recreational species and is a tasty food fish.

From 1973 to 1983, commercial landings of striped bass along the Atlantic coast have declined by 87 percent. In response, the Atlantic States Marine Fisheries Commission recommended a 55% reduction in fishing effort in some states. A complete ban has been instituted in others. At the same time, market demand for striped bass has increased five-fold since the early 1970s.

The current fishery problems and existing market pressures offer a unique opportunity to examine the development of commercial aquaculture of striped bass and the striped bass/white bass hybrid. In this context the Consortium funded a three-year study to (1) develop and demonstrate techniques for the controlled out-of-season spawning of striped bass and white bass to produce an F1 hybrid, (2) demonstrate intensive nursery systems for the production of hybrid bass fingerlings and, (3) examine striped bass, striped bass and white bass hybrids and F2 hybrids to identify the most suitable candidate for aquaculture.

To date striped bass/white bass hybrids have been spawned twice and, in 1984, they were spawned three months before the natural spawning season for the first time. Techniques involving the manipulation of temperature and photoperiod regimes for conditioning, and injections of human chorionic gonadotropin for induced ovulation were used. All bass larvae have been reared in intensive nursery systems and the resulting fingerlings stocked in comparative production trials. This means that brood stock have been grown, matured, and spawned under completely controlled indoor conditions; the first time this has been accomplished. Additionally, results have indicated that the striped bass/white bass hybrid is the most suitable candidate for aquaculture. Hybrids grow rapidly, exhibit high survival and production rates, and thrive in a wide variety of environments and rearing systems.

Current studies are focusing on the refinement of out-of-season spawning techniques and production methods for the grow-out of hybrid bass to market size. Researchers expect to demonstrate that hybrid bass can be raised from egg to pan or market size in nine months; reducing the natural grow-out time for bass and thereby reducing culture costs.

Crawfish is another attractive aquaculture species in South Carolina. Crawfish aquaculture was introduced to the State in 1977 by the U.S. Soil Conservation Service. Early growth in the crawfish industry was impeded by untested production methods, lack of sound economic data, and limited market development. It became clear that technical assistance would have to be provided to crawfish producers and growers for the crawfish industry to develop.

The Sea Grant Marine Extension program was contacted in early 1981 by crawfish growers and producers for assistance and, in response, a three-part program was developed. First, production methods were demonstrated by extension specialists from Louisiana State University and Texas A & M University through a series of workshops. The Crawfish Growers Association was then organized to improve the exchange of good management and production techniques. Second, economic data was generated by L.S.U., Texas A & M, and Clemson extension economists to inform potential culturists of the costs and returns of a crawfish operation and a number of workshops were held to disseminate this information. Finally, a number of activities have been sponsored to improve the marketability of crawfish, including the annual S.C. Crawfish Festival.

Results of these efforts have been significant. From 1980 to 1984 acreage managed for crawfish aquaculture has increased from 20 acres to 525 acres; production has increased from 8,000 to 250,000 pounds harvested; and harvest value has increased from $6,000 to $312,500. In 1985, 750 acres of ponds were stocked with crawfish. The ponds yielded about 300,000 pounds of crawfish at an estimated value of $397,500. These figures represent a percentage increase over 1984 production as follows: acreage under cultivation — 42.8%, pounds produced — 16.7%, and value of harvest — 21.4%.

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Exploring the coast today for a better tomorrow.

The hard clam, *Mercenaria mercenaria,* has become a priority species for both private and public sector mariculture initiatives. Techniques and procedures for larviculture have already been standardized. In addition, the availability of seed stock, the success of experimental growout efforts and the existence of favorable markets have spurred the development of clam mariculture operations along the East Coast.

One of the major impediments to the development of hard clam mariculture is the high cost and general unavailability of large (> 10mm) seed clams from commercial hatcheries. As a result, commercial and non-commercial operations are forced to build nursery facilities. In these facilities juvenile seed are grown to sizes that are required for field growout. But, traditional nursery systems are relatively expensive to build and very expensive to operate.

Upflow nursery systems for bivalve mollusk seed have received considerable attention in recent years. While in widespread use in Europe, particularly France and the United Kingdom, upflow systems have received only limited application in North America. Here nurseries have generally retained traditional raceway systems for juvenile bivalves. Recently, however, the success of European nurseries has prompted a re-examination of upflow culture systems by both research and commercial interests in the United States.

In this context, the S.C. Sea Grant Consortium entered into a cooperative research effort with the S.C. Wildlife and Marine Resources Department and a local private clam farm to determine the value of upflow culture systems for the nursery culture of bivalve mollusks. The study, conducted by Dr. John Manzi and his associates, included an analysis of upflow systems' operational capabilities and comparisons with traditional raceway culture systems.

One focus of the study involved a comparison of nutrient uptake within both systems. Researchers noted that the horizontal flow of water in raceway culture systems did not allow seed stock equal access to water-borne nutrients. Rather, nutrients were being removed from the water as it flowed through the system. As a result, clams located closest to the origin of water flow grew faster than clams at the opposite end. Typically, upflow systems use a vertical waterflow that passes up through the bivalve seed rather than across as in raceways. Dr. Manzi's work demonstrated that upflow systems require virtually the same water flow per unit of biomass as raceway systems. However, upflow systems offer all seed clams in the system equal access to nutrients.

The most apparent cost-savings involved diminished labor requirements; significant because day-to-day maintenance and operation amounts to 50% of the total cost of running the nursery system. Dr. Manzi calculated that labor costs added 1.1¢ per clam produced in raceways at the local clam mariculture operation. His research showed that these costs can be reduced by approximately 66% through conversion to upflow systems, a reduction in labor costs of 0.36 cents per clam. At a production rate of 12 million clams (>10mm) the local clam mariculture operation showed a labor savings of about $88,800 in absolute terms.

The upflow technology examined and proven through this research project has been adopted by several major clam producers around the country. Four of the companies are:

Aquaculture Research Corp.
P.O. Box 597
Dennis, MA 02638
(617) 385-3933
Contact — Dick Krauss

Bluepoints Company
West Sayville, NY 11796
(516) 589-0123
Contact — Stan Czyzyk

Aquafarms Corp.
P.O. Box 1520
Tuckerton, NJ 08087
(609) 296-6967
Contact — Todd Hollaway

Coast Oyster Company
P.O. Box 327
Quilcene, WA 98376
(206) 765-3345
Contact — Jim Donaldson

Though no specific numbers are available on labor cost savings, company contacts indicate savings similar to or greater than those demonstrated by Dr. Manzi. In addition to labor savings these companies noticed a marked decrease in the costs of electricity and of pumping water through the upflow system.

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TEXAS A&M SEA GRANT COLLEGE PROGRAM

Texas A&M University is the Sea Grant College for Texas . . .

...providing leadership for research, education and extension activities to promote wise use of our marine resources. Research focuses on fisheries, engineering, mariculture, the coastal environment and resources policy, and for more than 15 years has involved the knowledge, talent and skills of specialists from:

- The Texas A&M University System
- The University of Texas System
- University of Houston System
- Baylor College of Medicine
- Texas Southern University
- Texas Southmost College
- Lamar University
- Brazosport College
- Pan American University

Recent research and advisory efforts have made direct contributions to the state's economy and to the safe use of the marine environment. For example:

- Continuing Sea Grant-funded mariculture research has concentrated on nutritional requirements and disease prevention for shrimp, and on investigations of prospects for redfish mariculture in Texas. Researchers working on the latter have determined that captive redfish can be induced to spawn on a regular and predictable basis by manipulating light and temperature. Related work underway involves the role of the endocrine system in reproduction and nutritional needs of redfish larvae.

The commercial feasibility of a shrimp mariculture industry is also dependent on economical and nutritious diets. Researchers are determining which microscopic salt marsh plants contribute to shrimp nutrition in the wild, and have found that pond-reared shrimp appear to derive much of their food from the naturally occurring plants in ponds rather than from more expensive commercial feed.

Disease is, perhaps, the most devastating factor that can affect pond-reared shrimp in intensive mariculture operations. Veterinary experts have found that shrimp appear to have an immune response that can be induced by using killed bacterial agents to formulate vaccine-like preparations. They have also developed a sensitivity test to aid in diagnosis of shrimp disease and detection of disease carriers.

- Sea Grant researchers work closely with Mexico and U.S. government agencies on sea turtle conservation programs, since Texas is the site of important feeding grounds for the endangered Kemp's ridley, green and loggerhead species and hosts the U.S. portion of the Kemp's ridley experimental conservation program. Texas A&M researchers have found strong support for the imprinting theory, the role of temperature in sex determination, and the nutritional requirements for captive breeding programs.
- Marine biologists at Texas A&M University have determined that a small parasitic snail can reduce shell growth even in large oysters, and cause small oysters to die when subjected to the number of parasites normally found on oyster reefs. The snail also spreads a disease that is one of the primary causes of oyster mortality in the Gulf of Mexico. These linkages are important to sustain oyster fisheries in the wild and to develop oyster mariculture systems.
- Researchers at Baylor College of Medicine have determined that virus found in polluted waters often adhere to solid substances, which, in effect, form a virus reservoir when the solids settle to the bottom. As a result, the virus often is not detected when a bacterial analysis is performed on the water. Sea Grant-funded researchers developed a sensitive, specific test to detect hepatitis A virus. This assay may soon be able to forecast the likelihood and extent of potential virus pollution.
- Using controlled atmosphere packaging technology, researchers extended the shelf life of seafood between five and seven days for fresh fish fillets, swordfish steaks and shrimp. The process involves injecting carbon dioxide into a specially sealed container of seafood, which inhibits common types of spoilage organisms without changing the taste or appearance of the seafood. These few days mean millions of dollars to seafood marketers who are trying to meet a surging demand for fresh seafood in the United States.
- Recreation and tourism make a large contribution to the Texas economy, but the amount for each sector is not always clear. With support from Sea Grant and the Boating Trades Association of Texas, economists determined that the recreational boating industry added more than $1.7 billion to the Texas economy each year, far more than had been anticipated.

In addition to research and advisory service activities, education efforts by the Texas A&M Sea Grant Program provide increased understanding, appreciation and awareness of the coastal environment and resources.

- Public school teachers from throughout the country are given special inservice training in all aspects of marine education, both for in-class work and for field experiences.
- An annual Marine Education Symposium attracts high school students and teachers from throughout the state, and introduces them to current scientific research, career opportunities, and marine-related aspects of social studies and the humanities.

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TEXAS A&M
SEA GRANT
COLLEGE PROGRAM

Oyster parasites and disease

Perkinsus (=Dermocystidium) marinus, a disease-producing protozoan, is a primary cause of oyster mortality in the Gulf of Mexico and much of the southeastern coast of the United States. It spreads slowly from centers of infection within an oyster reef complex and moves even more slowly from reef to reef. The infection is patchily distributed on many reefs, often with uninfected oysters right beside infected ones. This sporadic pattern suggests that a slow-moving intermediate host is important to the spread of infection within an oyster population.

As a result of research by Texas A&M University Sea Grant's Dr. Eric Powell and his colleagues, it has become apparent that a small parasitic snail, **Boonea impressa**, is this intermediate host. **B. impressa**, which occurs from the Gulf of Mexico to southern New England, may appear in concentrations of up to 100 snails per oyster and frequently is found in concentrations of 5 to 20 snails per oyster. **B. impressa** can change hosts frequently, but normally these excursions are limited to relatively small areas within the host population. This behavioral pattern correlates with the dissemination pattern of **P. marinus**.

Field and laboratory research determined that **B. impressa** could reduce shell growth even in large oysters and could cause small oysters to die when subjected to the number of parasites normally found on oyster reefs. It also changed the internal chemical composition of the oysters, decreasing their health and ability to survive. In addition to sapping the vitality of the oysters, Powell and his co-researchers also determined that **B. impressa** increased both the occurrence and intensity of **P. marinus**-caused disease in oysters.

To estimate the effects of **B. impressa** on oyster reefs, the researchers developed a computer model to assess the impact of varying numbers and sizes of snails on oysters. Once data on the abundance of snails and oysters in the wild are known, the model can predict the impact of the snail on specific oyster reefs.

This research is providing an increased understanding not only of oyster reef communities, but of host/parasite relationships in general. The productivity of mariculture operations, as well as the harvest of wild oyster populations, will be improved by new insights gained through research such as this.

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Virginia Sea Grant College Program — Providing research, education, and marine advisory services for the development, use, and management of coastal resources

The Virginia Sea Grant College Program is administered through the Virginia Graduate Marine Science Consortium with members at University of Virginia, College of William and Mary, Old Dominion University, and Virginia Polytechnic Institute and State University.

Virginia Sea Grant is part of a nationwide network of 30 university-based Sea Grant programs funded through the National Oceanic and Atmospheric Administration. In a partnership between universities, government, and industry, Sea Grant programs work together to address coastal issues through research, education, and marine advisory services.

Through this partnership, Virginia Sea Grant brings diverse talents to bear upon problems and opportunites concerning state and national coastal resources. The following projects illustrate a few selected accomplishments.

Helping the Soft-Shell Crab Industry Grow

The growing demand for soft-shell blue crabs has created the opportunity for expansion of the industry. Since its publication in 1984, Virginia Sea Grant's "Manual for Handling and Shedding Blue Crabs (*Callinectes sapidus*)," has become the authoritative information source for the industry. Virginia Sea Grant Marine Advisory Services (MAS) has aided in the design and construction of over 20 new closed system shedding facilities, and provided consultation to over 50 established crab shedding operations. Since 1982, on-site diagnostic services have provided evaluation of shedding facility and crab mortality problems. For example, MAS diagnosed a Reedville, Virginia, crab shedder's problem with excessive peeler mortality problem as poor water quality and helped him redesign his shedding facility. Subsequent peeler survival rate increased from 35% to 65% in one season.

Solving the Mystery of Blue Crabs in the Bay

The blue crab fishery in the Chesapeake Bay undergoes significant annual fluctuations which cause economic hardship for the industry. But because little quantitative information is available about the movement of blue crabs in and out of the Bay, a tri-state research program was initiated in Virginia, Maryland, and Delaware in 1979. Virginia Sea Grant researchers have found that environmental forces, especially wind direction and strength, actually help keep blue crab larvae in the vicinity of the Bay's mouth instead of sweeping them further out to sea. This resulted in the development of a physical model that helps explain the movement and recruitment of blue crab larvae at the Bay mouth and in the adjacent ocean. The model will ultimately be used to predict the size of the Bay's harvestable blue crab population far enough in advance to develop optimal management and harvesting strategies.

Increasing the Economic Potential of Virginia's Fisheries

The harvest of shellfish and finfish in the Chesapeake Bay is of significant economic importance to both Virginia and the nation. However, while the tools of economic analysis have been used in fishery management programs, there have been few applications to Chesapeake Bay fisheries.

In a three-year study, Virginia Sea Grant researchers conducted an extensive economic analysis of the state's finfish and shellfish industries. The project evaluated the demand for Virginia's blue crabs, oysters, and food finfish, and assessed the impact that harvesting and marketing these resources have on the state's income. Researchers also developed integrated econometric models that analyze the effects of fisheries management policies on income, employment, and harvest. Results of this study have been used by the Joint Legislative Audit and Review Committee of the Virginia General Assembly, the Virginia Marine Resources Commission, and the Division of Fisheries Development of the National Marine Fisheries Service. Sea Grant researchers are now training VMRC personnel in the use of the econometric models developed in this project.

Developing Buffer Zone Standards

In the Chesapeake Bay, the effect that boating and marina activity have on the cleanliness of adjacent shellfish growing waters is an issue of great concern. In order to provide scientific, regulatory, and industry personnel with accurate data concerning areas of fecal coliform occurrence surrounding marinas, Virginia Sea Grant researchers conducted a combined field and numerical modeling study. Bacterial data from field studies was combined with mathematical models to determine at what distances from marinas significant levels of fecal coliforms attributed to marina activities can be found. Research results are being used as a foundation for a 1986-88 Chesapeake Bay Initiative effort to develop a scientifically sound method for establishing marina condemnation buffer zones.

Virginia Sea Grant supports many other research, education, and marine advisory services efforts from seafood technology to marine resource economics to aquaculture. For more information, please contact:

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Charlottesville, VA 22903

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Virginia Sea Grant College Program — Increasing the economic potential of Virginia's fisheries

The harvest of shellfish and finfish in the Chesapeake Bay is of significant economic importance to both Virginia and the nation. In the Bay, oyster production accounts for 40% of the nation's total yearly oyster harvest. In addition, the harvest of the Bay's blue crabs accounts for 40% of the nation's total yearly blue crab harvest.

The Need

The future economic value of the nation's fishery resources has become a matter of concern for scientists, fishery managers, and legislators. However, while the tools of economic analysis have been used in fishery management programs, there have been few applications to Chesapeake Bay fisheries.

Virginia Sea Grant Response

In a three-year study, Sea Grant researchers conducted an extensive economic analysis of Virginia's finfish and shellfish industries. The project evaluated the demand for Virginia's blue crabs, oysters, and food finfish, and assessed the impact that harvesting and marketing these resources has on the state's income. Researchers also developed integrated econometric models that analyze the effects of fisheries management policies on income, employment, and harvest in the shellfish and finfish industries.

The project involved gathering, organizing, and evaluating existing data to determine historical economic patterns and trends, market structure, factors influencing economic supply, and policy options for the fisheries. Research analyses demonstrated the relationship of harvest levels for blue crabs and oysters to environmental, public management, and economic forces. An input-output model relating the commercial seafood industry to the state's economy was also developed.

Selected Accomplishments

- Results of this study have been used by the Joint Legislative Audit and Review Committee (JLARC) of the Virginia General Assembly, the Virginia Marine Resources Commission (VMRC), and the Division of Fisheries Development of the National Marine Fisheries Service.

- When the JLARC was asked to develop policy alternatives that might help foster Virginia's economic position in the fishing and seafood industries, it worked with the project's principal investigator in compiling information for its report entitled "The Economic Potential and Management of Virginia's Seafood Industry."

- In order to more precisely incorporate economics into decision making, Sea Grant researchers are training VMRC personnel in the use of the econometric models developed in this project.

- Twenty-six published and working papers regarding fisheries economics have resulted from this effort.

- Research has supported three graduate students, and the completion of one doctoral dissertation and two master's theses.

Virginia Sea Grant supports many other research, education, and marine advisory services efforts from seafood technology to marine resource economics to aquaculture. For more information, please contact:

William L. Rickards, Director
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203 Monroe Hill House
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Charlottesville, VA 22903

(804) 924-5965

Washington Sea Grant—A university-based partnership with industry, government, and citizens that is providing innovative leadership for addressing problems and opportunities of marine resource conservation, development, and management . . .

To address the problems and opportunities of resource conservation, development, and management, the Washington Sea Grant Program undertook in 1968 a coordinated program of research, education, and advisory services. The effectiveness of this program is demonstrated by the following projects.

Reviving an Oyster Industry

Oysters have been harvested in southern Puget Sound and Willapa Bay for decades. By the 1950s, however, the native oyster had all but disappeared—the victim of pollution and overharvesting. To restore the once-abundant resource, measures were taken to clean up polluted waters and to limit harvests. Still growers depended upon imports of "seeded" oyster shells from Japan.

But today, the oyster industry in the Pacific Northwest is booming again—the result of Sea Grant research to develop a means for mass producing oyster larvae in hatcheries and a technique for producing sterile oysters that are edible year-round.

In the 1970s, researchers at the University of Washington's School of Fisheries found a way to induce captive oysters to spawn. This breakthrough has meant that growers can now fill plastic saltwater "setting tanks" with oyster shells and add larvae purchased from a nearby hatchery. Once the larvae attach, the shells are moved to deeper waters to mature. Acceptance of this new procedure was gradual, but in 1985 approximately 80% of West Coast oyster production was derived from hatchery-raised larvae.

In 1986, two Washington hatcheries began to market a genetically engineered oyster that remains plump and tasty even during summer months when oysters normally are mushy and milky. This "all-season" oyster results from a chemical treatment that produces a third set of genes. The sterile "triploid" oyster devotes its entire life cycle to growth rather than to seasonal reproduction and thus remains firm and sweet year-round. Another advantage is that the triploids grow faster and larger than diploids.

Early in 1987, Coast Oyster Company plans to switch entirely to triploid larvae and by 1990 projects that its entire production will be in triploids. Westcott Bay Sea Farms is currently test marketing triploids in Seattle and San Francisco and expects to meet the needs of a national market within three years.

Helping a Port Avert Bankruptcy

On a day-to-day basis, Sea Grant's port industries specialist works with port managers to help them assess financial performance of these public enterprises and to formulate effective management policies. For one small Washington port on the brink of bankruptcy, such assistance has meant continued operation.

In early 1986, the port was two years in default on a bank loan of approximately $1.5 million. Relations among three major parties (port, bank and county treasurer) had become very strained.

At this point, the port industries specialist was asked to assist. He spent 30 days discussing the matter with all parties and their advisors (attorney, accountants, etc.); reviewing financial and management documents; and inspecting facilities of the port and its competitors. Subsequently, he presented a formal report to a meeting of all those involved. The concept he outlined to solve the problem was adopted and is now being implemented to the satisfaction of everyone, especially those who rely on the port for services and livelihoods.

Locating Crab Nurseries

Dungeness crab has been a dominant commercial species among West Coast crustacean fisheries for more than four decades. The ex-vessel value of Washington's crab fishery ranges from $9 million to $30 million annually. In recent years, the fishery has undergone a severe decline, but this may not be permanent; on the West Coast, landings of Dungeness crab seem to cycle widely over 9–12-year periods. Cause of these fluctuations is not known, but habitat loss may be a significant problem.

Estuaries are known to provide protection and food for the young of many marine fishes and invertebrates. Whether they play this role for the Dungeness crab has never been entirely clear. While the adults, including egg-bearing females, are found almost exclusively offshore, the young-of-the-year and 1-year-old juveniles have been found both in offshore waters and in estuaries.

The question of estuaries and Dungeness crab has become a pressing one. Over the years, estuarine habitat has been lost or disturbed by development, and the pressure to develop continues.

Intensive surveys of Grays Harbor estuary and adjacent offshore waters and Port Gardner in Puget Sound have been conducted by University of Washington scientists for three years. They now have evidence that these areas are important nursery grounds for Dungeness crab.

Findings of the Sea Grant research have stimulated further studies which are necessary for sound economic and environmental decisions:

- Corps of Engineers (COE), which is responsible for maintaining navigation channels in Grays Harbor
- Washington Departments of Ecology (DOE) and of Fisheries (WDF) and associations of crabbers and oystermen, who are interested in gauging the extent of crab mortality caused by Sevin applied to the intertidal zone to control burrowing shrimp that disrupt oyster production
- WDF, EPA, COE, DOE, Lummi Tribe, and Padilla Bay National Sanctuary, who collectively wish to assess potential impacts of nearshore projects on juvenile recruitment and critical habitats
- U.S. Navy and COE, who need information about crab habitat in the area of the proposed home port at Everett

Further Information

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HIGH VALUED PRODUCTS FROM WASTE CRABSHELL

An example of the far-reaching results that can be achieved by directing academic research to contemporary concerns can be found in Washington Sea Grant's studies of chitin, a substance found in crabshell, and of a derivative of chitin called chitosan. Researchers followed two very different routes of investigation to develop two patented processes; both have been licensed by private companies, and one product has reached the market.

The Spur for Chitin Research

Chitin is a structural component of the outer shell of shrimps, crabs and lobsters and comprises the outer skeleton of insects and the cell walls of fungi as well. The second most abundant polymer in nature, after cellulose, chitin can be processed to make the deacetylated derivative, chitosan. However, neither the chemical properties nor potential uses of chitin or chitosan were investigated to any degree until a crabshell disposal problem threatened to bury seafood processors.

In 1969, a Seattle company was interested in establishing a pilot plant for producing chitin and chitosan. Supplies of raw material would be ample because of new Environmental Protection Agency regulations that prohibited seafood processors from dumping wastes around plants. Many processors were faced with finding an alternative means of treatment or disposal, or closing down.

Sea Grant's seafood processing specialist learned of the company's plans and put its founders in contact with two groups of Sea Grant researchers. One group was experimenting with chitosan to learn whether it could be used to improve paper processing. Other researchers were developing methods for completely separating seafood meat from shell.

By 1972 the researchers and their students were working in a pilot plant along with company personnel to develop salable products from shrimp and crab processing wastes. But economically viable applications did not surface immediately. More than 10 years of testing and research into new possibilities was required before some of the most exciting uses of chitosan appeared.

Contact Lenses for Injured Eyes

One researcher took up the task of research and development of a contact lens made wholly of chitosan. He succeeded, and the University of Washington was awarded a patent on this use of chitosan in July 1985.

Because it does not adhere to the surface of the eye, the chitosan lens, which is similar in size and flexibility to a soft contact lens, is expected to be an ideal "bandage" for injured eyes and for patients of such eye surgical procedures as cataract removal and radial keratotomy. A private company has licensed this use and is conducting pre-clinical tests, with the expectation that the product will be ready for FDA clinical trials in 1987. If FDA approval is eventually secured, then the lens could be used for the estimated one million interocular lens surgery cases each year as well as for cases of radial keratotomy and corneal abrasion.

Beyond its non-adhesive qualities, the chitosan lens may have inherent wound-healing qualities. Should these prove out in clinical trials, the lens could be a desirable alternative to currently available eye bandage material.

The chitosan lens is transparent. The company plans to test optical characteristics to determine whether it may be useful for correcting vision. If so, a disposable contact lens made of chitosan could be developed.

Chitosan's Bumper Crops

At present, chitosan's widest use—literally—is in the fields of eastern Washington. A Sea Grant researcher at Washington State University found that winter wheat seed treated with the compound yields 10 percent more grain per acre than untreated seed. His laboratory has shown that chitosan treatment helps keep wheat plants erect until harvest, thus reducing losses inflicted by root-rotting fungi which weaken wheat stems.

Chitosan also appears to inhibit the soil fungus that causes root rot. At $1 to $2 per acre, chitosan treatment is more economical than existing chemical preventatives for root rot; these typically cost $7 to $20 per acre, depending on strength and means of application. The research has resulted in:

- In 1986, the commercial planting of 100,000 acres of chitosan-treated wheat in eastern Washington;
- Sales of chitosan by a Seattle company to an Oregon company which converts chitosan into this patented seed treatment;
- Field trials in 1986 of chitosan-treated peas, oats, barley and potatoes.

But the future may belong to work being done at the molecular level. The WSU studies have determined that in peas, chitosan activates specific disease-resistance genes. Conversely, when chitosan is applied to plant pathogenic fungi, gene function is suppressed. Having identified some disease-resistant pea genes whose function chitosan enhances, the researchers have cloned this gene and will attempt to transfer it to other food-plant species, to try to enhance their disease resistance as well.

Already, more has been achieved than could have been dreamed possible by the Sea Grant investigators when they first began to study chitin and chitosan. They could hardly have envisioned any connection with genetic engineering, which had barely reached an embryonic stage at that time. Though we do not yet know the full significance of these molecular discoveries, the potential value for agriculture of finding a simple natural substance that increases disease resistance or enhances growth of many crop plants is by itself incalculable.

Further information

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Wisconsin

The University of Wisconsin Sea Grant College Program is a unique working partnership of federal, state, university and private sectors. Established in 1968, the UW Sea Grant Program reflects "The Wisconsin Idea" in action.

THE INLAND SEAS

Wisconsin's "oceans" are the Great Lakes, and the Sea Grant Program here focuses most of its attention on these inland seas. Headquartered in Madison, UW Sea Grant is a statewide program that conducts research, education and public service activities. Advisory Services field offices are located in Superior, Sister Bay, Green Bay and Milwaukee. More than 150 faculty, staff and students are involved in Sea Grant projects on campuses throughout the state.

THE RECORD

UW Sea Grant's major research efforts include microcontaminants in the Great Lakes, fisheries, aquaculture, diving physiology, Great Lakes policy, and a Green Bay research program. Sea Grant's Advisory Services field agents and specialists provide the essential link between the few who study the lakes and the many who use or manage their resources.

Microcontaminants. Sea Grant scientists are identifying the sources and fates of toxic chemicals in the aquatic environment and predicting how long these compounds will remain a problem in the Great Lakes. UW scientists have identified the atmosphere as a major source of PCBs and other toxic contaminants entering the Great Lakes. Because of concern over health effects on humans who ingest these contaminants by eating locally caught fish, UW Sea Grant is conducting an epidemiological study of pregnant women and babies in the city of Green Bay. The results of such projects allow industry and government to better manage and control discharges of toxic compounds.

Water Resources. Sea Grant researchers have discovered that groundwater may contribute 10 to 15 percent of the water in Lake Michigan—and possibly a significant amount of phosphorus and other nutrients. This information is essential in assessing the impact of landfill waste disposal on both ground and lake water quality, and could potentially improve the forecasts of lake levels. The U.S. Bureau of Mines and U.S. EPA are also adapting the UW researchers' technology to monitor groundwater flow.

Diving. The goal is to make diving safer and easier for sport and professional divers. UW researchers have discovered that the short, deep "bounce dives" often made by sport divers hold a greater risk of paralysis and death than previously believed. Sea Grant scientists are examining psychological factors which may be useful in identifying individuals who are likely to experience panic in underwater emergencies.

Fisheries. A major Sea Grant goal is to enhance Wisconsin's sport and commercial Great Lakes fisheries, which have an estimated annual worth of more than $60 million and $4.2 million, respectively. A computer model to determine predator-prey interactions in lakes has influenced the way Lake Michigan's fishery is being managed. Wisconsin and Michigan have developed forecast schemes and stocking rates based on the carrying capacity of the lake's forage base, and stocking rates for salmon have been reduced. Sea Grant scientists are also working to restore naturally reproducing lake trout populations to the lake and are investigating the economic returns of various lake trout management policies.

Education. More than 270 UW Sea Grant students have received Master's and Ph.D. degrees and have gone on to jobs in the private and public sectors, where they continue to apply the results of Sea Grant research.

THE WISCONSIN IDEA IN ACTION

"The Wisconsin Idea"—that the boundaries of the university are the boundaries of the state—is a strong tradition. UW Sea Grant embodies this philosophy by devoting 25 percent of its resources to education and service programs outside the classroom.

Sea Grant emphasizes public service by sponsoring workshops for commercial and sport fishermen, helping cities and homeowners minimize lakeshore erosion, and producing the popular *Earthwatch Radio* series.

THE GOAL

The resources of Lakes Superior and Michigan are extremely valuable to the people of Wisconsin. The lakes provide high quality water for coastal residents and industry and offer abundant recreational opportunities. The lakes also mean jobs for commercial and charter fishermen, shipbuilders, dockworkers, sailors, recreational businesses and others.

The UW Sea Grant College Program is dedicated to protecting and enhancing these resources, which are of vital importance to the economy and quality of life in Wisconsin.

For more information:

Sea Grant Institute
University of Wisconsin–Madison
1800 University Avenue
Madison, WI 53705
(608) 262–0905

The University of Wisconsin Sea Grant College Program has played a vital role in the rebirth of the Great Lakes fisheries—fisheries that were nearly destroyed by overexploitation, the invasion of alien species of fish and pollution in the first half of this century.

THE FISHERY TODAY

Virtually nonexistent just 20 years ago, the Great Lakes sport fishery in 1985 was valued at $1.4 billion. The Great Lakes also support a small but active commercial fishery with a dockside catch valued at $41 million a year. The rebirth of this fishery has been responsible for the economic revival of hundreds of Great Lakes coastal communities.

However, the fisheries of the Great Lakes could not exist without continuous control of the parasitic sea lamprey. Many native species have been lost, and the sport fishery is now largely dependent on hatchery-raised and stocked exotic species like coho and chinook salmon. The carrying capacity of the forage base is in question. Use of the resource is constrained by microcontaminants like PCBs in some of the larger fish. Balancing commercial and sport harvests remains a difficult policy issue.

Despite these problems, our understanding of the Great Lakes ecosystem, particularly the fisheries, has reached the stage where scientists are asking the right questions and management of the fisheries is entering a new and enlightened phase.

PROVIDING ANSWERS

University of Wisconsin Sea Grant researchers have taken a leadership role in establishing new directions for Great Lakes fishery management by providing:

An Ecosystem Approach to Fishery Management. The Lake Michigan ecosystem is undergoing rapid and dramatic changes. The exotic alewives, the principal forage fish for stocked salmonids, have declined sharply. Stocks of native species like the bloater chub and yellow perch are rebounding. Changes of such magnitude require precise, up-to-date information on the structure, function and interactions of the fish community for effective management.

It is now apparent that the reduced nutrient loading into the lakes and the effects stocked salmonids are having on the food web have resulted in water quality improvements. Water clarity during summer months and fishing in Lake Michigan are better than they have been in at least 60 years. Similar developments could occur in Lakes Superior, Huron, Erie and Ontario as stocking rates increase there. Sea Grant researchers continue to uncover the mechanisms by which these changes have occurred and the extent to which they can be controlled.

Fishery Management Tools. UW Sea Grant scientists have developed a prototype model of Great Lakes predator-prey interactions, which Wisconsin and Michigan fishery managers are now using to make stocking decisions based on trends in the forage base. Wisconsin scientists are also coordinating the first Great Lakes-wide survey of the diets of stocked salmon and trout to establish a baseline for monitoring the predator-prey system.

Another UW Sea Grant model is being used to guide the development of a cost-effective sea lamprey assessment program in Lake Ontario. Wisconsin researchers have also shown that fishery managers can use the early life history of fish like bloater chubs to forecast future populations and set catch limits. Sea Grant whitefish population models for Green Bay and northern Lake Michigan have also been used by management agencies to regulate the commercial whitefish fishery. Researchers are also working to restore naturally reproducing lake trout populations in the Great Lakes and are evaluating the economic returns of various lake trout management policies.

Contaminants and Fish. University of Wisconsin scientists are identifying the sources and fates of toxic chemicals in the aquatic environment and predicting how long these compounds will remain a problem in Great Lakes fish. UW scientists have identified the atmosphere as a major source of the PCBs and other toxics in the Great Lakes. Because of concern over health effects on humans who ingest contaminants in the fish, Sea Grant is conducting an epidemiological study of pregnant women and babies in the city of Green Bay. Sea Grant is also distributing information to the public on how to minimize the intake of contaminants by properly cleaning and cooking the fish. Such research has allowed industry and government to better manage and control discharges of toxic compounds.

Fishery Enhancement. UW Sea Grant Advisory Services field agents have conducted marketing workshops for the economically important charter fishing industry. Advisory agents are also working with Green Bay commercial perch fishermen to determine the best net mesh size to reduce mortality among sublegal fish. Sea Grant scientists have worked with the commercial fishing industry to develop better storage and packaging techniques.

THE FUTURE

The future of the billion-dollar fishery of the Great Lakes depends on enlightened management and continued, coordinated research on all facets of the Great Lakes ecosystem. Management agencies like the Wisconsin Department of Natural Resources, the U.S. Fish and Wildlife Service and the Great Lakes Fishery Commission, and advisory groups like the International Joint Commission, all rely on the research results and scientific expertise of the University of Wisconsin Sea Grant College Program.

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4. Regional and National Projects

Descriptions of five regional Sea Grant projects and of the National Sea Grant Depository and the related *Sea Grant Abstracts*

- New England
- Mid-Atlantic
- Southeast
- Great Lakes
- Pacific Rim
- National Sea Grant Depository

The New England Sea Grant Network

Massachusetts Institute of Technology
Woods Hole Oceanographic Institution
University of Maine
University of New Hampshire
University of Rhode Island
University of Connecticut
State University of New York
Cornell University

The New England Sea Grant Network cooperates in solving regional marine problems, and coordinates programs and activities in support of the regional marine industry.

Recently, the network . . .

. . . **established the Aquatic Animal Health Laboratory at the University of Maine.** The new lab is a resource for New England mariculturists, aquaculturists, lobster pound owners, bait fish dealers, fishermen, and universities, performing tests required by the government for the certification of seed stocks, and diagnosing and prescribing cures for aquatic animal diseases.

. . . **developed a shrimp separator trawl for the New England fishery** which eliminates 90-95 percent of juvenile fish trapped in shrimping nets and retains 90-95 percent of adult shrimp. New England fishermen were trained in the use of the trawl at the Naval Ship Research and Development Center in Maryland, where design of the net was perfected.

. . . **established a routine monitoring system, the first in the U.S., for diarrhetic shellfish poisons (DSP),** believed to be the cause of gastrointestinal reactions in humans from eating shellfish. Researchers are mapping areas along the New England coast where DSPs are present.

. . . **demonstrated to New England fishermen, through training courses** at the Navy's Ship Research and Development Center (NSRDC) in Maryland, how their nets behave underwater and how gear changes affect that behavior. Net manufacturers also perfected trawl designs using the NSRDC's sophisticated circulating water channel.

. . . **developed computerized hydrodynamic and dispersion models** to trace the movement of pollutants in estuaries and harbors. The models have been used throughout the region to, for example, locate sewage outfall pipes, position offshore breakwaters, and site spawning sanctuaries. Updated and improved versions of the models are now being distributed to consulting firms involved in the clean-up of Boston Harbor, where pollution is a grave problem.

. . . **trained public health personnel in four Northeast states in the identification of cysts** of the microbe in red tide that is responsible for paralytic shellfish poisoning (PSP), a potentially fatal illness caused by eating affected shellfish.

. . . **established the Northeast Marine Advisory Council (NEMAC),** in which Sea Grant and other institutions work cooperatively to coordinate and share marine information and research results and improve regional marine advisory services.

. . . **acquainted home economists with the New England seafood industry.** Home economists from throughout the region attended a "fish school" to learn about the variety of products of the seafood industry, market structures, and proper handling, storage, and preparation of various food species.

The Mid-Atlantic Sea Grant Network

From the slender finger of Long Island down to the sandy Carolina capes the Mid-Atlantic's coastal waters support numerous important marine industries, including commercially valuable fisheries. The Mid-Atlantic region is dotted with large estuaries and sounds — Great South Bay, Barnagett Bay, Chesapeake Bay, Albemarle Sound. Some of these embayments are among the richest seafood grounds in the world.

The Mid-Atlantic region also supports some of the most populated watersheds in the nation. Demand for the region's marine resources runs high, and a number of fishery stocks are facing serious decline. At the same time, there are new opportunities available thanks to developments in technology — opportunities that could help invigorate the region's marine economy.

Regional Cooperation

To help address the problems and opportunities of the Mid-Atlantic, Sea Grant programs work together in a regional network to share research results and practical information. The Sea Grant institutions in the region include: The New York Sea Grant Institute, The New Jersey Marine Sciences Consortium, The University of Delaware Sea Grant College Program, The Maryland Sea Grant College Program, the Virginia Sea Grant College Program, the University of North Carolina Sea Grant College Program, and the South Carolina Sea Grant Consortium.

Cooperative efforts often involve researchers, educators or extension specialists from a number of the region's Sea Grant programs. Here are some examples of recent regional issues:

- *Soft-Shelled Blue Crab Systems.* Blue crabs bring a better price as soft shells, but mortality rates can be high in shedding tanks. Researchers and specialists in the Mid-Atlantic region, working with their counterparts in the Gulf region, have devised better closed-system crab shedding tanks and better means for monitoring water quality. Extension agents have helped alert others to these new techniques through workshops, demonstration projects and publications.

- *Finfish and Shellfish Aquaculture.* To help expand our capabilities for raising finfish such as striped bass — in many places a species under heavy fishing pressure — specialists have traveled across state lines to share their knowledge about brood stocks, spawning, nutrition and survival rates. Much of this aquaculture work has focused on hearty striped bass hybrids which can grow faster and larger. Other aquaculture research focuses on valuable shellfish, such as clams and oysters, while related efforts turn new attention to previously underutilized species.

- *Coastal Development.* Sea Grant-supported engineers have helped design solutions for problems in the coastal zone, such as shoreline erosion and beach migration. Sea Grant programs in the region have also helped advise those, such as commercial fishermen and recreational boaters, whose lives and livelihoods could be threatened by severe weather — especially hurricanes — about how best to avoid personal danger and devastating damage.

- *Estuarine Research.* Because the Mid-Atlantic boasts a number of important estuaries, including the Delaware estuary and the nation's largest estuary, the Chesapeake Bay, regional programs share research results in such areas as nutrient processes and analyses of areas of low dissolved oxygen. Other regional research focuses on habitat and species important to coastal and estuarine fisheries, such as the blue crab. These studies help us understand the fundamental functions of estuaries, especially as valuable nurseries and feeding grounds.

Such cooperative efforts help expand the talents and experience of any one program well beyond state boundaries to solve difficult problems and to exploit emerging opportunities along the Mid-Atlantic coast.

For More Information

For more information about Sea Grant programs in the Mid-Atlantic region call:

New York Sea Grant Institute
(518) 436-0701

New Jersey Sea Grant Program
(201) 872-1300

Delaware Sea Grant College
(302) 451-8062

Maryland Sea Grant College
(301) 454-5690

Virginia Sea Grant College
(804) 924-5965

University of North Carolina
(919) 737-2454

South Carolina Sea Grant Consortium
(803) 795-9650

The Southeast Sea Grant Network

The Southeast Sea Grant Marine Advisory Service (SESGMAS) Network

The SESGMAS Network is one of 5 Sea Grant Networks in the United States that are used to pool regional expertise and resources to solve state, regional, and national problems. The Southeast Sea Grant Marine Advisory Service (SESGMAS) Network covers the 8 states from North Carolina through Texas and the Commonwealth of Puerto Rico. Through this network, publications, research, personnel, and audio visual materials can be shared by each of the states in the network and/or with any other Sea Grant state in the nation.

The Network allows business, constituent groups, or private citizens in the region access to regional Sea Grant expertise without having to go to each individual member. The Network also allows resources to be shared that might be difficult for one program to afford. The following are examples of this resource sharing and cooperation that makes the SESGMAS Network such a viable system.

PERSONNEL SHARING

By sharing personnel the SESGMAS Network can hold down manpower costs. The Georgia Sea Grant Program recently hired Duncan Amos, a commercial fisheries expert from the University of Rhode Island, who is available to the entire Network as a specialist. He is one of the first regional specialists hired by a Sea Grant regional group, and will be available to state programs who need his expertise without the cost of hiring a full time employee. By sharing expenses, the Georgia program gets a full time specialist at reduced costs.

INDUSTRY ASSISTANCE

A current example of industry being able to access regional expertise was the Workboat Show '86 in New Orleans, where SESGMAS coordinated all the educational workshops for the commercial fishing industry programs. The Network arranged the speakers, materials, and displays on specific projects and areas of interest such as safety equipment, marine paints, boat electronics, oyster depuration, insurance, and trawling efficiency. This allowed fishermen from the entire Gulf area to meet with commercial fishing experts from the entire Southeast, and nationally in some cases.

In the summer of 1986 the SESGMAS Network met with the Marine Retailers Association of America in Atlanta during their regional meeting. By tying the Network's and the Association's regional meetings together, the Sea Grant programs were able to locate areas where the industry might need specific help, such as educational programs at the trade show for the members of the industry.

TECHNOLOGY TRANSFER

With computer use on the rise, the ability to make large amounts of useful data available has improved greatly. The SESGMAS Network has taken advantage of this technology and begun using computers and the associated software for several applications which are being shared among the member states. Alabama has made a net "hang" guide available to recreational and commercial fishermen who have personnel computers. Now constituents can access up-to-date material whenever they need it.

Florida is currently developing a Marine Data Base that will have current weather forecasts and information as well as the Gulf Stream location, which is essential for fishermen and commercial vessel operators. This information function can also be reversed; coastal boaters can send weather observations back to the National Weather Service through their computers. These observations will then be used to correct forecasts and improve NWS weather models.

Several SESGMAS members are developing computer software that can be used by constituents to better manage their business. Texas has recently developed a program that will allow fishing tournament directors to run more efficient tournaments and keep better records. Louisiana is keeping a listing of the different programs from across the country so that constituents can know what is available to them. Other programs cover such areas as aquaculture potentials, and commercial fishing cash flow analyses.

Videotapes are becoming very popular as teaching tools and the network is currently developing ways to get workshops recorded so that constituents can view them at home at their own pace. The popular Shrimp Trawl (new 1985) movie made by Georgia Sea Grant and the National Marine Fisheries Service, which shows actual fish nets underwater, is now being distributed in several states as a VHS recording suitable for home viewing.

RESOURCE CONSERVATION

The SESGMAS Network, both as individual states and collectively, supports the conservation ethic as a major premise in resource management. Several projects are currently underway to show fishermen how to use the resource without devastating it.

North Carolina Sea Grant, in conjunction with NMFS, is putting together a program to introduce fishermen to underutilized species that have the same game and taste characteristics as the fish they are currently overfishing. Three examples of these underutilized species are jack crevalle, skate, and spade fish.

All the states in the Southeast and Gulf have sea turtles that migrate during certain fishing seasons, some of which used to be caught in fishing nets and drowned. The National Marine Fisheries Service (NMFS), in cooperation with the SESGMAS, has placed Turtle Excluder Devices (TED's) on fishing vessels for testing, and suggested improvements which have been incorporated into new designs. Not only has the device worked to keep out turtles, but it has also helped to cut down on an unwanted bycatch of finfish. It also helps increase fuel efficiency by relieving the weight in the fish net that must be towed.

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The Great Lakes Sea Grant Network

The Great Lakes Sea Grant Network includes programs in Illinois–Indiana, Michigan, Minnesota, New York, Ohio and Wisconsin. Major issues confronting the Great Lakes today involve the fishery, economic development, high lake levels and shore erosion, and the contaminants problem.

SEA GRANT AND THE GREAT LAKES

Sea Grant has the capacity and a strong commitment to transfer the results of university research to a wide range of audiences and to give special assistance to local communities and individuals. Through its network of advisory agents and the use of modern communication and education techniques, the Great Lakes Sea Grant Network supplies the region with usable solutions to pressing problems and provides the basic information needed to better manage the Great Lakes for both present and future generations.

The Fishery. Practically nonexistent just 20 years ago, the Great Lakes sport fishery in 1985 was valued at $1.4 billion. A small but active commercial fishery has a dockside catch valued at $41 million annually. Management of the fishery is plagued by uncertainties about predator-prey interactions and the stability of key fish populations.

Scientists from all six Great Lakes Sea Grant programs and the Province of Ontario recently conducted the first Great Lakes-wide survey of the diets of stocked salmon and trout. This effort helped establish a critical baseline for monitoring salmonid diet shifts.

Sea Grant scientists have also developed and are refining microcomputer models of the bioenergetics and predator-prey interactions of key Great Lakes fish. Fishery management agencies are now using this valuable new tool to take into account the forage base carrying capacity of Lake Michigan in making their salmonid stocking decisions.

Sea Grant research on the life history of the commercially valuable lake whitefish populations in Lake Michigan and Green Bay has also helped fishery managers better forecast whitefish yields.

Economic Development. The boom in the Great Lakes fishery has been echoed by tremendous growth in charterboat fishing, marinas and hospitality enterprises.

The 1985 Sea Grant Great Lakes Charterboat Fishing Workshop revealed that the number of Great Lakes charter fishing boats has increased tenfold over the last decade and now totals more than 2,400 boats.

Every Sea Grant program in the Great Lakes network has been conducting regular conferences and marketing workshops for charterboat captains. Sea Grant surveys and studies have provided basic information about and for this new industry to local and state agencies and operators alike.

Information about the thermal zone preferences of valuable predator species was used with great success by more than 90% of Lake Ontario's charter fishing businesses and led to the creation of a new, offshore rainbow trout fishery that has had a $2 million economic impact on lakeshore counties.

Sea Grant research detailing the tourism potential of the Lake Superior region enabled developers to procure private financing for a large restaurant and lodging complex in an economically depressed area. Sea Grant efforts were also instrumental in the establishment of four underwater Great Lakes bottomland preserves in Lakes Huron and Superior. Surveys have shown that the thousands of tourists who visit these sites spend millions of dollars in adjacent coastal communities each year. Sea Grant has also worked with the McDonald's Corporation to develop a nature walk and "McDock" at a new McDonald's restaurant on Lake Erie's Sandusky Bay.

Coastal Erosion. The water levels of all the Great Lakes except Ontario have exceeded the record highs of the past 125 years, and all the lakes are likely to remain high for several years. In the last few years, erosion and flooding from storm surges along the 4,500 miles of U.S. Great Lakes shoreline have caused hundreds of millions of dollars damage to lakeside homes, communities and facilities—despite large expenditures by coastal homeowners and local communities to protect their property.

Working together, Sea Grant agents, coastal engineers and communications specialists throughout the region have spearheaded efforts to warn and advise coastal communities and homeowners of the immediate threat of high lake levels. These efforts have included workshops and publications on what can—and cannot—be done to protect private and public investments in coastal property and structures. As a result, many communities and homeowners have already taken steps to prepare for floods and to reduce losses due to shore erosion.

Microcontaminants. First it was DDT and dieldrin, then PCBs and mirex, toxaphene and dioxins. These toxic substances pose a threat to both the vitality of the fisheries and the health of the region's people.

Great Lakes Sea Grant scientists are national leaders in determining the sources, transport, environmental fate and human health effects of a wide range of contaminants. They are also studying how the basic structure of whole classes of toxic substances may be related to their environmental behavior and health effects. Such research has allowed industry and government to better manage and control the discharge of toxic substances.

Sea Grant is also a leading source of information about the contaminants problem and ways people can minimize their risk of exposure when eating Great Lakes fish.

The Pacific Sea Grant Network

THE PACIFIC SEA GRANT COLLEGE PROGRAM—FORGING LINKS IN THE PACIFIC

The Sea Grant programs of the Pacific states—Alaska, California, Hawaii, Oregon and Washington—work cooperatively to achieve sound management and utilization of the vast resources of the Pacific.

The regional network organized by these programs, known as the Pacific Sea Grant College Program (PSGCP), provides coordination and support for major activities, including conferences, research, training, and talent sharing.

Recent Activities

- In June 1984, California Sea Grant in cooperation with the other PSGCP states sponsored an international workshop on the taxonomy of commercially important seaweeds in the Pacific and Caribbean. Participants included scientists from Taiwan, China, Japan, Chile, Guam, New Caledonia, and the United States. As a result, California Sea Grant published a taxonomic guide. And, at the suggestion of China's Academia Sinica, it co-sponsored a second taxonomic workshop, held in China in September 1986.

- "Seafood—Harvest the Profits," a series of 30 retailing seminars sponsored by the Washington Sea Grant Program under a grant from the Alaska Seafood Marketing Institute, was presented in 16 West Coast cities from San Diego to Fairbanks in 1985-86. The seminars demonstrated the basics of seafood handling, merchandising, quality evaluation, and sanitation to over 1,000 retailers. Additional assistance for the seminars was provided by PSGCP, the National Fisheries Institute, the Food Marketing Institute, the California Fisheries Association, the Northwest Fisheries Association, and the West Coast Fisheries Development Foundation among others.

- A conference on sharks was held in Portland, Oregon in October 1985. Titled "Sharks: An Inquiry into Biology, Behavior, Fisheries, and Use," it sought to promote the development of commercial and recreational shark fisheries on the West Coast.

- A workshop was held in Portland, Oregon in February 1985 to address the misuse of economic impact data when analyzing fishery management options. The meeting was co-sponsored by PSGCP and the Pacific Fisheries Management Council. Participants included university and agency economists, Marine Advisory staff from Alaska, Washington, Oregon, and California, fishing industry and harbor district representatives, and Council members.

- Among numerous examples of talent-sharing, a Washington marine advisory specialist spoke to the Alaska Harbormasters Association; communicators from California and Wisconsin were invited to evaluate communications efforts in Hawaii; a University of Washington School of Fisheries faculty member provided advice to the Alaska Oyster Growers Association; and a University of Washington expert in vessel stability met with supervisors of university research vessels in California.

- Research projects being supported by members of PSGCP appear in a Project Directory, which was compiled by Alaska Sea Grant. PSGCP member programs also fund some cooperative research. The Alaska and California Sea Grant programs are, for example, examining the rapid decline in stocks of Alaskan red king crab. Also, a proposal by whale researchers from the University of Hawaii is being funded by the Alaska and Hawaii programs.

- Programs in Hawaii and California will hold a forum on risk management in waterfront and open water areas; and the Alaska, Oregon, and California Sea Grant programs are cooperatively organizing a conference, to be held in Washington, D.C. in February 1987, on the marine insurance crisis.

- An education needs assessment meeting, held in February 1985 by the California Sea Grant College Program, included participants from Hawaii and Guam. Participants sought to determine how educators in California and the Pacific Rim might become more knowledgeable about marine education activities in the region.

- California Sea Grant has worked cooperatively with the University of Hawaii for the past several years to sponsor training workshops for science teachers from the U.S. trust territories in the Pacific.

- Advisory personnel from the Oregon, Washington, and University of Southern California Sea Grant programs are developing curricula for managers at small and middle-size ports. In addition, specialists from Alaska, California, and Washington participated in various port management studies organized by an Oregon Sea Grant marine economics specialist. These studies provided recommendations for improvement in the areas of management, finance, accounting, and public relations for small ports in Oregon, Washington, and California.

- At the most recent meeting of PSGCP directors and key staff, held in La Jolla, California in August 1986, discussion topics included international science cooperation in the North Pacific and Bering Sea, talent-sharing, joint research topics, and networking in the Pacific Rim.

For information about Sea Grant programs in the Pacific region call:

Alaska Sea Grant College Program
(907) 474-7086

California Sea Grant College Program
(619) 534-4440

USC Sea Grant Program
(213) 743-6068

Hawaii Sea Grant College Program
(808) 948-7031

Oregon State University
Sea Grant College Program
(503) 754-2714

Washington Sea Grant Program
(206) 543-6600

THE NATIONAL SEA GRANT DEPOSITORY

The National Sea Grant Depository

The **National Sea Grant Depository (NSGD)** is an information center that provides access to all publications generated through the National Sea Grant Program. Established at The University of Rhode Island's Pell Marine Science Library in 1970, the NSGD collection is available to all who are interested in America's oceans, its Great Lakes, and its coastal zone.

Scope

The publications housed in the Depository cover a wide variety of marine-related subjects. These include aquaculture, mineral resources, law and socioeconomics, fisheries, biomedicinals, ocean engineering, coastal zone management, marine education, marine recreation, and applied oceanography.

Holdings

The Depository collection comprises technical reports and journal reprints produced by Sea Grant-funded researchers; newsletters, annual reports, and marine advisory reports; a variety of manuals, guides, directories, bibliographies; and maps, charts, and atlases.

Services

All publications in the Depository are available for a one-month loan. The loan limit is 15 documents. Personal copies are obtainable from the originating Sea Grant Program.

A data base of over 22,000 citations is available. On-line literature searches, using keywords or authors, can be conducted on any marine-related topic.

Telephone, mail, and interlibrary loan requests are welcome.

Publications

Sea Grant Abstracts is a quarterly publication (produced by Woods Hole Data Base, Inc., in cooperation with the NSGD) which abstracts Sea Grant documents received by the Depository. Its primary purpose is to advise readers of the availability and acquisition procedures of publications generated by the National Sea Grant College Program. Abstracts are arranged by subject discipline to facilitate browsing.

For further information on the National Sea Grant Depository, please contact:

National Sea Grant Depository
Pell Library Building
The University of Rhode Island
Narragansett Bay Campus
Narragansett, RI 02882-1197

(401) 792-6114

5. Sea Grant Contributions to the National Interest

Five areas where Sea Grant is making an impact on matters of broad public interest

- Marine Biotechnology
- Exclusive Economic Zone
- Coastal Development
- Balance of Trade
- Seafood Industry

SEA GRANT CONTRIBUTIONS TO FIVE AREAS OF NATIONAL INTEREST

Within the span of only two decades the Sea Grant institutions have built a remarkable network—one that is capable of focusing the diverse talents and resources of these universities on national needs and opportunities, and one that is capable of achieving this feat on a timely basis.

The effectiveness of the Sea Grant network is amply demonstrated by the following articles which describe five areas where Sea Grant is making an impact on matters of broad public interest.

SEA GRANT—AT THE FOREFRONT OF MARINE BIOTECHNOLOGY

Biotechnology, the use of biological systems for the production of goods and services, is making exciting contributions to medicine, agriculture, and industry—largely from work with terrestrial organisms. But the ocean can also be a source of new biological materials and processes, as Sea Grant research is demonstrating.

Drugs and Other Marine Products

Sea Grant researchers working in Hawaii, California, Texas, and New York have isolated from marine organisms substances with potential value as painkillers or as anti-inflammatory, anticancer, or cardiovascular-active drugs. One such compound with pharmaceutical potential is called pseudopterosin. Derived from a sea coral, it is more potent than commonly prescribed anti-inflammatory drugs and may one day be used to treat degenerative diseases such as arthritis.

A blue-green alga from Minnesota waters has been found to contain a potential herbicide—toxic to certain aquatic and terrestrial weeds but harmless to other plants and fish. At MIT, a substance that inhibits the vascularization of solid tumors has been isolated from shark cartilage. And New Jersey Sea Grant research on the blood of the primitive, armor-plated horseshoe crab has identified a protein useful in measuring vitamin B12 in humans. A test kit is now being devised for clinical use. The method could replace the current reagent for vitamin B12, which costs thousands of dollars per milligram.

Several high-valued uses have been found for chitin, a component of the crab and shrimp shell wastes that cause disposal problems for seafood processors. Sea Grant research in Washington state has shown that a derivative of chitin—called chitosan—can be applied to wheat seeds to reduce crop losses caused by root rot. This use was patented, and in 1986 Washington farmers planted 100,000 acres of chitosan-treated wheat. At the molecular level, the compound appears to activate disease resistance in peas.

Two other patented chitosan uses are targeted for commercial production: Washington Sea Grant research led to development of a contact lens made wholly of chitosan. Non-adhesive, the lens is ideal for eye-surgery patients and is undergoing preclinical trials. And chitin sutures, which are non-allergenic, strong, and can be absorbed by the body, have been developed by Delaware researchers.

Mississippi-Alabama Sea Grant researchers have developed controlled-release herbicide systems that bond small, mobile herbicide molecules to large chitin molecules. These systems decrease the amount of herbicide needed and thus the likelihood of harm to the environment. Other important work on chitin is being done in Alaska, California, and Virginia.

A bacterium called LST, newly isolated from oyster spat tanks by Delaware scientists, promises—with the help of biotechnology—to provide a number of diverse products, such as a powerful attractant to oyster larvae, food additives, and waterproofing materials.

Aquaculture and Fisheries

The aquaculture of marine fish and shellfish is still largely a matter of farming "wild" organisms. But Sea Grant research in biotechnology is bringing several important species under greater control. In California, researchers have identified a hormone that stimulates abalone to spawn and are now working to clone the genes for abalone insulin, which promotes growth in this highly valued, slow-growing species.

Oyster growers in the Northwest sell little product in summer, when the bivalves are in unappetizing spawning condition. Sea Grant research in Maine and in Washington state has led to oysters that will be marketable year round. These "triploid' oysters, which have an extra set of genes and are sterile, should be available in West Coast cities in 1987.

In Maryland, Sea Grant scientists are using recombinant DNA techniques to increase the growth rates of striped bass, white perch, and carp. They have made strides in cloning trout growth hormone, which may find use in increasing hatchery production or improving the timing of releases to streams.

Detection of Microorganisms and Toxins

Two powerful detection tools developed through biotechnology are monoclonal antibodies and DNA probes. Monoclonal antibodies have been used by Hawaii Sea Grant researchers to detect a toxin in fish tissue—ciguatoxin—which can harm humans eating the fish. Researchers in Oregon are using monoclonal antibodies to diagnose IHN and BKD, two salmonid diseases that kill millions of fish each year. At MIT, Sea Grant researchers are developing a DNA probe to detect sewage coliform bacteria in coastal waters. And in Texas, Sea Grant researchers are working to develop a rapid detection technique for hepatitis-A virus and human rotavirus in estuarine environments.

Mineral Scaling

The crystallization of minerals on the inner surfaces of cooling systems, pipes, and boilers used in industry is costly in terms of preventative treatment, maintenance, and equipment replacement. Major U.S. chemical companies alone supply, worldwide, more than $1 billion in water treatment chemicals yearly. Researchers with South Carolina and Mississippi-Alabama Sea Grant discovered compounds in oyster shell and marine algae that form the basis for new, nontoxic biodegradable preventatives of mineral scaling. The new compounds make traditional treatments cheaper and more effective.

Sea Grant's biotechnology commitment is yielding these results of fundamental scientific and economic value, and also, through graduate training, is ensuring a supply of skilled individuals for this promising area of research.

SEA GRANT—EXPLORING THE EXCLUSIVE ECONOMIC ZONE

In 1983, the United States acquired a vast new frontier—an undersea domain nearly twice as large as its land area—the U.S. Exclusive Economic Zone, or EEZ.

Proclamation of the EEZ gave the nation sovereign rights over all resources within 200 miles of its shores. Now the nation's job is to explore this frontier: to determine the extent of its resources and how these can be used wisely.

How resource rich is the EEZ? We know, of course, that major deposits of oil and gas lie off U.S. coasts. In fact, Sea Grant programs in Massachusetts, California, Ohio, and Maine/New Hampshire, among others, have worked for many years on petroleum-related research to learn, for example, which geological features are associated with oil deposits and how to make offshore drilling platforms safer.

We know, too, that there is a wealth of life off our coasts. The United States now controls about one-fifth of the world's edible fish! Because of the importance of these resources, Sea Grant invests more in fisheries research than in any other research area.

But our vision of the potential resource wealth of the EEZ is rapidly expanding, with important contributions from Sea Grant.

Mineral Deposits

One of the main reasons why the U.S. proclaimed the EEZ was to obtain clear rights to strategically important seabed minerals. Deposits of black sands, for example, are rich in the metals chromium and titanium. Sea Grant scientists in Oregon have found that the annual cycle of tides concentrates these mineral-rich black sands at the back of beaches, and have also determined where deposits are most likely to form. Their work should help geologists find similar deposits on submerged beaches off our coasts.

The discovery of mineral-rich deposits in the form of nodules and seabed crusts in the central Pacific makes ocean mining and processing a potentially important economic activity for Hawaii and the nation.

Sea Grant researchers in Hawaii have been studying potato-sized lumps of minerals from the deep ocean floor called cobalt-manganese nodules. They have developed techniques for extracting metals from the nodules and for separating the metals from each other. Other Hawaii scientists have studied the potential economic and legal aspects of processing nodules in a number of Pacific Rim nations. Their work will allow U.S.-based business consortia to evaluate political and economic risks before siting plants.

Still other Sea Grant scientists are studying cobalt-manganese crusts found on Hawaiian seamounts. These will be much more economical than manganese nodules to mine and are clearly located within the U.S. EEZ. Meanwhile, in California, researchers have been developing detectors for cobalt in nodules and crusts.

Within the last decade, mineral deposits called metallic sulfides have been discovered on the ocean floor. A result of volcanic activity on the ocean floor, the deposits have been found to occur in mounds around newly discovered hot springs called "vents."

Little is yet known about these vents, but, with partial support from Washington Sea Grant, U.S. oceanographers have tested monitoring instruments at a vent off British Columbia. Their prototype seafloor observatory measured the chemistry, temperature, and rate of flow of superheated, mineral-rich water issuing from the vent. Meanwhile, a time-lapse camera recorded mineral deposits forming alongside the vent. The scientists see the need to have observatories at a number of vents. Observing these processes at a number of sites along the ridge systems on the seafloor will aid in understanding the formation of ore deposits and the chemical composition of the world's oceans.

Scientists at the University of Hawaii have a unique laboratory—seabed volcanoes. They are using a number of techniques, including a submersible vehicle, to study geothermal systems of young volcanoes on the south flanks of the island of Hawaii. Rock dredges and a core sample they have taken from the undersea volcano Loihi suggest the presence of metal-rich mineral deposits.

Phosphorite for Fertilizer

Phosphorite is used to make fertilizer. But U.S. land deposits of this critical mineral are expected to be unavailable within 20 years. So Sea Grant scientists are studying the giant resources that exist off the nation's east and west coasts and on several Pacific seamounts.

Researchers have studied the distribution of deposits off California. Others are mapping the continental shelf off North Carolina, looking for areas where both phosphate and heavy mineral deposits are found. Still others from North Carolina are studying the formation of phosphate rocks—their work has led to a model for the formation of phosphorite deposits around the world.

Policy Issues

Wise development of the EEZ will involve economic, legal, and political issues, which Sea Grant programs from Wisconsin to Louisiana are bringing to the attention of policy makers. For example, Woods Hole scientists are making a comprehensive study of the economic and policy aspects of the EEZ's mineral potential, including where mineral deposits

are likely to occur and in what quantity, the factors affecting timing of development, and environmental impacts. Early results of their work have been presented to Congress.

Our planet's land-based resources are limited. As we head into the 21st century, we will increasingly look to the U.S. EEZ for resources. Sea Grant is among those in the forefront of the exploration of our nation's new frontier.

SEA GRANT–STEWARD OF THE COUNTRY'S COASTS

Since explorers first raised the New World out of the sea's empty horizon, we have been a nation concentrated on the coast. By the year 2000, some predict, three-quarters of our population will live within seven miles of a coast, whether the Atlantic or Pacific, the Great Lakes or the Gulf of Mexico.

The Sea Also Rises

Even as we live and work by the sea, it is changing. It appears that the sea is now rising at a rate of 33 centimeters per century—more than double the 15-centimeter rise witnessed early in the 1900s. Sea Grant researchers are monitoring that rise and determining its effects on coastal communities.

In Maine, geologists are tracking the movement of sediments, now and in the distant past, to determine the character of the changing coast. In Delaware, researchers track changes by analyzing the evolution of tidal marshes. In Florida, Massachusetts, Rhode Island, New Jersey, South Carolina, Texas, and elsewhere, Sea Grant is helping to map the effects of erosion and accretion on the shape of the coast, in some cases warning builders about the dangers of construction in unstable coastal areas.

In recent years the Great Lakes too have risen, if for different reasons. In four out of five lakes, according to a Wisconsin Sea Grant report, lake levels are above the century-long record. In Wisconsin, Michigan, and Minnesota, coastal engineers have issued warnings and advice about floods and erosion caused by record-setting water levels.

Protecting the Shore

After a northeaster lashed the mid-Atlantic in the 1960s—pounding the shore with tides nine feet above normal and waves over 20 feet high and causing $125 million worth of damage—Delaware Sea Grant engineers focused their attention on techniques for preventing shoreline erosion. Bulkheads, they found, can sometimes be the worst form of erosion control.

Similar stories have come in from other parts of the country. Oregon researchers, for example, used wavetank models to show how seawalls can increase erosion by setting up violent currents and wave action. Offshore breakwaters, it appears, are often more effective.

Shoreline development everywhere pits manmade structures against the formidable powers of the ocean. Sea Grant researchers in Florida and California and at MIT are investigating the makeup of reinforced concrete used in bridges and a variety of sea structures and evaluating the properties of fiber and polymer-modified concrete, as well as welded steel, to increase their usefulness in a coastal environment. Engineers at MIT have even improved methods for underwater welding.

In California, Sea Grant scientists are studying the combination of ocean and weather factors that causes sea levels to exceed predicted high tides, sometimes causing devastating storm damage to coastal structures.

Making the Most of a Good Thing

The challenge of the coast does not stop at the water's edge, as America's booming boating business reveals. A study by Rhode Island Sea Grant, in cooperation with 26 other Sea Grant programs, has identified 10,000 marinas around the nation. In virtually every coastal state, Sea Grant's marine agents have helped marinas confront problems ranging from winter ice to zoning problems to pier construction.

In some areas vacant warehouses and rotting commercial piers prevent easy (or pleasant) access to the water. In Oregon, Sea Grant specialists have brought together city administrators, businessmen, and others to help explore potential for breathing new life into old waterfronts. In Virginia, specialists have worked with national waterfront associations to tackle problems facing the marine trades industry and advised local communities about money-making riverside festivals and tourism.

To help improve residential areas, Florida Sea Grant specialists developed canal construction designs that actually increased property values because of better flushing and cleaner water.

Managing Bays and Backwaters

In America's estuaries, where fresh water meets the salt sea, there teems a seafood bonanza—more seafood per square mile than in the open ocean. But these areas serve us in other ways as well, especially as highways and drainage basins, and they feel the brunt of runoff from some of the nation's most populated watersheds.

Sea Grant programs around the nation are helping to unlock the secrets behind estuarine productivity and their highly fertile wetlands. Researchers in Massachusetts, looking at the effects of urbanization, are studying the fate of the last salt marsh in Boston. Delaware scientists have probed new ways to control the noxious weed *phragmites* and pioneered methods for producing full-grown salt-tolerant plants from tissue culture. California researchers are showing how West Coast estuaries differ from those in the East.

The presence of dangerous pollutants in our waters is also

stimulating important Sea Grant work. In the Great Lakes, Wisconsin Sea Grant has tracked such toxins as PCBs and Dioxin. Researchers at Woods Hole have been able to improve the accuracy of testing for PCBs and their movement along the coastline. And computer modeling is allowing investigators at MIT to show where pollutants (including oil spills) will likely drift, and scientists in California to describe the movement of sewage.

Through Sea Grant research and education, we now know more about changes at the coast, where the landscape responds to the shaping hand of the sea. We know more about using the coastline for economic benefit and how to protect our investment through better planning and improved designs and materials.

SEA GRANT—CONTRIBUTING TO AMERICA'S BALANCE OF TRADE IN SEAFOOD

Sea Grant is helping the United States seafood industry meet the new challenges of today's global marketplace for seafood.

The 29 Sea Grant programs are diverse in their resources and rich in their expertise. They contribute in several key ways to make the U.S. seafood industry more competitive and help reduce the trade deficit.

The driving purpose behind Sea Grant since its beginning 20 years ago has been to link the research capabilities of our institutions of higher learning to the development of marine resources for the public good. Fundamental research has always been the foundation of the program, and over the years Sea Grant research in fisheries, aquaculture, food science, economics, and trade has made significant contributions to the competitiveness of the U.S. industry.

Enhancing the U.S. Position

Recent Sea Grant research projects in several states have led to the establishment of new fisheries. As one example, the softshell blue crab industry, relatively undeveloped for more than a hundred years, is now undergoing rapid expansion throughout the mid-Atlantic and Gulf Coast states. Driving this growth are burgeoning demand and improved production and marketing techniques.

The production expertise of Sea Grant programs in North Carolina, Florida, and Mississippi-Alabama was instrumental in helping increase the supply of softshell crab. And this production expansion has opened up trade opportunities, assisted by the export marketing expertise of Virginia Sea Grant. In 1986 softshell crabs with a value of $2 to $3 million will be exported to some 14 countries, including Canada, Japan, and England. The outlook for continued export growth is considered bright.

New production is one way to add more to our side of the trade balance. Improved marketing of existing products is another way. For one example, Sea Grant advisory specialists in New York saw that local tuna fishermen were missing an opportunity to sell to the Japanese trade by not understanding their quality standards. The specialists produced a brochure and held meetings, reaching hundreds of fishermen. Tuna sales subsequently soared from $300,000 in 1982 to nearly $2 million in 1985.

While U.S. exports may be hampered by a variety of factors, including the strong dollar and the weakened economies of trading partners, the U.S. trade position can be improved by another approach. We can replace some imports with domestic production.

Historically, U.S. seafood imports have exceeded exports since the 1890s; in 1985, despite U.S. fishery exports amounting to $1 billion, the trade deficit in seafood stood at more than $5 billion. Sea Grant has implemented long-range strategies that can act to at least diminish this trend.

Aquaculture production is one of these strategies. Between 1975 and 1985, U.S. aquaculture production increased from 130 million pounds to about 500 million pounds, and the National Science Foundation has predicted that the U.S. will produce 2 billion pounds by the year 2000. With a strong national research program in aquaculture, Sea Grant is taking a leadership role in achieving this goal. In a notable success, Sea Grant research in Hawaii has contributed substantially to the development of that state's freshwater prawn industry, valued at $2 million. Research in marine shrimp culture at several Sea Grant institutions has led to the development of shrimp farms in Texas, Hawaii, South Carolina, and Louisiana. Advances in aquaculture production are also occurring with clams, oysters, mussels, marine finfish, and anadromous fish, such as Atlantic salmon. These efforts will result in significant gains in domestic production over the next few decades.

A companion strategy to aquaculture also involves the application of technology to seafood. This opportunity is surimi. Where aquaculture production generally focuses on high-demand, high-quality fish and shellfish species, surimi processing focuses on abundant but underutilized species.

Surimi is a bland fish paste that can be prepared from many different varieties of underutilized fish and transformed into a variety of end products of increased value. The explosive growth in the 1980s in the market for crab "analog" products shows the potential of surimi technology. In 1985, the $88 million worth of surimi sales in the U.S. was dominated by Japanese crab products derived from pollock, but the technology is inherently adaptable to other species and products. It is currently being explored at Sea Grant institutions in Alaska, Massachusetts, New York, North Carolina, Oregon, Rhode Island, Virginia, Washington, and Wisconsin.

Policy Studies

Seafood is today an inter-

national commodity, subject to economic, governmental, and political forces that are complex, interrelated, and often decisive in their impact. The recent high value of the U.S. dollar, for just one example, has been a damper on virtually all American exports, including seafood. Sea Grant economics and policy research is directed to understanding these factors and making this new understanding available to industry, government, and academia. One signal contribution to this effort was establishment of the International Institute for Fisheries Economics and Trade, largely through the support of Oregon Sea Grant.

Sea Grant research and extension activities are helping the American seafood industry to make the most of existing and future trade opportunities, to increase exports, to substitute for imports. They are making seafood a more important and less expensive product for the American consumer. Over time, these Sea Grant efforts will continue to make a positive contribution to the nation's balance of trade.

SEA GRANT—INCREASING THE PRESENCE OF SEAFOOD ON AMERICA'S MENUS

Five years ago it wasn't an American meal without fried chicken, roast beef, or pork chops. Now salmon steaks, cod fillets, and grouper nuggets increasingly fill our plates.

From coast to coast, Americans have developed a growing appetite for the fisherman's catch. Per capita consumption of seafood increased from 13.6 pounds in 1984 to 14.5 pounds in 1985. Overall, we ate 3.2 billion pounds of fish and shellfish in 1985.

But seafood's rise to popularity didn't come without some help. Through research, promotion, and education, Sea Grant programs from Alaska to Puerto Rico help to put more and better fish and shellfish on the nation's tables.

The Blue Mussel

Ten years ago, the blue mussel was a has-been. The mollusk had been extensively harvested during World War II as a source for protein. But the high demand left only limited quantities of good quality mussels for the post-war years. And besides, American taste buds were set for red meat.

The Maine mussel fishery floundered.

But the blue mussel is back, thanks largely to efforts of the Maine/New Hampshire Sea Grant Program.

Sea Grant scientists felt they could improve the mussel's quality if the mollusk was cultured. They were right. Culturing not only improved quality, it also produced a marketable-size mussel in 18 months to two years, substantially less time than a wild mussel takes to reach the same size.

Today about 100 people actively participate in Maine's mussel culture industry, producing 3 million pounds of the mollusks valued at $1.5 million. With improved quality and better production, the blue mussel has gained favor among gourmets nationwide. Now the lowly mussel is as chic as the lobster.

Surimi

The label on the box says "imitation crab meat." But inside, the product looks, feels and tastes like the real thing. This "crab meat" is made from surimi.

The Japanese developed the surimi process. Using Alaska pollock, for example, the Japanese process the fish into a paste, add a little of the real product for flavor, and shape the paste into crab legs, scallops, and lobster tails.

So far, American consumers don't mind a little Japanese ingenuity making it to the dinner table. Experts estimate that Americans bought about 150 million pounds of surimi-based products in 1985.

But American seafood processors wanted to cash in on the country's hunger for the lower-priced imitations.

Sea Grant scientists in North Carolina, Oregon, Washington, Alaska, Virginia, Rhode Island, New York, and Massachusetts have been tailoring the surimi process for American production. And they're basing that production on cheap, but abundant fish such as Alaska pollock, Pacific whiting, and menhaden.

Using Sea Grant research, U.S. processors are poised to launch American-made surimi in the marketplace. Three land-based plants have already begun production in Alaska. Another company is outfitting ships as floating factories.

In Massachusetts, red hake surimi products will soon be rolling off the conveyor. And in Virginia, a pilot menhaden surimi plant, supported by a National Marine Fisheries Service development grant, is gearing up for production.

And that's not all. Sea Grant scientists in Wisconsin are studying the possibilities of freshwater drum surimi. And Louisiana and Mississippi researchers are trying to get catfish into the paste.

The American surimi industry is on the verge of rapid expansion that could have happened only with Sea Grant research. In just a few years, U.S. processors expect the nation to be eating "homemade" surimi products.

Good Health

Seafood has many positive aspects—it tastes good, it is nutritional, it offers variety, and it is easy to prepare and cook. Now doctors tell us a good thing is even better—seafood is heart food.

The New England Journal of Medicine reports that a link exists between seafood consumption and a low death rate from heart disease.

Fifteen years ago, Oregon Sea Grant researchers did some basic research into the benefits of fish oils. They demonstrated that replacing corn oil with fish oil in the diets of hatchery-raised salmon and trout improved the

fishes' growth and reduced mortality.

Today New York Sea Grant scientists are learning what the natural oils in fish and shellfish can do for people. They have found that under certain conditions fish oils lower harmful fats and cholesterol in the blood and reduce blood clots. The ultimate benefit may be a lower risk of heart disease and stroke.

With this information, Sea Grant seafood education specialists from the Great Lakes to Texas, from Puerto Rico to Hawaii, are spreading the word that the ocean's bounty may be an entree that people can't live without.

Whether it's nutrition or processing, Sea Grant gives the seafood industry an important research boost that increases its productivity and expands its markets.

6. Spending Patterns of the Sea Grant Universities

An analysis of spending patterns by the nation's Sea Grant universities, 1976–1985

A Preliminary Analysis of SPENDING PATTERNS BY THE NATION'S SEA GRANT UNIVERSITIES 1976–1985

EXECUTIVE SUMMARY

Under the National Sea Grant College & Program Act, a network of coastal and Great Lakes universities has developed a program of research, advisory services and education that effectively addresses national marine resource problems and opportunities. Recently, there has been concern in some arenas that Sea Grant may be perceived as a block grant or otherwise static program that is unresponsive to priority needs of the nation.

In a survey conducted by the Council of Sea Grant Directors, the 29 Sea Grant programs were asked to assess the pattern of their expenditures for the period 1976-85, and the data they provided were analyzed for trends in activities. This analysis shows that, despite the constraints imposed by level funding, the National Sea Grant College network has responded to changing national priorities in a relatively timely mode. Moreover, a parallel study reveals that the program gets the most results for the least cost and that its multidisciplinary research is highly competitive.

BUDGET SYSTEM

This analysis, which was completed in early 1986, is the result of a three-year effort by the Council of Sea Grant Directors. Each of the 29 Sea Grant universities participating in this nationwide program coded its budget expenditures for each year during the period 1976-85. These data were subsequently analyzed to determine trends in activities.

It is important to note that these data represent only federal Sea Grant funds spent by the universities and do not include matching funds, pass-through money from other federal agencies, or management expenditures and other activities by the NOAA Sea Grant College Program Office.

The heart of the budget information system is a common set of descriptors for Sea Grant expenditures which permits aggregation of federal dollar expenditures for system-wide planning and projection. The descriptors (listed below) depict the output of the program in a terminology more constituent-related than disciplinary. This allows an analysis, for example, of funds going into a certain component area (e.g., fisheries) from all program functions such as research, advisory service, and education.

- Fisheries—Work dealing with finfish, mollusks, crustacea, marine mammals, and plants; and with habitat improvement and management of these living marine resources.
- Aquaculture—Activities affecting finfish, mollusks, crustacea and plankton cultured in a marine environment.
- Minerals and Energy—Exploring for and improving utilization of placers; polymetallic sulfides; oil and gas; and energy arising from wind, waves, currents and tidal and thermal sources.
- Transportation and Boating—Developing marine industries including work with ports and harbors, cargo movement, ships, vessels and gear, routing and navigation, marketing, labor, safety and facilities and material design.
- Marine Processes and Sediments—Studies of physical forces such as shoreline erosion, waves, and currents and of their impacts on natural and man-made structures along the nation's coasts and estuaries.
- Recreation and Tourism—Working with marine industries that serve the demands of the nation in fishing, boating, diving and other water and coastal based activities.
- Contaminants—Measuring and determining the sources, transport, fate, effects and utilization of contaminants.
- Coastal and Ocean Government and Management—Solving social, political and legal issues in our estuaries, the territorial sea, the exclusive economic zone and on the high seas.
- Programwide—Activities that cut across all program functions. These include such items as regional or international projects, national fellowships and interns, management and communications.

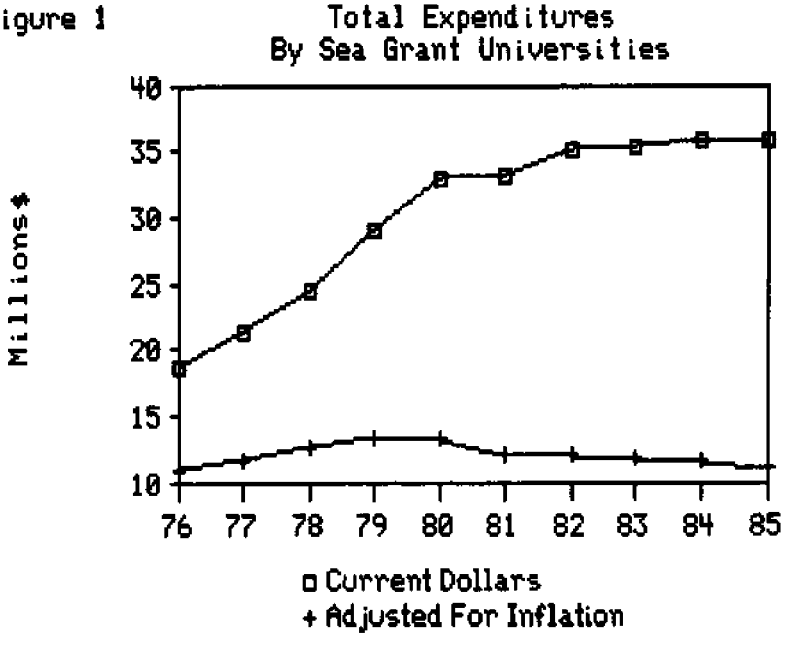
EXPENDITURE TRENDS

Annual expenditures by the Sea Grant universities continued an upward trend until 1982 when appropriations became level (Figure 1). When these expenditures are adjusted for U.S. Consumer Price Index inflation rates (1967 base year), the trend peaks in 1979 and declines each year since 1980. Total deflated expenditures by the 29 Sea Grant universities in 1979 were $13.4 million ($29.2 million current) but have since fallen to $11.3 million ($35.9 million current). This represents a 16 percent decline in buying power for Sea Grant research, advisory services, and education efforts to develop the nation's marine resources. It should be noted that this reduction in buying power does not include adjustments necessitated by increased costs at the state and institutional levels.

Expenditures By Program Function

Research: Research expenditures consist of faculty salaries, equipment, operating expenses and graduate student support. Since 1980, total expenditures for Sea Grant research have been vir-

Figure 1



tually level (Figure 2) at about $19 million (current dollars). As a percentage of total Sea Grant spending, however, research expenditures have gradually declined over time (Figure 3) from the 1976 high of 60 percent to the 1985 level of 54 percent.

Although the share of research expenditures devoted to graduate student support has increased since 1976 (Figures 12 and 13), all other research expenditures have declined. Graduate student support as a percent of total Sea Grant spending has gradually increased from about 10 percent to almost 12 percent. Other research spending as a percent of the total has thus declined by about 8 percent.

Advisory Services: Total expenditures for advisory services increased slightly over time until 1983 when they peaked at $8.8 million. Expenditures in 1984 and 1985 were lower. As a percent of total spending, however, advisory service expenditures have gradually increased from about 22 percent in 1976-78 and now represent about 24 percent of the budget. Most advisory service expenditures are for personnel which represent fixed costs. Increases in salaries have necessitated a reduction in the number of advisory personnel despite this modest growth rate.

Education: Expenditures for education (K–12) and university course and curriculum development have declined since the early 1980s and in recent years have been only slightly over $1 million. As a percent of the total, education spending has declined from about 5 percent to slightly over 3 percent.

Public Information: Expenditures for public information increased slightly until 1984 when they peaked at $3.1 million. Expenditures in 1985 were lower and they now represent between 7 and 8 percent of total spending.

Management: University program management expenditures increased gradually over time and now are slightly over $3 million. On a percentage basis, however, program management expenditures declined from 1976 through 1980. Since that time they have remained at about 9 percent of the total, about the same as in 1976. Management expenditures represent primarily fixed personnel costs which have continued to increase although the effort level has remained stable.

Expenditures for Research

During the ten-year period of analysis the amount of funds devoted to various research components changed significantly. These changes are in response to perceived relevance of research needs (Table 1).

Expenditures for fisheries research (about 1/3 of total research) steadily increased during this period, both in actual dollars and percent of total research (Figures 4 and 7). Aquaculture research (Figure 4) was maintained at an almost constant percentage of research (Figure 7) during that period. It is very important to note, however, that the kinds of research conducted within these components has changed significantly as noted in the two following examples:

> During the 1970s, fisheries research focused on response to stress, population dynamics and seafood technology. From an independent analysis of projects funded since 1980, it is clear that the research emphasis is changing. More attention is now being placed on population modeling and recruitment issues in fisheries and less on stress response (Figure 10). This general trend also indicates a shift from the focus on individual species to work in the primary nursery area that benefits all species.
>
> Similarly, salmon aquaculture studies, for which data are available since 1976, have moved from a focus on aquaculture systems (general husbandry work) to specific attention to genetics and disease (Figure 11). This is an expected transition, for once the systems have been developed to produce the fish, attention is turned to solving problems encountered during the grow-out phase.

Research in marine processes and sediments increased to about $3.6 million in 1979 (11% of total), but has steadily declined since (Figures 5 and 8). Overall contaminants research expenditures have also declined during this period (Figures 5 and 8). An independent examination of yearly project reports show that in the 1970s contaminant research focused on environmental mapping, but in response to national needs, undertook in the 1980s experimental efforts to discover fates and impacts of contaminants. Expenditure levels for minerals and energy research have been modest, with a slight increase in the 1980s (Figures 5 and 8).

Research directed toward marine industries has focused on economics, engineering and business administration of ports, har-

Table 1. Changes in Sea Grant research component emphasis, 1976–85.

Research Component	Average Percent of Total 1976–85	Trend (10 years)	Average Current Percent 1984–85
Fisheries	32.8	Increase	37.9
Aquaculture	19.4	no change	19.3
Marine Processes/Sediments	15.3	peak in 1979	13.1
Contaminants	9.2	decline	7.2
Marine Industries	8.4	peak in 1982	8.5
Transportation/Boating	5.0	peak in 1982	4.7
Recreation/Tourism	3.4	peak in 1982	3.8
Coastal/Ocean Management	6.9	decline	6.4
Minerals/Energy	3.3	no change	3.1
Programwide	4.5	no change	4.4

Figure 2

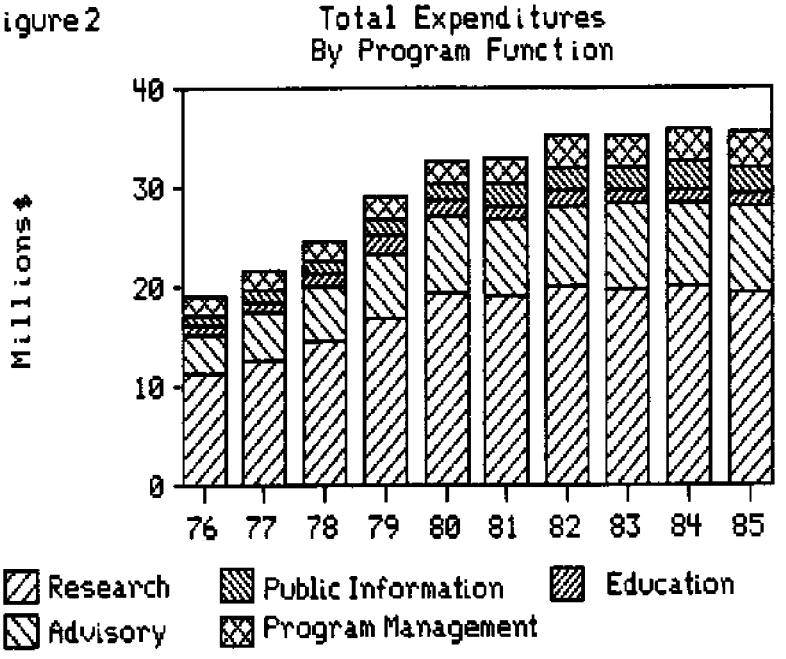
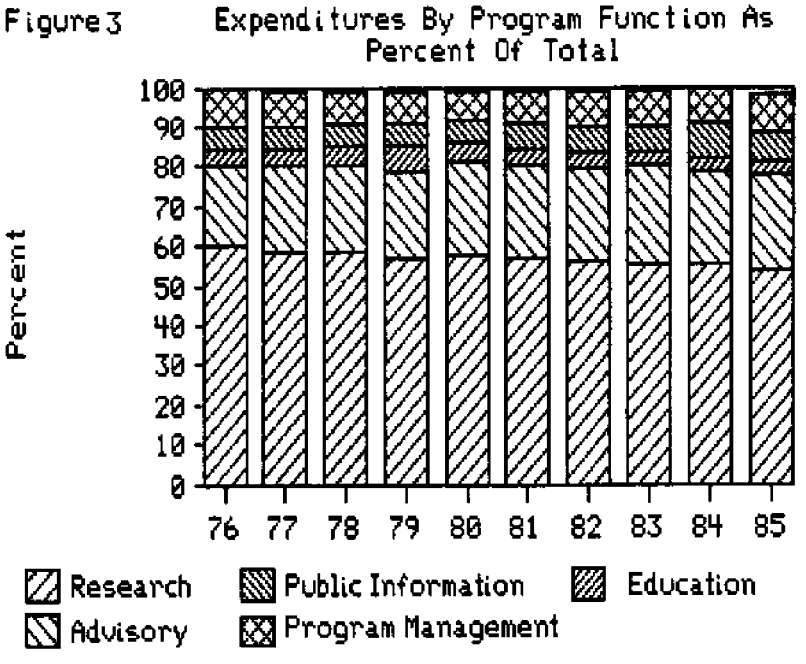


Figure 3



bors, boat manufacturing, recreational businesses, etc.—all of which contribute significantly to the U.S. economy. Expenditures in this important research area (shown as transportation and boating) increased until 1982, but have since fallen off somewhat to the ten-year average (Figures 6 and 9). Research in coastal and ocean management has declined (Figures 6 and 9) as the nation has implemented its coastal management program. Research efforts in this area are expected to increase again as the importance of estuarine management is recognized, and as exploration and development of the Exclusive Economic Zone increases.

Expenditures for Education

Sea Grant education efforts have historically taken three forms:

- course and curriculum development
- K–12 teacher training
- graduate student support

Course and curriculum development has been represented by stand-alone projects, because once developed, university courses, vocational/technical training courses, and marine science curriculum materials do not require further Sea Grant support. K–12 materials development has concentrated on fulfilling general marine science needs through teacher training workshops and classroom materials. Stipends and assistantships for graduate students as they work on specific research projects are funded on a competitive basis and their work is directed by research faculty.

Total spending for course and curriculum development increased from 1976 to a peak in 1979 of slightly over $1 million but since then has declined steadily to about $.5 million annually (Figure 12). As a percentage of total spending, course and curriculum development has declined from about 3 percent in 1976 to one-half that amount in 1985 (Figure 13). During the same time, spending for K–12 teacher training increased from about $200 thousand annually to a peak of $860 thousand in 1981 and has since declined. The same trend follows in terms of percentage of total expenditures which grew from about 1.0 percent in 1976 to about 2.5 percent in 1979 and then fell back to slightly more than 1.0 percent.

These patterns seem reasonable. Courses and curricula need to be developed only once, so it is appropriate that this type of activity has declined. When curriculum materials became available, expenditures for teacher training peaked, held steady for several years, and then declined as teachers were trained who then trained other teachers. The Sea Grant "multiplier" effort was thus at work by helping those who can first help themselves and then others.

Sea Grant education efforts and priorities now focus primarily on graduate student support to solve research problems and to educate future manpower. Graduate student support spending has grown from about $2 million in the mid 1970s to slightly over $4 million in 1985. On a percentage basis, the growth has been from about 10 percent to the 12 percent level in 1985. This has been one of the few Sea Grant areas that has grown as a percent of total expenditures in the face of level budgets.

Expenditures for Advisory Services

Sea Grant's marine advisory service is diversified and has developed a well respected technology and information transfer system. It is important to note that this multidisciplinary team and national network of expertise was built in less than two decades. Expenditures have changed over the ten-year period of analysis in spite of the "fixed" nature of appropriations and long-term institutional building (Table 2).

Expenditures for fisheries—which traditionally has been a major component of Sea Grant advisory services—peaked in 1981 and slowly declined since (Figures 14 and 17). This trend has occurred not because of a decline in fisheries development, but rather in response to increasing needs to assist development of other marine industries. Aquaculture activity is increasing (Figures 14 and 17) in response to the emerging aquaculture industry and as research results become available.

Marine advisory services expenditures in marine processes/sediments, minerals/energy and contaminants have been very modest (Figures 15 and 18). Activities in the contaminants component are currently increasing in response to needs for information and management in that area.

Programwide activities are increasing (Figures 16 and 19). Marine industries have become more sophisticated and their information needs more complex. Thus, Sea Grant universities are tending to diversify their advisory services components to meet these emerging needs. Direct marine industries advisory service expenditures (i.e., transportation, boating, recreation, tourism) have recently declined after peaking in 1980 (Figures 16 and 19). It is ap-

Table 2. Changes in Sea Grant advisory service component emphasis, 1976–85.

Advisory Services Component	Average Percent of Total 1976–85	Trend (10 years)	Average Current Percent 1984–85
Fisheries	33.6	peaked in 1981	31.5
Aquaculture	4.7	increased in 1980s	6.4
Marine Processes/Sediments	3.2	peaked in 1982	2.7
Contaminants	1.1	increased in 1980s	1.7
Marine Industries	14.6		13.3
Transportation/Boating	4.6	peaked in 1980	4.3
Recreation/Tourism	10.6	peaked in 1980	9.0
Coastal/Ocean Management	5.2	no change	5.1
Minerals/Energy	0.7	no change	0.5
Programwide	35.3	increased	37.6

Figure 4

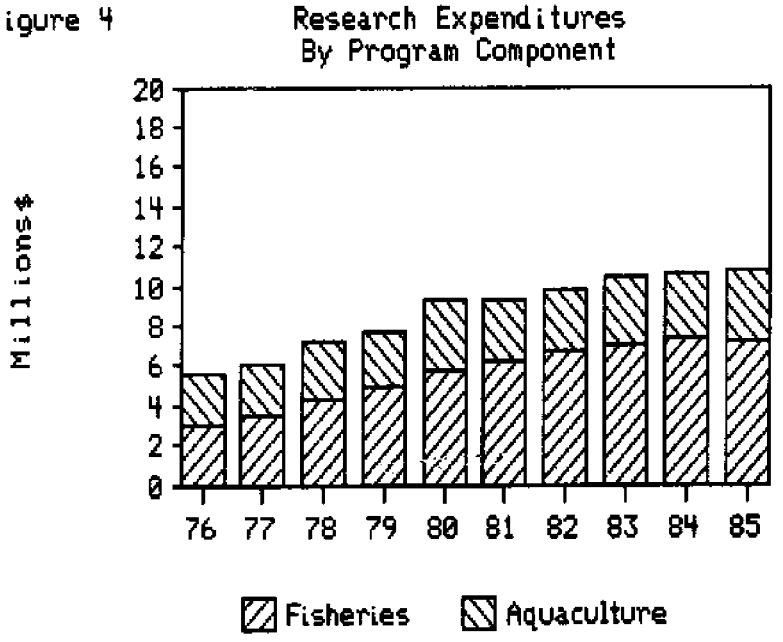


Figure 5

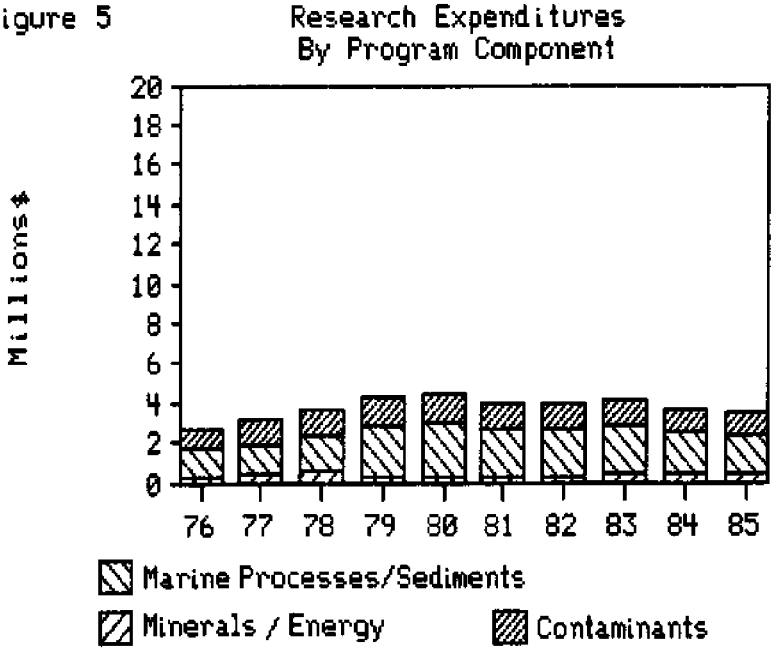


Figure 6

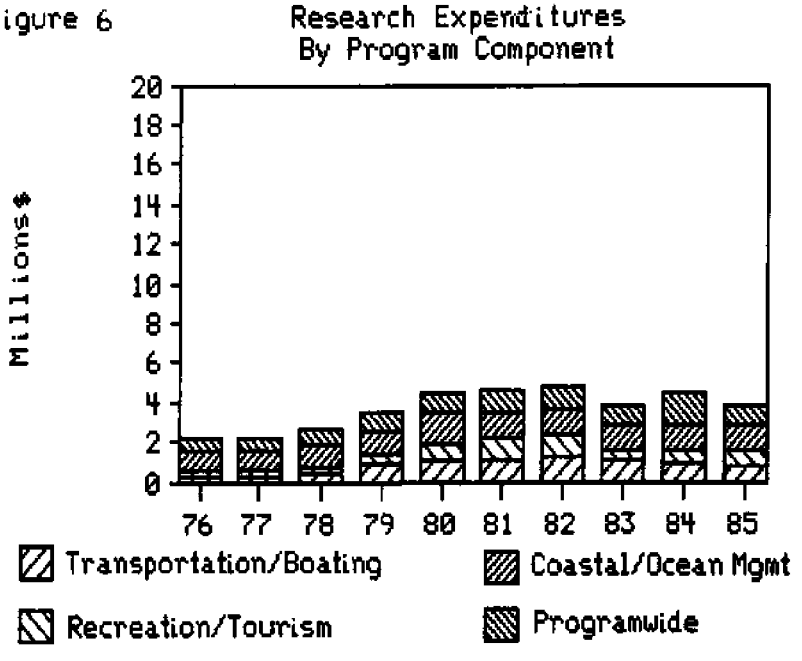


Figure 7

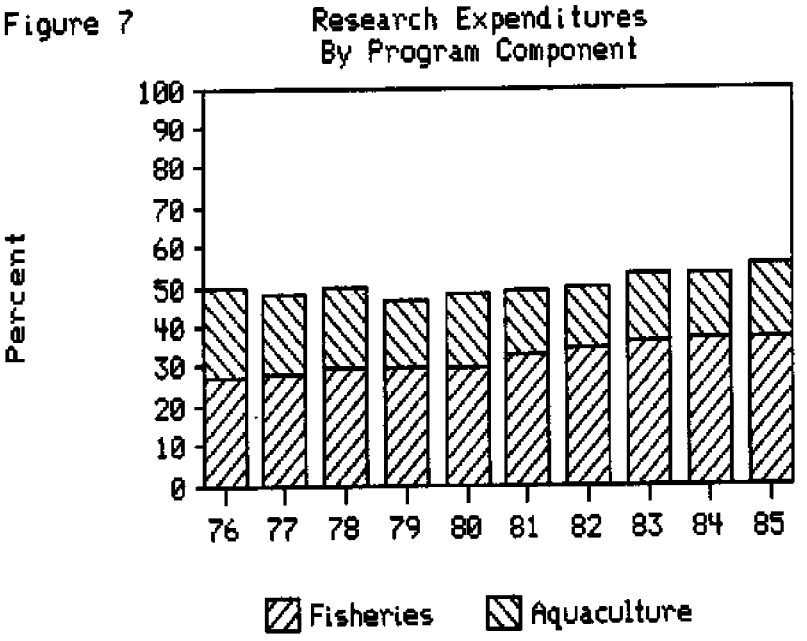


Figure 8

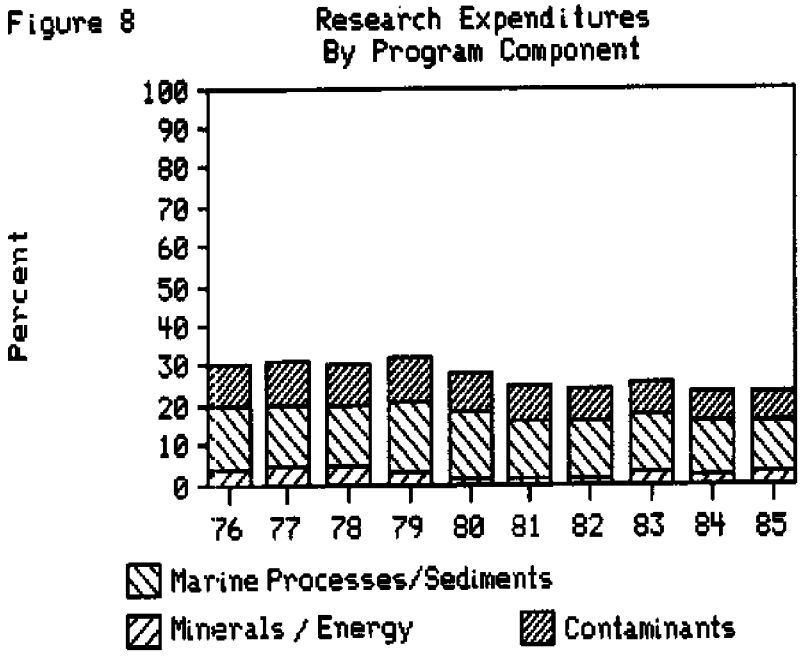


Figure 9

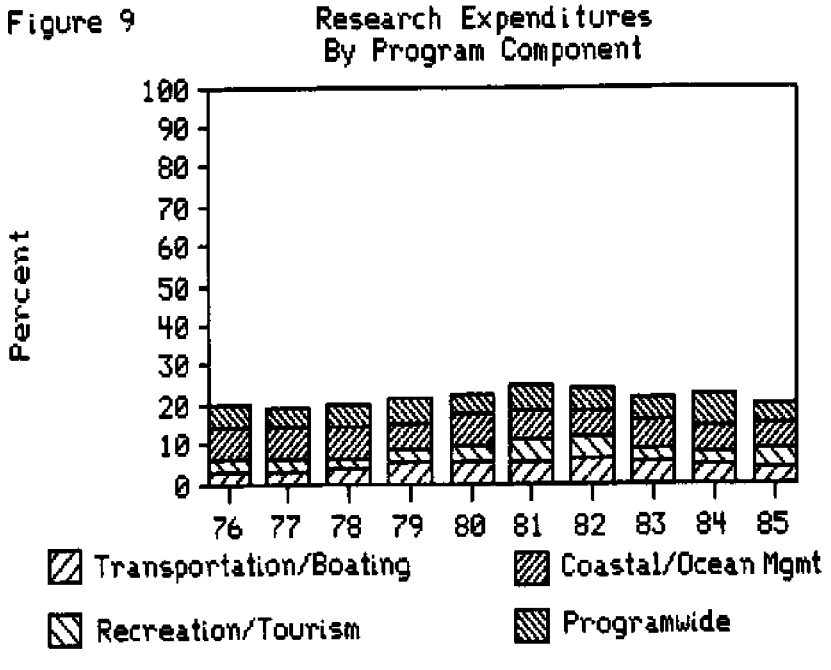


Figure 10 Types Of Fisheries Research

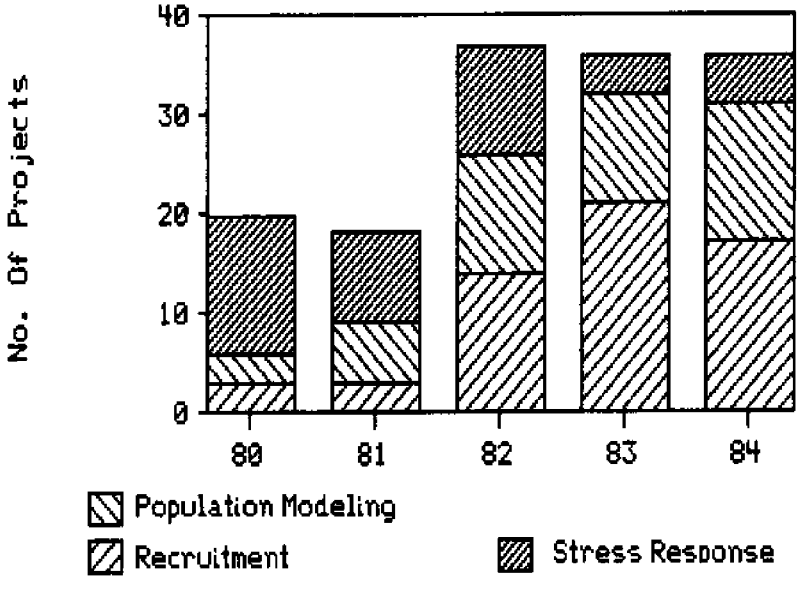


Figure 11 Types Of Salmon Aquaculture Research

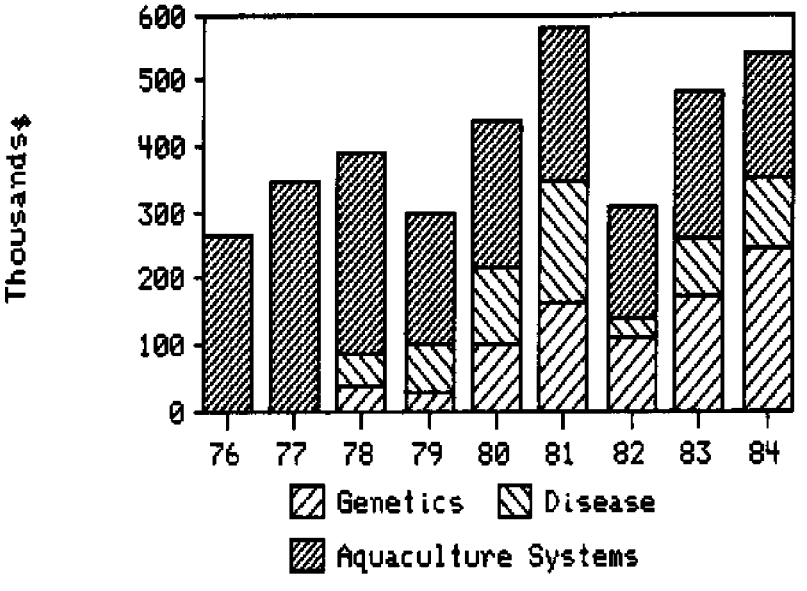


Figure 12

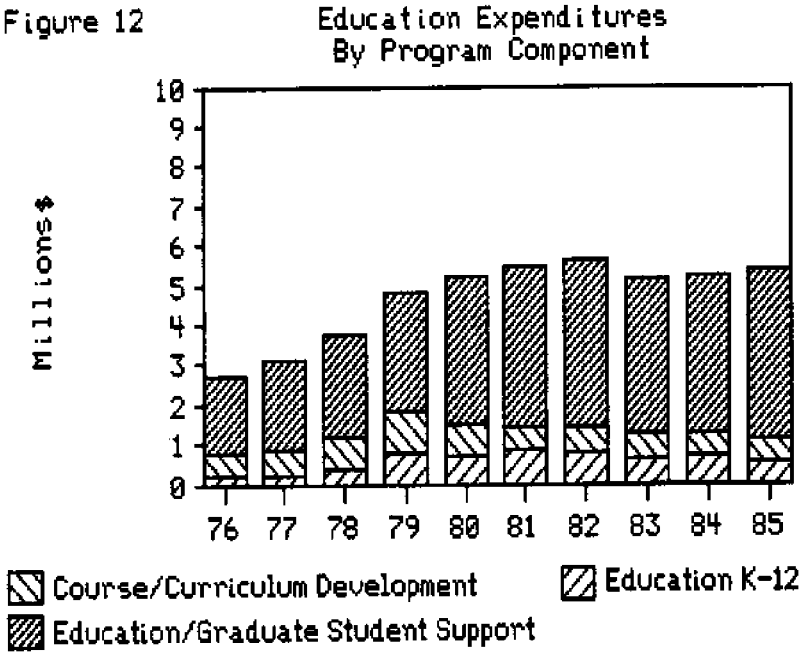


Figure 13

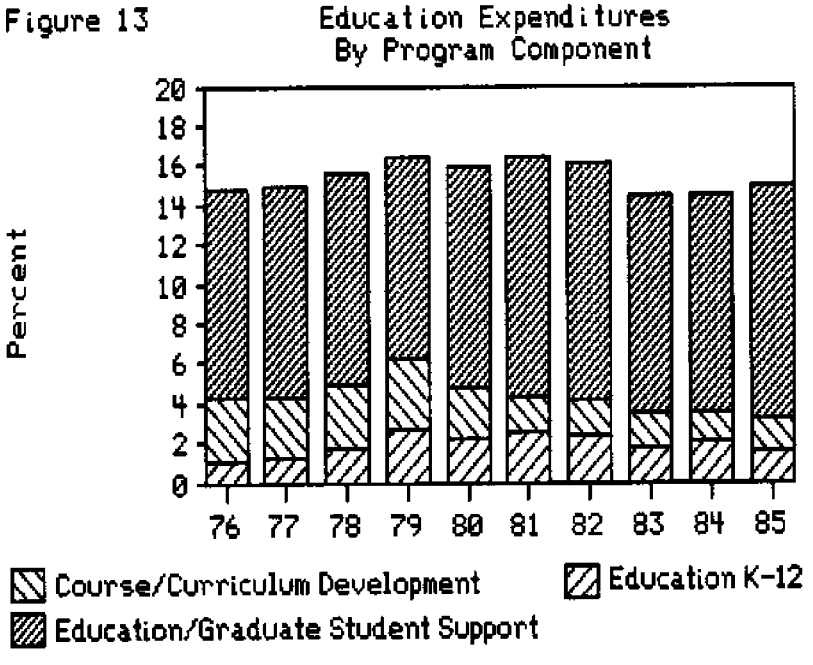


Figure 14 Advisory Services Expenditures By Program Component

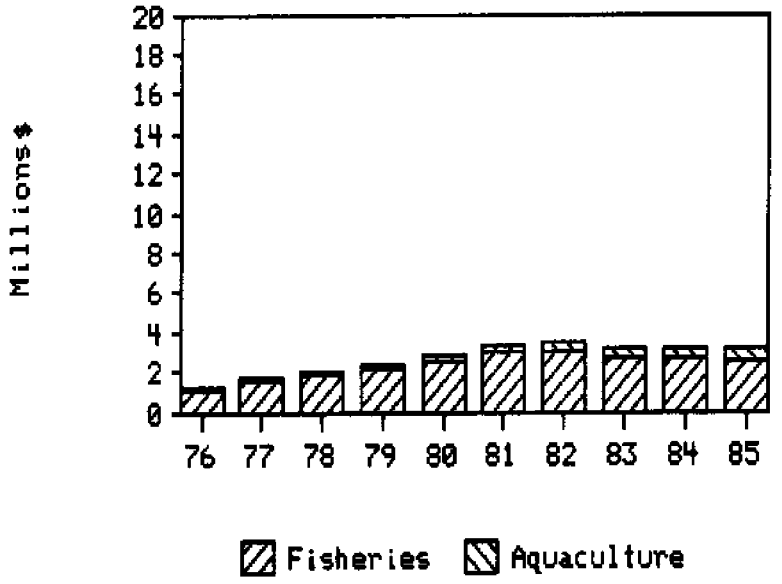


Figure 15 Advisory Services Expenditures By Program Component

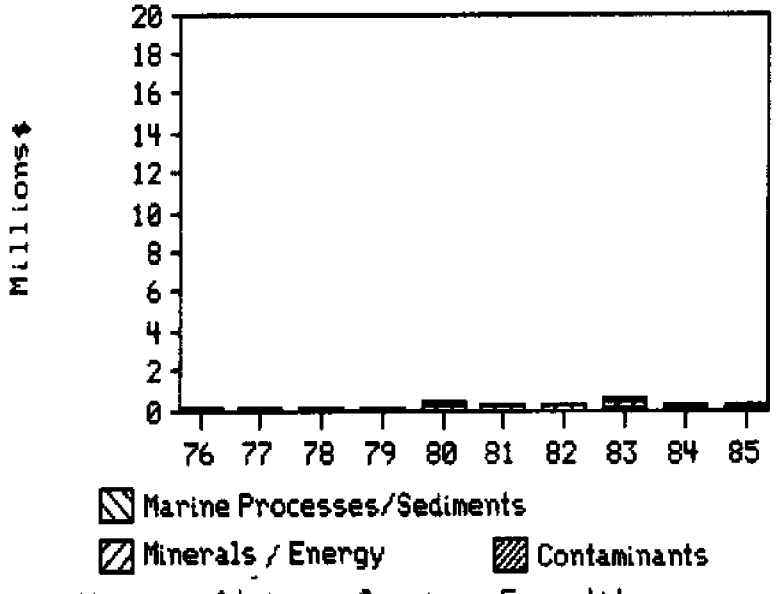


Figure 16 Advisory Services Expenditures By Program Component

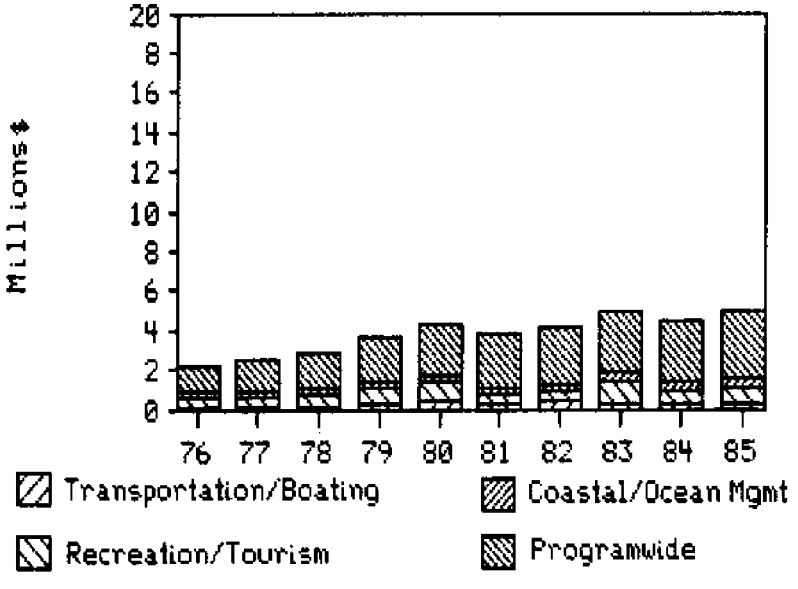


Figure 17 Advisory Services Expenditures By Program Component

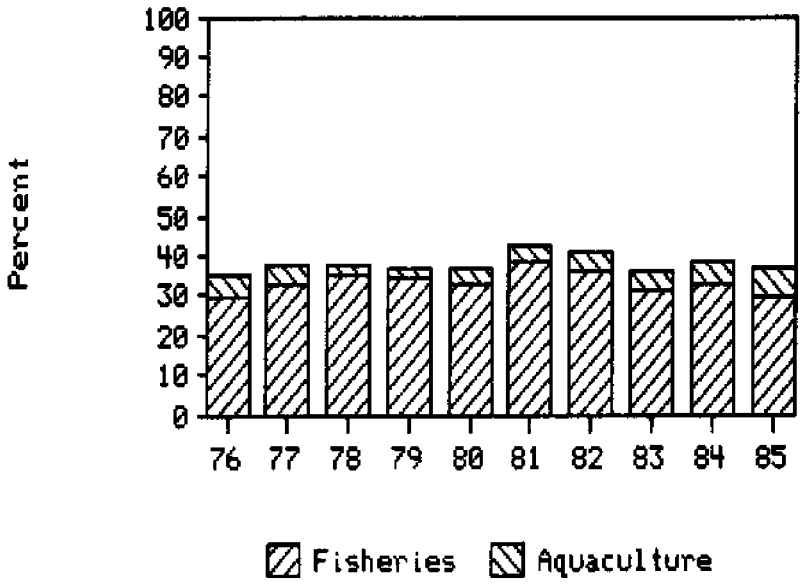


Figure 18 Advisory Services Expenditures By Program Component

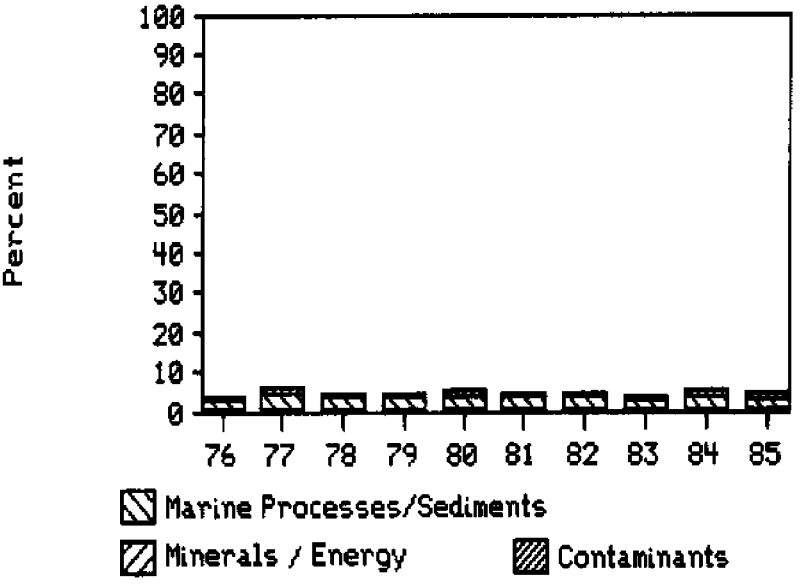
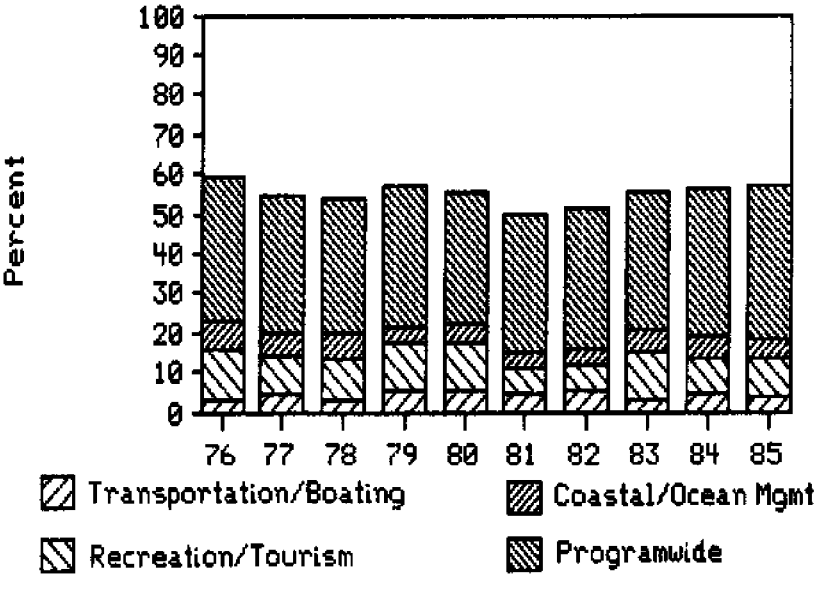


Figure 19 Advisory Services Expenditures By Program Component



parent that more attention needs to be directed toward this area in response to developing technology and industry growth. Coastal and ocean management advisory service expenditures continue at about the level as in previous years.

SEA GRANT IS MULTIDISCIPLINARY

Sea Grant focuses its efforts on priority problems that will ultimately enhance the nation's marine productivity, and it provides the means through which university faculty can apply their knowledge and talents to the nation's marine needs. The National Sea Grant College Program is the national model for multidisciplinary university work, and is one of the few scientific programs that operates in this manner, rather than along strict disciplinary lines.

Nowhere is this more evident than in the budget data collected for the 1976-85 period. Sea Grant program activities in research, education and advisory services were reported under 50 selected disciplines. For 24 of these disciplines, at least $.5 million was spent in at least one of these ten years. These are noted as major disciplines. For most of these 24, major expenditures were reported each year. For the remaining 26 disciplines, expenditures were reported in each of them for at least eight of the ten years. These 50 disciplines account for only about 80 percent of total expenditures. The remaining 20 percent was reported under "other", emphasizing even further the multidisciplinary nature of Sea Grant. These listings are not complete, and a more comprehensive set is being developed based on further experience.

Major Disciplines

Aquaculture
Animal Physiology
Biochemistry
Bioengineering
Biology
Chemical Oceanography
Civil Engineering
Coastal Engineering
Ecology
Economics
Education
Fisheries
Food Science
Genetics
Geology
Law
Management
Microbiology
Ocean Engineering
Pathology
Pharmacology & Toxicology
Physical Oceanography
Policy
Recreation

Other Disciplines

Anthropology
Behavioral Science
Botany
Chemical Engineering
Chemistry
Electrical Engineering
Engineering
Geochemistry
Geophysics
History
Human Physiology
Marketing
Materials Science
Mathematics
Mechanical Engineering
Medical Science
Meteorology
Natural Products Chemistry
Naval Architecture
Nutrition
Physics
Physiology
Plant Physiology
Political Science
Sociology
Zoology

CONCLUSIONS

- The National Sea Grant College Program is a viable, responsive research, advisory services and educational force in the nation's marine and coastal sector.
- Funding limitations have imposed serious constraints on the ability of the Sea Grant universities to respond to changing and emerging national needs.
- In spite of the constraints, the national Sea Grant universities network has effectively changed the thrust of its research, advisory services and education efforts in response to some high priority needs. It still needs to address others.
- Fisheries research and advisory services expenditures dominate total Sea Grant efforts but the emphases within this broad and nationally important context have changed significantly.
- Research and advisory services efforts in support of emerging marine industries needs to be strengthened, but funding will need to be increased to create that strength.
- Educational activities leading to course and curriculum development have significantly declined as this national need was fulfilled and educational expenditures are now being directed at graduate student development in concert with research priorities.
- The Sea Grant advisory services capabilities have been built in an incredibly short time and the potential effects of its multidisciplinary capability are just now being realized.
- Sea Grant is indeed multidisciplinary, having significant research, advisory services and education projects in more than 50 professional disciplines.

Sea Grant research is cost effective and competitive. Its review processes assure the most meritorious and relevant projects are selected for funding. As a result, it is likely to remain responsive to changing national needs and priorities.

7. Economic Effects

A reprint of a 1981 report documenting $230 million in annual gross revenue or savings (cost avoidance) resulting from or stimulated by selected Sea Grant projects

ECONOMIC EFFECTS OF SEA GRANT

Reprinted from a report prepared by the Sea Grant Task Force, Washington, D.C., March 26, 1981, on behalf of the Marine Affairs Committee of The National Association of State Universities and Land-Grant Colleges in conjunction with the Sea Grant Association.

Sea Grant Task Force - 1981

Chairman
R. Corell, University of New Hampshire*

Members
D. Horn, Massachusetts Institute of Technology*
F. Jennings, Texas A&M University*
J. Judd, University of Michigan*
J. Kermond, Sea Grant Association/NASULGC
N. Rorholm, University of Rhode Island*
D. Rosenberg, University of Alaska*
V. Scottron, University of Connecticut*

* For identification purpose only

The National Association of State Universities and Land-Grant Colleges, Suite 710, One Dupont Circle N.W., Washington, D.C. 20036

ECONOMIC EFFECTS OF SEA GRANT

EXECUTIVE SUMMARY

- Examples for this economic appraisal came from Sea Grant programs nationwide
- Economic effects on industry, business and commerce, derived from 57 projects stimulated by federal investment through Sea Grant, showed:

A.	Fish harvesting	$ 37,552,000
B.	Seafood processing and marketing	17,500,000
C.	Aquaculture	21,752,000
D.	Marine construction	126,896,000
E.	Marine transportation	2,890,000
F.	Marine-related retail trade	19,400,000
G.	Marine-related real estate	3,000,000
H.	Marine service industry	813,000
	Total	$229,803,000

- This *annual* figure ($230 million) approaches the *total* federal investment in the Sea Grant program over its thirteen-year history.

PARTIAL LISTING OF ECONOMIC EFFECTS OF THE NATIONAL SEA GRANT COLLEGE PROGRAM

Summary: Estimates and analyses of *parts* of the Sea Grant program indicate it has led to or stimulated over $230 million in annual gross revenue or savings (cost avoidance) leading to fuller utilization and greater efficiency in marine or coastal resource based industries.* Not accounted for are contributions to better management of these resources. Neither do we attempt to place a monetary value on the manpower development role of Sea Grant. The latter is a major contribution to the nation's ability to use its coasts and water productively whether for commerce, food, or for recreation.

Twenty-six Sea Grant programs participated in developing the data for an analysis of economic effects. A substantial volume of background data was prepared as source information on the economic stimulation to industry, business, and commerce. The data obtained (based on fifty-seven projects) represent a few percent of the total project activity within Sea Grant. Each program selected only a few examples of documented economic effect from its research and educational efforts. The intent of this report is to provide, from a nationwide point of view, a partial assessment of economic effects of Sea Grant's work. A summary (Table 1) of the findings for eight major categories of Sea Grant research and educational activity indicates the aggregated annual effects.

The material that follows provides summary information on each of the fifty-seven projects in eight major categories outlined in Table 1.

* Production costs have not been subtracted. Later analysis will attempt more detailed net benefit studies of selected parts. The partial nature of this analysis should also be stressed. It is based on examples from individual programs rather than on total coverage. Hence, it is conservative.

Table 1. Selected set of economic effects from the National Sea Grant College Program.

A. FISH HARVESTING Increase the economic productivity of commercial shellfish, groundfish, and mid-water fisheries.	$ 37,552,300
B. FISH PROCESSING AND MARKETING Expand the economic base of the seafood processing industry.	$ 17,500,465
C. AQUACULTURE Provide new commercial opportunities by developing the science, technology, and economic potential of aquaculture of marine species.	$ 21,752,000
D. MARINE CONSTRUCTION Facilitate improvements in environmentally sound, economical, and safe waste disposal and offshore construction activities.	$126,895,771
E. MARINE TRANSPORTATION Increase the efficiency and safety of the U.S. shipping fleet and the competitiveness of U.S. boat manufacturers in the foreign market.	$ 2,890,000
F. MARINE-RELATED RETAIL TRADE Promote the growth of precious coral and pet turtle industries and reduce the loss of lives from cold-water drownings.	$ 19,400,000
G. MARINE-RELATED REAL ESTATE Develop new technologies for shoreline stabilization, flood control, and alternative methods of sewage treatment.	$ 3,000,000
H. MARINE SERVICE INDUSTRY Reduce wave damage to marinas and find an economically feasible alternative to breakwater construction for small marinas.	$ 812,760
TOTAL	$229,803,296

SEA GRANT AND THE ECONOMY

The economic development potential of the marine and coastal resources of the United States has attracted much attention in recent decades. The magnitude of 1972 economic activity within the coastal and ocean sectors only recently has been assessed (*Science*, Vol. 208, 30 May 1980). This analysis of the ocean economic sector in the National Income Accounting System (NIAS) places the ocean sector value at $30.6 billion in 1972 which is comparable to agriculture ($35.4 billion), mining ($18.9 billion), construction ($58 billion), transportation ($46.2 billion), and communications ($29.4 billion). The NIAS is an analysis technique that indicates the contribution of various economic sectors to national income and, hence, provides a way of understanding the composition of the economy. The NIAS assessment is based upon nine major subsectors, with the percentage indicated:

1. Commercial Fishing (1%)
   Harvesting, processing, and aquaculture
2. Marine Mining (7%)
   Oil and gas, sand and gravel, and limestone
3. Marine Construction (1%)
4. Manufacturing (4%)
   Ship and boat building
5. Marine Transportation and Communications (8%)
   Shipping, cargo handling, and warehousing, transportation, services, and marine-related communications
6. Marine-related Retail Trade (24%)
   Marine-related merchandising and retailing
7. Marine Financing, Insurance, and Real Estate (15%)
8. Marine Services (3%)
   Hotels, marine recreation, educational services, museums, and marine organizations
9. Public Administration--State and Local (37%)
   Federal government, ocean-related activities

These data provided the first major overview of the oceans' economic importance. A more recent assessment of the magnitude of the private marine sector has been conducted by the Sea Grant Association Budget Committee. Considering all aspects of fishing, marine-related manufacturing, marine transportation and marine-related tourism, it was found that total sales exceeded $58 billion in 1978, with employment in these industries at nearly 1.4 million. Further, Department of Commerce figures indicate that sales within these industries increased 21.4% from 1977 to 1978 with an increase of 8% in employment, for a productivity increase of 14% in sales or shipment per person before adjustment for inflation.

Understanding the structure and characteristics of the industrial, business and commerce components of the ocean sector is important. A preliminary analysis suggests, that with some exceptions such as the oil and gas industry, most of the components within the private marine sector are disaggregated and evolving in nature. The fisheries component, for example, is comprised mainly of small independent businesses that have been shown to be the most viable economic force in the catching sector.

Most observers agree that the university/industry commitment to research and extension was the key Federal policy that contributed so significantly to the productivity of our agricultural industry. In 1966, the Federal Government established the policy and structure for similar activities aimed at marine resources through the National Sea Grant College Program Act. Fortunately, like the agricultural sector, the oceans sector has access to universities and industry. Primarily, the focus is on fisheries and aquaculture, seafood processing, marine construction and transportation, and marine-related trade, real estate, service industries, recreation, and tourism.

The Sea Grant College and Program Act of 1966 (P.L. 89-688) was passed "to accelerate national development of marine resources, including their conservation, proper management, and maximum social and economic utilization." More specifically, the program was directed to "achieve the gainful use of marine resources" (Sec 202(d)) through a partnership between the Federal and State Governments, universities, and the private sector. The term "Sea Grant" was chosen to emphasize the agricultural parallel in meeting present needs of the nation by developing the economic potential of our marine resources.

Since 1966, the United States has laid claim to a 200-mile economic zone, including all resources in the water column, on and under the ocean floor. By this single action, the United States almost doubled the territory under sovereign jurisdiction. When developed wisely, these vast new areas offer the nation economic opportunities equal to or greater than the agricultural sector of the nation's economy.

The factors that contribute to the productivity of the Sea Grant Program are:

1. The partnership of universities, industry, and government.
2. Sea Grant is the only Federally stimulated program focused on developing the resources of the ocean on a broad economic front.
3. Economic analyses of the Sea Grant Program, such as the following, clearly demonstrate an unusually good return on investment.
4. The Sea Grant Program is identifying and developing new resources for the nation in such areas as biomedicinals, aquaculture, ocean energy, conversion, diverse waste conversion, reduction of marine corrosion and biofouling.
5. Several independent assessments of the Sea Grant Program have been made in the past. The productivity of the program is generally recognized. The most recent assessment was made by the Heritage Foundation, which reviewed all Federal programs in 1980 and reported the following on Sea Grant:

> It has an impressive record of success . . . . It operates in partnership with state and local governments, private industry, universities, organizations and individuals concerned with or affected by ocean and coastal resources . . . . A key element of Sea Grant is its outreach mechanism whereby results of research are provided to users in industry, government agencies, and the general public.

This appraisal demonstrates the economic effects of the Sea Grant Program. The sections that follow were based on data supplied by 26 Sea Grant Programs. However, this report must be seen as a partial assessment, prepared on relatively short notice. The Sea Grant Program will continue to improve its means of assessing benefits and documentation of program accomplishments.

ECONOMIC EXAMPLES

A. Fish Harvesting

Sea Grant's assistance in increasing the productivity of the commercial shellfish, groundfish, and mid-water fisheries resulted in annual economic effects of $37,552,300 on industry, from sixteen projects on which data are readily available.

Examples of annual economic effects	
1. Eel fishery	$ 148,000
2. Herring fishery	1,250,000
3. Commercial fish	6,500,000
4. Shrimp trawl obstruction	3,500,000
5. Side trawler operations	494,000
6. Soft blue crab production	1,000,000
7. Oyster fishery	98,100
8. Black cod fishery	321,000
9. Net damage by underwater obstructions	600,000
10. Offshore fishery	11,210
11. Alaska commercial fishery	1,055,000
12. Swordfish and blackfin tuna fisheries	2,600,000
13. Finfishery	475,000
14. Herring fishery	1,500,000
15. Great Lakes commercial fishery	6,000,000
16. Crab fishery	12,000,000
TOTAL	$37,552,300

A1. Challenge Develop the eel fishery in North Carolina.

Solution Provide research to improve fishing and handling techniques and development of export market for fresh frozen eels to Europe and Japan.

Benefit Growth of eel fishing industry from $16,000 in 1972 to $1,200,000 of foreign exports in 1980, an average annual growth of $148,000.

Source North Carolina

A2. Challenge Assist ground fishing fleet changeover to deep water species.

Solution Development of midwater fishing gear for herring export catch.

Benefit Has led to annual gross increases of $1,250,000, or net increases of $431,000 of exportable fish from 18 vessels. Technology is still spreading.

Source Rhode Island

A3. Challenge Improve the efficiency of harvesting by commercial fishermen.

Solution Assisted the fishermen to develop new and improved technology for handling nets, crab pots, and other fishing gear. Cost-effective hydraulic gear is now being used on 60 medium-sized boats.

Benefit $6,500,000 per year increased income for fishing industry.

Source North Carolina

A4. Challenge Reduce loss and damage to shrimp trawls (subject to federal compensation by law) from bottom obstructions.

Solution Collected data on obstruction locations from personal contacts with boat captains and the historical record, assembled their data with LORAN navigation coordinates, and disseminated the information to the shrimping fleet.

Benefit $3,500,000 per year.

Source Texas

A5.	**Challenge**	Improve the safety of side trawler operations; the attachment of towing cables to the stern of a side trawler is extremely hazardous, sometimes causing serious injury or death to fishermen.
	Solution	Developed and introduced to New England fishermen a quick-acting, remote-releasing hook-up block. Modification of this unique device has adapted it for use by U.S. Coast Guard for life boat handling. A commercial concern is studying use of the block as an anchor release.
	Benefit	Increased one fishing captain's earnings by at least $3,000 per year. When fully implemented, a modified block for successfully handling its new RHI lifeboat will save the Coast Guard an estimated $3,500,000 or $491,000 annually over 15 years.
	Source	Massachusetts
A6.	**Challenge**	Revitalize declining soft blue crab production.
	Solution	Provided technical, economic feasibility analysis and marketing assistance to the industry.
	Benefit	$1,000,000 per year.
	Source	Florida
A7.	**Challenge**	Reduce threat to Chesapeake Bay oyster industry of the widespread occurrence of pink coloration in oysters.
	Solution	Showed the pink coloration had no effect on the oysters' wholesomeness or palatability, publicized these findings, and convinced a Federal purchasing agent to reverse an earlier shipment rejection.
	Benefit	This one incident had a $500,000 benefit but the aggregate value to the Chesapeake Bay oyster fishery is hard to calculate. Over 15 years this amounts to an annual amount of $ 98,100.
	Source	Virginia
A8.	**Challenge**	Re-establish black cod fishing catch.
	Solution	Provided research and developed new design traps.
	Benefit	Landings increased by a factor of 8 (poundage) from 1973 to 1975 with an average annual value of $321,000.
	Source	California
A9.	**Challenge**	Prevent net damage by underwater obstructions (reimbursable by the Federal Government by law).
	Solution	Collected information on such obstacles from individual fishermen and published the descriptions and locations in a log book.
	Benefit	Saved fishermen $600,000 per year in net costs plus unaccounted reduction of losses in fishing time.
	Source	North Carolina
A10.	**Challenge**	Locate offshore fishing grounds and disseminate new sonar tracking techniques.
	Solution	Provided offshore research and training in advance fish travel, radar and navigation.
	Benefit	$80,000 in one harvest involving 5 boats (otherwise idle due to failure of inshore fishery). This amounts to $11,210 annually over 15 years.
	Source	Georgia
A11.	**Challenge**	Enhance income of native Alaskan fishermen from commercial fishing.
	Solution	Designed program to improve effectiveness of native Alaskan fishermen in commercial herring fishery.
	Benefit	Earnings increased by $1,055,000 in first year after program started.
	Source	Alaska

A12.	**Challenge**	Develop a winter catch supplement for the seasonal Gulf coast shrimp fishery to provide year-round employment and capital utilization.
	Solution	Developed new swordfish and blackfin tuna fisheries.
	Benefit	$2,600,000 per year.
	Source	Texas
A13.	**Challenge**	Find alternative fisheries for shrimpers in South Carolina.
	Solution	Helped shrimp fishermen adapt their vessels to fish for previously unexploited finfish and instructed fishermen in new techniques.
	Benefit	$475,000 annual gross income from finfish over past 5 years.
	Source	South Carolina
A14.	**Challenge**	Accurately determine the herring fish stock, to increase harvesting efficiency while protecting against over fishing.
	Solution	Successfully applied acoustic techniques for more accurately estimating fish populations for the Pacific herring fishery. Data are used in establishing the Regional Fisheries Management Plan for Pacific herring.
	Benefit	Increased the allowable harvest from approximately 30 percent resulting in an annual landed value increase of approximately $1,500,000.
	Source	Washington
A15.	**Challenge**	Rebuild the Wisconsin Great Lakes Fishing Industry.
	Solution	Identified historical spawning reefs in Lake Michigan, developed new processing and new marketing techniques for under-utilized sucker fish, developed canned pack for improved marketing of under-utilized alewives, and provided research data and technical assistance to the industry.
	Benefit	Recovery of Wisconsin commercial fishing industry from brink of collapse to $6,000,000 annual dockside sales.
	Source	Wisconsin
A16.	**Challenge**	Increase number of crab species harvested by U.S. fishermen.
	Solution	Carried out a marketing study in conjunction with North Pacific Fishery Management Council which successfully showed that Japanese Tanner Crab fishing fleets should be removed from U.S. waters.
	Benefit	Tanner Crabs now totally harvested by domestic fishing industries with a value of $18,000,000 per year to date. The U.S. industry was $6,000,000 prior to 1977.
	Source	Alaska

B. Seafood Processing and Marketing

Through Sea Grant's efforts to expand the economic base of the seafood processing industry, the annual aggregate economic effects from eleven projects on which data are readily available was $16,500,456.

Examples of annual economic effects	
1. Salmon canneries	$ 4,615,465
2. Seafood quality	150,000
3. Storage of fresh fish	454,000
4. Clam-mincing by-products	500,000
5. Oyster industry	1,000,000
6. Crab-processing wastes	2,500,000
7. Oyster-cleansing system	1,000,000
8. New domestic seafood markets	100,000
9. Shrimp processing	5,600,000
10. Fish processors	1,231,000
11. Frozen seafood packaging	350,000
TOTAL	$17,500,465

B1. Challenge Help prevent closing of Alaska salmon canneries that would result from proposed environmental regulations on disposal of salmon-processing waste requiring modification of equipment.

Solution Studied economic impact of proposed regulations and revealed serious errors in the contractor data and analysis report supporting the regulations. As a result of the Sea Grant study, EPA regulations were modified.

Benefit The requirement for modifications to waste processing equipment was rescinded with the resulting saving of $22,500,000 to the Alaskan salmon processors in 1979. This amounts to $4,615,465 annually over a 15-year period.

Source Washington

B2. Challenge Improve seafood quality by insulating boat holds.

Solution Promoted engineering and research to develop insulation requirements and handling techniques for improved quality of catch and increased income to fishermen for higher quality products.

Benefit $150,000 per year increased revenue for fishermen.

Source North Carolina

B3. Challenge Extend storage time in transportation of fresh fish.

Solution Developed CO2-modified atmosphere containers.

Benefit Estimated savings of $454,000 per year for transporting Alaskan salmon into California as well as saving one-third of energy costs.

Source California

B4. Challenge Recover and utilize protein and other nutrients from surf clam processing waste.

Solution Development of marketable clam broth and freeze-dried clam flavor ingredient.

Benefit Clam broth - $500,000 per year in sales and reduced waste treatment cost for one firm. Flavor ingredient - one firm estimates potential annual sales of $750,000.

Source New York

B5.	**Challenge**	Sustain Apalachicola Bay oyster industry threatened with shutdown due to water-quality problem.
	Solution	Through technical assistance in sanitation and processing procedures and cooperation with the state Oyster Task Force, sustained and enlarged continued production of safe oysters, even under newly strengthened sanitation requirement.
	Benefit	Not only was disaster to the industry averted, but oyster production was increased from 5,784,930 pounds in 1979 to 6,395,778 pounds in 1980 equaling a landing value of $5,800,000.
	Source	Florida
B6.	**Challenge**	Reduce the cost of disposal of crab processing wastes (many processors faced shutdown due to increased cost of waste disposal).
	Solution	Demonstrated crab-meal production, using 20-30 million pounds of hard-crab processing scrap.
	Benefit	A gross benefit of $2,500,000 per year, through reduction of waste disposal costs and sale of crab meal, has been achieved in the Middle Atlantic region.
	Source	Virginia
B7.	**Challenge**	Develop an off-bottom oyster cleansing system.
	Solution	Developed mechanization system for depuration process and performed biological studies enabling lifting of some regulatory restrictions.
	Benefit	Productive and economically feasible depuration process resulting in $1,000,000 of oysters.
	Source	Mississippi
B8.	**Challenge**	Find new seafood markets (domestic).
	Solution	Perform market research and provide technical assistance.
	Benefit	$100,000 per year to *one* company in Tennessee.
	Source	Georgia
B9.	**Challenge**	Prevent waste of edible portion of shrimp that is lost during processing.
	Solution	Developed and introduced to industry improved handling and processing techniques to reduce waste by increasing yield and saving energy.
	Benefit	Annual yield region was increased by 4 percent; the equivalent of $5,600,000 per year direct return to processors.
	Source	Oregon
B10.	**Challenge**	Assist fish processors to cope with environmental regulation problems.
	Solution	Studied operations of fish meal plants and developed a procedure to increase productivity simultaneously with reduction of problems from effluent pollution.
	Benefit	Prevented closure of fish processor allowing continuance of industry amounting to $1,231,000 gross annual income to processor and commercial fishermen.
	Source	Wisconsin
B11.	**Challenge**	Develop new convenience seafood products from under-utilized species of fish.
	Solution	Develop and market test a number of new frozen products, several eventually adopted by commercial processors.
	Benefit	Additional annual sales revenues to fish wholesalers and processors of at least $350,000.
	Source	New York

C. Aquaculture

Aquaculture of marine species provided new commercial opportunities by developing the science, technology, and economic potential. $21,752,000 represents the annual aggregate economic effects on industry from projects on which data are readily available.

Examples of annual economic effects	
1. Crawfish aquaculture	$ 8,450,000
2. Pen-reared salmon	192,000
3. Oyster beds	160,000
4. Net-pen fishery	3,000,000
5. Land clam and oyster spawn	400,000
6. Seafood production	6,000,000
7. Maine fishing industry	1,000,000
8. Ocean ranching	2,300,000
9. Salmonid mortality	250,000
TOTAL	$21,752,000

C1. Challenge Develop crawfish aquaculture as an industry in Louisiana.

Solution Since 1969, introduced research on crawfish aquaculture to pond operators and to rice farmers where crawfish are now being stocked in rice paddies.

Benefit Increased pond acreage from 12,000 acres in 1969 to 62,000 acres in 1980 with associated increased income for crawfish farmers of $8,450,000 per year.

Source Louisiana

C2. Challenge Reduce mortality rate (50 to 80 percent) of pen-reared salmon when smolt are transferred from freshwater to saltwater.

Solution Through genetic research (similar to that applied to the poultry industry), developed a strain of Coho salmon specifically adapted to pen-rearing with one-half the mortality rate of natural stock.

Benefit One commercial salmon grower realized a net saving of $192,000 per year raising this new strain.

Source Washington

C3. Challenge Help prevent continual reduction of the size of natural oyster beds due to development and pollution.

Solution Develop pilot closed-system oyster culture facility.

Benefit Understanding in oyster spawning, spot setting, nutrition, and water quality control are already contributing an estimated $160,000 per year benefit to the natural bed fisheries. The ultimate goal of commercial sized closed-system aquaculture facilities will be a major industry and conservation breakthrough.

Source Delaware

C4. Challenge Develop a net-pen fishery.

Solution Provided research and demonstrated projects that resulted in several companies in the Pacific Northwest going into commercial production of salmon using this technology.

Benefit DomSea Farms, now a subsidiary of Campbell Soup, is harvesting over $3,000,000 of salmon per year.

Source Washington

C5.	**Challenge**	Reduce disease-related mortalities in New York shellfish hatcheries.
	Solution	Research/extension program to identify diseases of New York shellfish, develop disease-control procedures and train hatchery operators in these procedures.
	Benefit	Doubling of effective hatchery production on Long Island should produce annual market sales increases of $400,000.
	Source	New York
C6.	**Challenge**	Increase the production of seafood through aquaculture.
	Solution	Conducted research to identify and select the most promising plant and animal species for aquaculture, developed the supporting technology and marine science for commercial expansion, and provided advisory assistance to the developing industry.
	Benefit	Aquaculture in Hawaii now produces a wholesale value of over $6,000,000 (1980) and is projected to increase to over $32,000,000 in 1985.
	Source	Hawaii
C7.	**Challenge**	Bring greater economic stability to the Maine fishing industry.
	Solution	Stimulated the formation of a new shellfish aquaculture industry.
	Benefit	This still young industry's last year's sales exceeded $1,000,000 with a projected five-fold increase over the next five years.
	Source	Maine
C8.	**Challenge**	Develop ocean ranching in Alaska.
	Solution	Assisted development of private non-profit aquaculture corporation and hatchery to stock salmon in geographic areas where salmon fisheries do not exist.
	Benefit	New salmon fishery where salmon stocks had not existed with a catch in 1980 valued at $2,300,000.
	Source	Alaska
C9.	**Challenge**	Excessive mortality in smoltification of salmonids.
	Solution	By demonstrating the role of ammonia in oxygen transport in fish, investigators have helped the Dworshak National Fish Hatchery to reduce salmonid mortality during smoltification from 35,000 per day to 300 per day.
	Benefit	An annual savings of $250,000.
	Source	Rhode Island

D. Marine Construction

Facilitating improvements in environmentally sound, economical and safe coastal and offshore construction activities has resulted in $126,895,771 annualized cost avoidance or savings aggregated from projects on which data are available.

Examples of annual economic effects	
1. Mathematical modeling	$ 80,645,771
2. Construction aggregates	45,000,000
3. Sand and dredging industry	250,000
4. Wave-tracking buoy	1,000,000
TOTAL	$126,895,771

D1. Challenge Assess impacts on marine environment of offshore construction and disposal permitting.

Solution Developed finite element mathematical models to accurately assess impacts and successfully predict transport and disposal of materials in semi-enclosed water bodies.

Benefit Saved $29,000,000 to $54,000,000 in estimated circulating-water channel modifications or new construction costs. An annual saving of $5,417,779 over 15 years. Using the minimum estimate amortized over an assumed 10-year construction period, this represents a $2,900,000 annualized cost avoidance. Demonstrated environmental acceptability of sewage outflow led to EPA approval of a waiver request and will result in construction cost avoidance of $400,000,000 ($300,000,000 is federal subsidy). Amortizing this saving over a 10-year construction period, this represents a $74,727,992 annualized cost avoidance. Contractor reports savings of $15,000 to $80,000 for each application of the model over conventional techniques and estimates total savings of up to $500,000 per year.

Source Massachusetts

D2. Challenge Assure availability of reasonably-priced supply of construction aggregate to New York Metropolitan Area.

Solution Econometric models capable of predicting net cost reductions from aggregate mining in New York Harbor.

Benefit Development of most cost-effective mining scenario would produce annual cost savings of $20,000,000 to sand suppliers and $45,000,000 to building industry.

Source New York

D3. Challenge Revitalize sand and dredging industry in Toledo, closed because of environmental concerns.

Solution Showed that the sand and gravel used for construction aggregate could be dredged without harming the environment.

Benefit $250,000 worth of sand and gravel now dredged annually.

Source Ohio

D4. Challenge Obtain accurate wave-spectra data for design and construction of offshore facilities and structures.

Solution Developed wave-tracking buoy to directly measure and record wave directional spectra.

Benefit New wave-tracking buoy has been added to a small business product line with projected annual sales of $1,000,000.

Source Massachusetts

E. Marine Transportation

The result of increasing the efficiency and safety of the U.S. shipping fleet and the competitiveness of U.S. boat manufacturers in the Mexican market meant an annual aggregate economic benefit to industry of $2,890,000 from four projects on which data are readily available.

Examples of annual economic effects	
1. Satellite information	$1,560,000
2. Shrimp boat manufacturing	700,000
3. Fishing vessel replacement	40,000
4. Offshore tanker mooring	590,000
TOTAL	$2,890,000

E1. Challenge Disseminate NOAA's satellite information on Gulf Stream dynamics to disaggregated user industries.

Solution Worked with NOAA satellite and weather service personnel to locate and establish communication linkages to a broad-base user clientele.

Benefit One shipping company estimates $1,560,000 annual savings in fuel costs.

Source Florida

E2. Challenge Increase competitiveness of U.S. shrimp boat manufacturing (for international markets).

Solution Trained international boat operators for maximum vessel usage (on site) (e.g., Mexican fishermen).

Benefit Continued gross sales of U.S.-built vessels amounted to $700,000 in a year.

Source Georgia

E3. Challenge Replace worn out fishing vessels for individual fishermen.

Solution Instructed fishermen how to build their own fiberglass boats.

Benefit Sixteen boats built resulted in total net saving of $40,000.

Source South Carolina

E4. Challenge Improve the safety of offshore tanker mooring operations.

Solution Developed prototype talking current spar buoy that reports ocean currents to ship operators making offshore moorings.

Benefit A new talking current spar buoy instrument has been added to a small business product line with projected annual gross sales of $590,000.

Source Massachusetts

F. Marine-related Retail Trade

Sea Grant helped promote the growth of precious coral and pet turtle industries and helped reduce the loss of lives from cold-water drownings. $19,400,000 represents the annual aggregate economic effects on industry from only three projects on which data are readily available.

Examples of annual economic effects	
1. Cold-water drowning	$10,000,000
2. Pet turtle industry	2,100,000
3. Precious coral industry	7,300,000
TOTAL	$19,400,000

F1. Challenge Reduce loss of lives resulting from cold-water drownings.

Solution Studied temperature regulation of humans in cold-water environments and, in partnership with industry, designed new kinds of personal flotation devices that minimize body temperature loss.

Benefit Stimulated production in three new lines of personal flotation devices and thermal suits grossing $10,000,000 in 1980.

Source Minnesota

F2. Challenge Help prevent collapse of pet turtle industry threatened due to FDA ban on interstate shipment of carriers of salmonella.

Solution Developed antibiotic treatment of turtle eggs in vacuum chamber that eliminated the salmonella transmission problem.

Benefit Industry expanded in business to $2,100,000 yearly production.

Source Louisiana

F3. Challenge Develop a precious coral industry while husbanding rare stocks of coral.

Solution Promoted research and application of undersea technologies.

Benefit The industry grew from 50 employees and gross sales of $500,000 to 214 employees and gross sales of $7,800,000.

Source Hawaii

G. Marine-related Real Estate

The economic importance of coastal real estate has motivated the development of new technologies for shoreline stabilization, flood control, and alternative methods of sewage treatment. This represents $3,000,000 aggregated annual economic effects on industry from four projects on which data are available.

Examples of annual economic effects	
1. Shoreline erosion	$1,000,000
2. Flood control	750,000
3. Waste disposal	850,000
4. Irradiation of sewage sludge	400,000
TOTAL	$3,000,000

G1. Challenge Reduce economic losses to coastal property owners from shoreline erosion.

Solution Performed research on vegetation to stabilize shorelines, studies of cement-asbestos bulkhead failure, and research on erosion in local communities, providing information to adjust building setbacks.

Benefit $1,000,000 saved from property damages and remedial actions.

Source North Carolina

G2. Challenge Improve flood control techniques.

Solution Developed and demonstrated new design concepts.

Benefit Reduction in federal flood insurance payments (e.g., $750,000 per flood) and reduced flooding.

Source New York

G3. Challenge Reduce the impact of waste disposal on the economic development of coastal land and water.

Solution Provide research on environmental distribution of sewage waste and developed alternative, cost-effective disposal system which has been approved and adopted by coastal communities.

Benefit $850,000 per year increase in shellfish harvest and the lifting of building restrictions to allow $4,000,000 of new building during 1980.

Source North Carolina

G4. Challenge Provide a new method of sewage sludge treatment that is less capital and energy intensive.

Solution Developed and had approved by EPA an electron irradiation process for pasteurizing sewage sludge.

Benefit Miami-Dade Water and Sewage Authority is now constructing the first facility based on this process which is projected to perform at an annual savings of $400,000.

Source Massachusetts

H. Marine Service Industry

Reducing wave damage to marinas and finding an economically feasible alternative to breakwater construction for small marinas resulted in annual aggregate economic effects on industry of $812,760 from just three projects. These savings have been replicated numerous times in many regions of the United States.

Examples of annual economic effects	
1. Small-marina operators	$ 176,760
2. Wave damage reduction	500,000
3. Marine trade seminars	136,000
TOTAL	$ 812,760

H1. Challenge Find an economically feasible alternative to traditional breakwater constructions for small-marina operators.

Solution Introduced marina operators to the concept of floating tire breakwaters and floating tire docks, gave the needed design and construction information, and advised on the construction and installation of an expanded marina facility.

Benefit Saved $176,760 in annual facilities costs.

Source Michigan

H2. Challenge Develop low-cost, effective shore protection technologies.

Solution With Rhode Island, design, construct, and field test several floating tire breakwaters.

Benefit Annual savings to shorefront property owners of $500,000 through reduced wave and storm related damage.

Source New York

H3. Challenge Improve efficiency of marine recreational firms.

Solution Formulated and conducted ten marine trade management seminars along the U.S. East Coast involving 680 firms.

Benefit $136,000 in immediate savings.

Source Rhode Island

8. External Evaluations

Evaluations of the National Sea Grant College Program by seven federal, academic, and private sector organizations

- National Advisory Committee on Oceans & Atmosphere
- Department of Commerce, Office of Program Evaluation
- General Accounting Office
- University of Connecticut, Institute of Social Inquiry
- National Oceanic & Atmospheric Administration, Office of Policy & Planning
- Massachusetts Institute of Technology, Center for Policy Alternatives
- Heritage Foundation

EXTERNAL EVALUATIONS OF THE NATIONAL SEA GRANT COLLEGE PROGRAM

Although funding for Sea Grant represents a mere fraction of the billion dollar federal ocean program, it has been the subject of continuous scrutiny and evaluation for more than a decade. Studies have focused on:

- The general effectiveness of the program
- Sea Grant's relationship to the National Oceanic and Atmospheric Administration
- Contributions of individual research projects
- Attitudes and perceptions of academic marine scientists toward Sea Grant

Several themes emerge in these assessments:

- Sea Grant plays a unique and important role in the nation's marine program.
- The program's strengths reside in its ability to promote interdisciplinary marine research, education, and advisory activities responsive to both local and national needs. Its biggest limitation in fulfilling its promise has been insufficient funding.
- Perceptions about the quality of Sea Grant research and administrative effectiveness depend largely on whether researchers are interested primarily in basic or applied research.
- A variety of administrative changes would improve the effectiveness of the program.
- The relationship between Sea Grant and its parent agency, the National Oceanic and Atmospheric Administration, can and should be clarified in a manner that would enable each to draw on the strengths and resources of the other.

The following sections summarize, with a minimum of commentary, the major points made in these reports. Although many of the recommendations made have been addressed by the National Sea Grant Office and the Sea Grant directors, no effort is made here to trace these actions or to summarize the evaluations of the Sea Grant programs made as a regular part of the congressional oversight or budget process. All of these forms of oversight and review have been useful in helping lead to the program's accomplishments cited in other sections of this book.

National Advisory Committee On Oceans and Atmosphere, 1976

During the fall of 1975, the members and staff of the National Advisory Committee on Oceans and Atmosphere (NACOA), embarked on a year-long evaluation of the Sea Grant program. Based on extensive interviews, site visits, panel reviews, attendance at directors' meetings and a review of the extensive documentation about the program, the Committee concluded:

> Sea Grant plays an important role in the national effort to develop and conserve our marine resources. Its ability to draw on the pool of talent in our universities and other research institutions, and its close contacts with users and potential users of marine information and technology, enable it to complement the activities of the numerous other Federal agencies and programs also concerned with marine resource development. Its most significant contributions have stemmed from its sensitivity to regional and local perceptions of issues which, while collectively important to the Nation, may be individually too small or too new to have attracted attention at the Federal level.

The National Sea Grant Program: A Review
A Report for the Secretary of Commerce
Washington, D.C., November 3, 1976

Sea Grant plays an important role in the national effort to develop and conserve our marine resources. Its ability to draw on the pool of talent in our universities and other research institutions, and its close contacts with users and potential users of marine information and technology, enable it to complement the activities of the numerous other Federal agencies and programs.

In strongly recommending that the program be continued, NACOA noted that Sea Grant had been "responsive to its legislative charter", had "contributed significantly to the Nation's marine effort," and that there was "a continuing need for the kind of service it provides." To strengthen the program, the Committee made recommendations on policy, management and funding.

With respect to policy, NACOA urged the Administator of NOAA to "clarify the goals and role of Sea Grant in relation to NOAA's overall mission", to make more extensive use of the Sea Grant Advisory Panel for advice on broad policy issues, and to develop and implement procedures for improved coordination between other agencies, other parts of NOAA, and Sea Grant.

The Office of Sea Grant was encouraged to clarify its guidelines; aid participating institutions in establishing priorities; expedite its proposal review process; ensure that engineering is incorporated into research projects where appropriate; and, for projects with commercial potential, consider economic as well as technical feasibility.

NACOA concluded that federal funding was "inadequate for the task assigned to the program," hence should be increased to a minimum of $40 million per year over the next several years.

Department of Commerce Office of Program Evaluation, 1976

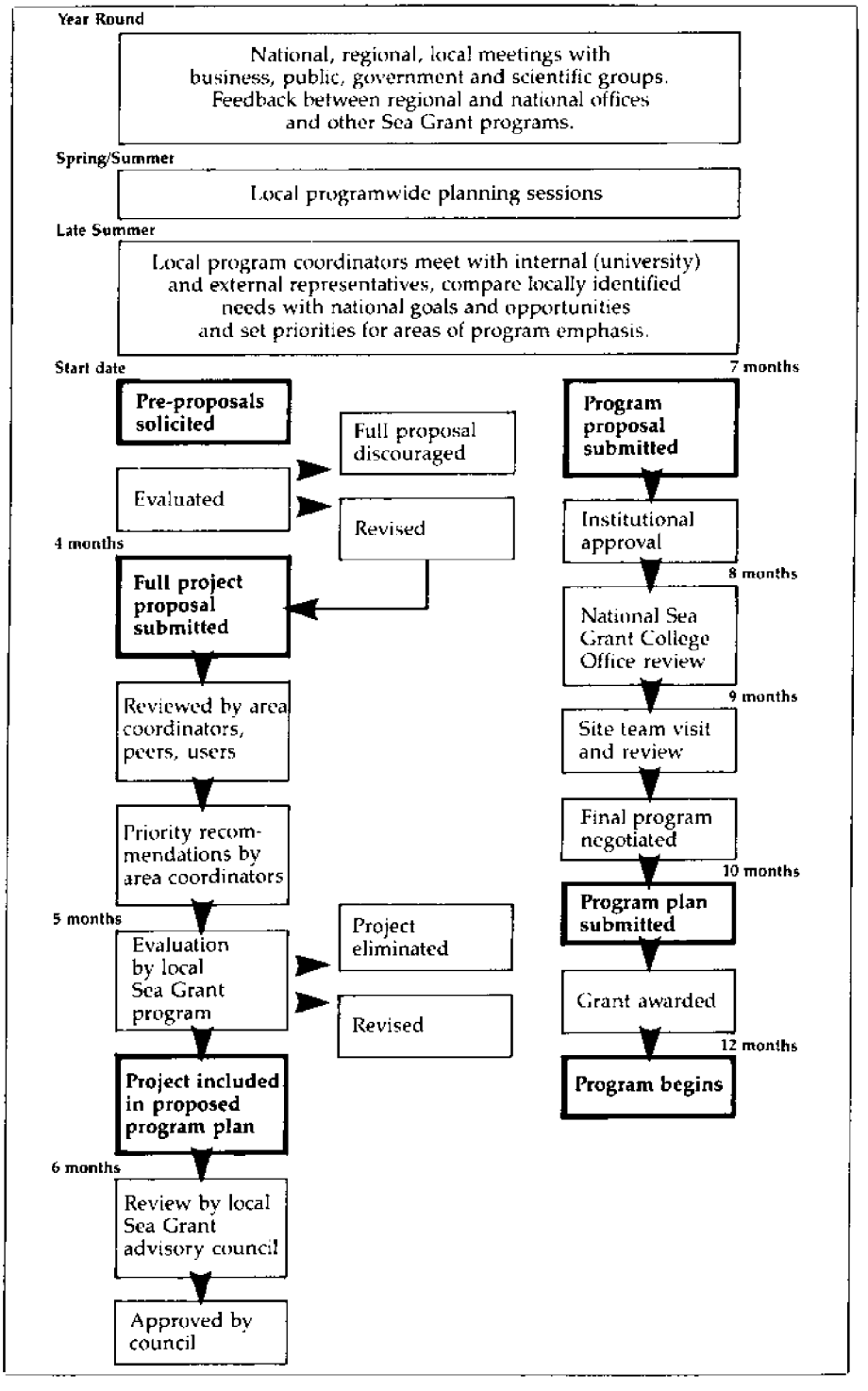
In a staff study, Department of Commerce evaluation specialists addressed two questions raised initially by the Office of Management and Budget. These were whether Sea Grant was a "capacity-building program" or a conduit for grants, and whether or not these grants duplicated work supported by other agencies. The report noted that Sea Grant represented only a fraction of the total funding for federal marine programs but endorsed Sea Grant's role in developing institutional capabilities (e.g., "capacity-building").

They concluded that Sea Grant research was funded by a variety of public and private sources; provided a mechanism for passing funds from other agencies which reduced administrative costs and duplication; and employed an effective six-stage (see figure) review process which assured project quality. They also noted that peer reviews of the Sea Grant approach and program administration had been favorable and that "the local

initiative model" was preferred to a model which sought to impose national criteria for requesting and selecting research proposals.

With respect to "capacity-building", however, there was no common understanding of the goals, objectives, and procedures for developing the kinds of institutions and resources required to fulfill government mission. It did seem possible, however, that a model of "capacity-building could be developed and tested which would have pay-offs in Sea Grant's resource management and program structure." The evaluators recommended that the Office of Management and Budget develop a "capacity-building model" for application throughout the government.

Sea Grant Programs
Planning, Proposal and Review Process



This diagram outlines the planning, proposal and review process at major Sea Grant institutions. Though details will vary from institution to institution, the process is typical. The diagram, which does not appear in the 1976 report from the Department of Commerce, is included here for information purposes.

General Accounting Office 1974 and 1979

The General Accounting Office (GAO) has conducted two assessments of Sea Grant. The first and most extensive was conveyed by letter to the Office of Sea Grant on March 16, 1974, and the second, far more limited in scope, was summarized in a letter dated October 15, 1979.

The 1974 observations were directed primarily at issues of program management and reporting. Recommendations included more explicit attention to relating efforts to accomplishments and benefits; increased suggestions for program development by local advisory groups; more attention by Sea Grant to matching costs; development of procedures that would, before final approval of a proposal, resolve and document actions taken as a result of peer reviews; and creation of a NOAA-wide advisory service. Additional suggestions concerned establishing guidelines and procedures for the management of Sea Grant programs in the universities.

The 1979 letter was based on an examination of the administration of Sea Grant to identify areas needing further review and analysis. On the basis of visits to Sea Grant programs in six states, personal contacts in four others, and discussions with NOAA personnel, the reviewers concluded that: (1) "Many Sea Grant projects appear to have only limited application and to be of little benefit to the identified user community," and (2) "A followup evaluation appears to be needed to determine if the federally supported Sea Grant projects are meeting expected goals and objectives."

The first observation was based on a strictly literal interpretation of the relationship between research, advisory services and users, a point made with great clarity and force in the Office of Sea Grant's explanation of why it could not accept that statement as valid. The second statement involved evaluation of completed projects, procedures for which were well established in Sea Grant administrative practices.

University of Connecticut Institute for Social Inquiry, 1977-79

W. Wayne Shannon and David D. Palmer of the Institute for Social Inquiry at the University of Connecticut undertook an extensive study of the relationship between federal funding agencies and university marine scientists. Their report, *The Federal Funding of Academic Marine Science*, is the only report that examines Sea Grant in the context of the broader pattern of federal support for academic marine programs.

Data were compiled between 1977 and 1979 from mail questionnaires received from 793 academic marine scientists, 918 questionnaires from recent graduates of marine programs, and 153 interviews with federal agency and university administrators.

The researchers noted that Sea Grant, along with the National Science Foundation's Oceanography Section and Office for the International Decade of Ocean Exploration (since 1980 merged in the Division of Ocean Sciences), and the Navy's Office of Naval Research have the most extensive linkages to the university ocean research community of all federal agencies.

Interviews and survey data revealed several areas of dissatisfaction on the part of university marine scientists:

- That the national Sea Grant office had not followed a consistent program
- That site visit review teams assigned to various institutions were often comprised of individuals who were deemed insufficiently familiar with the programs to evaluate them "in a professional and consistent manner over time"

- That Sea Grant was "too sensitive to political winds" and the wants of different users, "too prone to 'target' various desired areas of research, too much concerned with relevance and too anxious to cite accomplishments in the real world."
- That there was an "excessively arduous review process" for Sea Grant proposals and too little money to support and sustain those who were interested in doing Sea Grant research

At the heart of many of these concerns was the tension between Sea Grant's emphasis on applied research and university scientists' desire to pursue basic problems of their own choosing.

The authors observed, however, that often after such critical comments were made, persons expressing them would quickly reaffirm interest in and devotion to the "Sea Grant idea." They concluded:

> While it is surely not everyone's enthusiasm, a broad range of individuals in the academic marine science community see Sea Grant as a highly important part of the federal funding system. Recognition is widespread that Sea Grant is the most durable and institutionally committed program supporting academic marine science research beyond the disciplines of oceanography, proper. Its importance as a catalyst for interdisciplinary activity, marine-related engineering, and social science is widely recognized. Generally, however, there is a pervasive sentiment in the academic community, even among some of Sea Grant's strongest supporters, that the Sea Grant idea--a creative partnership between the federal government, the university, and the governmental and private users of marine technology--needs continuing assessment and perfected implementation.

Recognition is widespread that Sea Grant is the most durable and institutionally committed program supporting academic marine science research beyond the disciplines of oceanography, proper.

National Oceanic and Atmospheric Administration Office of Policy and Planning, 1980

This internal staff report reviewed the legislative origins of Sea Grant, its administrative practices, and funding history as a basis for improving Sea Grant's relationships with other parts of NOAA. The basic questions included: (1) the responsiveness of Sea Grant to NOAA's needs and (2) ways in which cooperation between Sea Grant and other parts of NOAA might be improved.

Sea Grant, noted the report, fills a number of roles for NOAA. It is NOAA's largest "marine outreach arm, through its advisory services, educational activities and university research," and thus is able to maintain close contact with marine specialists in the universities. Sea Grant with its constituency base and attention to local needs, is able to respond to local issues and concerns, as well as serve as an effective early warning system for emerging national problems. Sea Grant had not, however, "been used adequately to enhance NOAA's stature and image."

The report recommended improved communication between Sea Grant and other parts of NOAA, more participation in the Sea Grant review process by other NOAA specialists, and improved understanding of the roles, mission, and priorities by those in Sea Grant and NOAA in order to improve the performance of each.

Massachusetts Institute of Technology Center for Policy Alternatives, 1977

A study of program development procedures and transfer mechanisms in the National Sea Grant Program was undertaken by the Center for Policy Alternatives at Massachusetts Institute of Technology. This study evolved from an earlier MIT evaluation of the commercial and foreign trade impact of the Sea Grant program, and it sought to suggest ways Sea Grant could increase the speed and frequency of economic benefits without sacrificing other benefits of Sea Grant support, or "distorting the fundamental characteristics of participating institutions."

The analysis reviewed the conditions that influenced commercially successful Sea Grant projects, program orientation, and development procedures and transfer mechanisms, with particular emphasis on the strengths and deficiencies of each of these aspects of the program. Inadequate funding was a key problem. "Many imaginative initiatives" had been rejected and Sea Grant institutions had few incentives to promote new ideas in the face of limited funding. A more fundamental problem, however, was the failure of Sea Grant "to project itself forcefully and prove its usefulness."

The researchers concluded that "the objective which it established for itself during its first ten years--the construction of a forceful and balanced network of institutions to implement the Sea Grant concept--has been achieved, and in the opinion of the authors, with highly superior marks."

They urged that attention turn to defining those areas where Sea Grant wished to make an impact, to promote a network of diverse institutions, each with its own special strengths and capabilities, and continue to play a "forceful catalyst role, linking university and community together in research on relevant and highly present" marine resource issues.

In addition, Sea Grant should make a "more unabashed effort to 'sell' itself", and to continually emphasize the close working relationship between advisory services and research projects which "remain Sea Grant's strongest asset."

To pursue these goals, the analysts called for a more active role in program development by the national Sea Grant office, the review panel, and the directors, in particular in setting priorities and identifying clusters ("portfolios") of research projects, and the use of site visits to review past performance.

They also recommended greater latitude for high-risk proposals (which the earlier MIT study found produced the greatest pay-offs), and active pursuit of more cooperation with the private sector, including joint university-industry programs.

Massachusetts Institute of Technology Center for Policy Alternatives, 1981-82

The National Sea Grant College Program has many goals and activities that are important to the nation and to the individual states. Given the nature of marine problems and opportunities and of universities, not all activities can or should lead to readily quantifiable results. However, the work of the Sea Grant institutions has led to a number of demonstrable economic benefits.

In 1981, annual sales in the range of $44-62 million resulted from the 19 projects surveyed that have led to commercial developments. Thus, even with the most conservative figure, annual sales from this small sample exceed the highest annual federal appropriation ($41.8 million in FY81) to the National Sea Grant College Program.

One class of economic benefits can be measured by commercial product developments that result in sales. In 1976, the Massachusetts Institute of Technology's Center for Policy Alternatives (CPA) looked at a sample (77) of Sea Grant projects funded in 1975 that might lead to new commercial products and tried to predict future sales.

In 1981-82, a team at the Center headed by Professor James Utterback and Margaret Linskey reviewed developments in 59 of the 77 projects over the intervening six years. Results were published in a CPA report entitled, *A Reevaluation in 1981 of the Commercial Use of Sea Grant Projects Funded in 1975.* Highlights of the report include:

- In 1981, annual sales in the range of $44-62 million resulted from the 19 projects surveyed that have led to commercial developments. Thus, even with the most conservative figure, annual sales from this small sample exceed the highest annual federal appropriation ($41.8 million in FY81) to the National Sea Grant College Program.
- Eleven new products have resulted as a direct consequence of the Sea Grant projects studied.
- Ten new companies have been formed primarily as a direct result of Sea Grant efforts to introduce the projects' results commercially.

- There have been approximately 25 secondary companies that have started producing products similar to those of the 10 primary companies.
- High risk, broadly based research projects have actually produced more of the values reported than have those that were seemingly less risky and more specific at the outset.
- The more successful projects often go in directions other than their originally stated objectives, exhibiting Sea Grant flexibility to accommodate emerging industrial and market needs.
- At least 15 additional projects from the sample which have not yet produced commercial results are thought still to have potential. This underlines the long-term nature of research and development.
- Sea Grant has built a stable and reliable marine research base.
- Graduate students from Sea Grant programs are particularly effective in transferring Sea Grant research results to industry and government agencies.
- There have been many indirect or social returns from Sea Grant work, such as increased personal safety at sea, increased quality and availability of seafood products, and the introduction of new production methods and new uses for products originating in the oceans.

It should be reemphasized that the report, like the 1981 *Economic Effects of Sea Grant*, studied only a small sample of Sea Grant work and only a specifically prescribed set of benefits. Even in the circumscribed area of economic benefits, it did not look at all projects or at the many other kinds of economic benefits, such as cost savings or jobs preserved. In that light, the results are even more impressive.

Heritage Foundation, 1981

Sea Grant funding should be increased by 10 percent per year in real terms for the next five years.

Prior to President Ronald Reagan's first inauguration, teams of knowledgable individuals, under the auspices of the Heritage Foundation, surveyed the role and performance of programs throughout the federal government. The group that evaluated the Department of Commerce found that:

> The Sea Grant Program has an impressive record of success, primarily because it is based largely on local priorities and needs. It operates in partnership with State and local governments, private industry, universities, organizations and individuals concerned with or affected by ocean and coastal resources. The Congress makes regular requests of Sea Grant for information.
>
> A key element of Sea Grant is its outreach mechanism whereby results of research are provided to users in industry, government agencies and the general public.
>
> Sea Grant funding should be increased by 10 percent per year in real terms for the next five years.

Mandate for Leadership
Charles L. Heatherly, editor
Heritage Foundation, Washington, DC, 1981

9. Legislation

The Sea Grant Program Improvement Act of 1976 (P.L. 94 = 461) and Amendments of 1978, 1980, and 1984.

Public Law 94-461
94th Congress

An Act

To improve the national sea grant program and for other purposes.

Oct. 8, 1976
[H.R. 13035]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Sea Grant Program Improvement Act of 1976".

Sea Grant Program Improvement Act of 1976. 33 USC 1121 note.

SEC. 2. AMENDMENT TO THE NATIONAL SEA GRANT COLLEGE AND PROGRAM ACT OF 1966.

Title II of the Marine Resources and Engineering Development Act of 1966 (33 U.S.C. 1101 et seq.) is amended to read as follows:

"TITLE II—NATIONAL SEA GRANT PROGRAM

National Sea Grant Program Act. 33 USC 1121 note.

"SEC. 201. SHORT TITLE.

"This title may be cited as the 'National Sea Grant Program Act'.

33 USC 1121.

"SEC. 202. DECLARATION OF POLICY.

"(a) FINDINGS.—The Congress finds and declares the following:

"(1) The vitality of the Nation and the quality of life of its citizens depend increasingly on the understanding, assessment, development, utilization, and conservation of ocean and coastal resources. These resources supply food, energy, and minerals and contribute to human health, the quality of the environment, national security, and the enhancement of commerce.

"(2) The understanding, assessment, development, utilization, and conservation of such resources require a broad commitment and an intense involvement on the part of the Federal Government in continuing partnership with State and local governments, private industry, universities, organizations, and individuals concerned with or affected by ocean and coastal resources.

"(3) The National Oceanic and Atmospheric Administration, through the national sea grant program, offers the most suitable locus and means for such commitment and involvement through the promotion of activities that will result in greater such understanding, assessment, development, utilization, and conservation. Continued and increased Federal support of the establishment, development, and operation of programs and projects by sea grant colleges, sea grant regional consortia, institutions of higher education, institutes, laboratories, and other appropriate public and private entities is the most cost-effective way to promote such activities.

"(b) OBJECTIVE.—The objective of this title is to increase the understanding, assessment, development, utilization, and conservation of the Nation's ocean and coastal resources by providing assistance to promote a strong educational base, responsive research and training activities, and broad and prompt dissemination of knowledge and techniques.

"(c) PURPOSE.—It is the purpose of the Congress to achieve the objective of this title by extending and strengthening the national sea

AMENDMENTS *

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the title heading of title II of the Marine Resources and Engineering Development Act of 1966 (33 U.S.C. 1101 et seq.) is amended to read as follows:

National sea grant program, appropriation authorization. 1978

"TITLE II—NATIONAL SEA GRANT COLLEGE PROGRAM".

Section 201 of the National Sea Grant Program Act (33 U.S.C. 1121) is amended by inserting "College" immediately before "Program". 33 USC 1121 note. 1978

Sections 202(a)(3), 203(3), 204, and 211 are each amended by striking out "national sea grant program" each place it appears therein and inserting in lieu thereof "national sea grant college program". 33 USC 1121-1123, 1130. 1978

* 1978 = 1978 Amendments
Public Law 95-428-Oct. 7, 1978(92 Stat. 999)
1980 = 1980 Amendments
Public Law 96-289-June 28, 1980(94 Stat. 605)
1984 = 1984 Amendments
Public Law 98-623—November 8, 1984

grant program, initially established in 1966, to promote research, education, training, and advisory service activities in fields related to ocean and coastal resources.

33 USC 1122. "SEC. 203. DEFINITIONS.

"As used in this title—

"(1) The term 'Administration' means the National Oceanic and Atmospheric Administration.

"(2) The term 'Administrator' means the Administrator of the National Oceanic and Atmospheric Administration.

"(3) The term 'Director' means the Director of the national sea grant program, appointed pursuant to section 204(b).

"(4) The term 'field related to ocean and coastal resources' means any discipline or field (including marine science (and the physical, natural, and biological sciences, and engineering, included therein), marine technology, education, economics, sociology, communications, planning, law, international affairs, and public administration) which is concerned with or likely to improve the understanding, assessment, development, utilization, or conservation of ocean and coastal resources.

"(5) The term 'includes' and variants thereof should be read as if the phrase 'but is not limited to' were also set forth.

"(6) The term 'marine environment' means the coastal zone, as defined in section 304(1) of the Coastal Zone Management Act of 1972 (16 U.S.C. 1453(1)); the seabed, subsoil, and waters of the territorial sea of the United States; the waters of any zone over which the United States asserts exclusive fishery management authority; the waters of the high seas; and the seabed and subsoil of and beyond the outer Continental Shelf.

"(7) The term 'ocean and coastal resource' means any resource (whether living, nonliving, manmade, tangible, intangible, actual, or potential) which is located in, derived from, or traceable to, the marine environment. Such term includes the habitat of any such living resource, the coastal space, the ecosystems, the nutrient-rich areas, and the other components of the marine environment which contribute to or provide (or which are capable of contributing to or providing) recreational, scenic, esthetic, biological, habitational, commercial, economic, or conservation values. Living resources include natural and cultured plant life, fish, shellfish, marine mammals, and wildlife. Nonliving resources include energy sources, minerals, and chemical substances.

"(8) The term 'panel' means the sea grant review panel established under section 209.

"(9) The term 'person' means any individual; any public or private corporation, partnership, or other association or entity (including any sea grant college, sea grant regional consortium, institution of higher education, institute, or laboratory); or any State, political subdivision of a State, or agency or officer thereof.

"(10) The term 'sea grant college' means any public or private institution of higher education which is designated as such by the Secretary under section 207.

"(11) The term 'sea grant program' means any program which—

"(A) is administered by any sea grant college, sea grant regional consortium, institution of higher education, institute, laboratory, or State or local agency; and

"(B) includes two or more projects involving one or more of the following activities in fields related to ocean and coastal resources:

Sec. 203(3): See amendment (1978) at Sec. 202(a)(3)

in section 203(6) by inserting "Great Lakes and the" immediately before "territorial sea"; 33 USC 1121 note. 1980

"(i) research,
"(ii) education,
"(iii) training, or
"(iv) advisory services.

"(12) The term 'sea grant regional consortium' means any association or other alliance which is designated as such by the Secretary under section 207.

"(13) The term 'Secretary' means the Secretary of Commerce.

"(14) The term 'State' means any State of the United States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Commonwealth of the Mariana Islands, or any other territory or possession of the United States.

"SEC. 204. NATIONAL SEA GRANT PROGRAM.

33 USC 1123.

"(a) IN GENERAL.—The Secretary shall maintain, within the Administration, a program to be known as the national sea grant program. The national sea grant program shall consist of the financial assistance and other activities provided for in this title. The Secretary shall establish long-range planning guidelines and priorities for, and adequately evaluate, this program.

Planning guidelines and priorities.

"(b) DIRECTOR.—(1) The Secretary shall appoint a Director of the national sea grant program who shall be a qualified individual who has—

"(A) knowledge or expertise in fields related to ocean and coastal resources; and

"(B) appropriate administrative experience.

"(2) The Director shall be appointed and compensated, without regard to the provisions of title 5, United States Code, governing appointments in the competitive service, at a rate not in excess of the maximum rate for GS-18 of the General Schedule under section 5332 of such title.

5 USC 3301 *et seq.*
5 USC 5332 note.

"(c) DUTIES.—The Director shall administer the national sea grant program subject to the supervision of the Secretary and the Administrator. In addition to any other duty prescribed by law or assigned by the Secretary, the Director shall—

"(1) apply the long-range planning guidelines and the priorities established by the Secretary under subsection (a);

"(2) advise the Administrator with respect to the expertise and capabilities which are available within or through the national sea grant program, and provide (as directed by the Administrator) those which are or could be of use to other offices and activities within the Administration;

"(3) evaluate activities conducted under grants and contracts awarded pursuant to sections 205 and 206 to assure that the objective set forth in section 202(b) is implemented;

"(4) encourage other Federal departments, agencies, and instrumentalities to use and take advantage of the expertise and capabilities which are available through the national sea grant program, on a cooperative or other basis;

"(5) advise the Secretary on the designation of sea grant colleges and sea grant regional consortia and, in appropriate cases, if any, on the termination or suspension of any such designation; and

"(6) encourage the formation and growth of sea grant programs.

"(d) POWERS.—To carry out the provisions of this title, the Secretary may—

The section heading of such section 204 is amended to read as follows: 1978

"SEC. 204. NATIONAL SEA GRANT COLLEGE PROGRAM."

Sec. 204(all parts): See amendment (1978) at Sec. 202(a)(3)

in section 204(c) by redesignating paragraphs (5) and (6) as paragraphs (6) and (7), respectively, and by inserting immediately after paragraph (4) the following new paragraph: 1980

33 USC 1122.
33 USC 1123.

"(5) encourage cooperation and coordination with other Federal programs concerned with ocean and coastal resource conservation and usage;".

"(1) appoint, assign the duties, transfer, and fix the compensation of such personnel as may be necessary, in accordance with the civil service laws; except that five positions may be established without regard to the provisions of title 5, United States Code, governing appointments in the competitive service, but the pay rates for such positions may not exceed the maximum rate for GS-18 of the General Schedule under section 5332 of such title;

5 USC 3301 et seq.

5 USC 5332 note.

"(2) make appointments with respect to temporary and intermittent services to the same extent as is authorized by section 3109 of title 5, United States Code;

Publication.

"(3) publish or arrange for the publication of, and otherwise disseminate, in cooperation with other services, offices, and programs in the Administration, any information of research, educational, training, and other value in fields related to ocean and coastal resources and with respect to ocean and coastal resources, without regard to section 501 of title 44, United States Code;

"(4) enter into contracts, cooperative agreements, and other transactions without regard to section 3709 of the Revised Statutes of the United States (41 U.S.C. 5);

"(5) accept donations and voluntary and uncompensated services, notwithstanding section 3679 of the Revised Statutes of the United States (31 U.S.C. 665(b)); and

Rules and regulations.

"(6) issue such rules and regulations as may be necessary and appropriate.

33 USC 1124.

"SEC. 205. CONTRACTS AND GRANTS.

"(a) IN GENERAL.—The Secretary may make grants and enter into contracts under this subsection to assist any sea grant program or project if the Secretary finds that such program or project will—

"(1) implement the objective set forth in section 202(b); and

"(2) be responsive to the needs or problems of individual States or regions.

The total amount paid pursuant to any such grant or contract may equal 66⅔ percent, or any lesser percent, of the total cost of the sea grant program or project involved.

"(b) SPECIAL GRANTS.—The Secretary may make special grants under this subsection to implement the objective set forth in section 202(b). The amount of any such grant may equal 100 percent, or any lesser percent, of the total cost of the project involved. No grant may be made under this subsection unless the Secretary finds that—

"(1) no reasonable means is available through which the applicant can meet the matching requirement for a grant under subsection (a);

"(2) the probable benefit of such project outweighs the public interest in such matching requirement; and

"(3) the same or equivalent benefit cannot be obtained through the award of a contract or grant under subsection (a) or section 206.

The total amount which may be provided for grants under this subsection during any fiscal year shall not exceed an amount equal to 1 percent of the total funds appropriated for such year pursuant to section 212.

Application.

"(c) ELIGIBILITY AND PROCEDURE.—Any person may apply to the Secretary for a grant or contract under this section. Application shall be made in such form and manner, and with such content and other submissions, as the Secretary shall by regulation prescribe. The Secretary shall act upon each such application within 6 months after the date on which all required information is received.

by amending section 204(d)— 33 USC 1123 1978

(A) by striking out "and" at the end of paragraph (5),

(B) by redesignating paragraph (6) as paragraph (7), and

(C) by inserting immediately after paragraph (5) the following new paragraph:

"(6) accept funds from other Federal departments, agencies (including agencies within the Administration), and instrumentalities to pay for grants made, and contracts entered into, by the Secretary under section 205(a); and"; 33 USC 1124.

by striking out the period at the end of the last sentence of section 205(a) and inserting in lieu thereof the following: "; except that this limitation shall not apply in the case of grants or contracts paid for with funds accepted by the Secretary under section 204(d)(6)."; 1978 33 USC 1123.

"(d) TERMS AND CONDITIONS.—(1) Any grant made, or contract entered into, under this section shall be subject to the limitations and provisions set forth in paragraphs (2), (3), and (4) and to such other terms, conditions, and requirements as the Secretary deems necessary or appropriate.

"(2) No payment under any grant or contract under this section may be applied to—

"(A) the purchase or rental of any land; or

"(B) the purchase, rental, construction, preservation, or repair of any building, dock, or vessel;

except that payment under any such grant or contract may, if approved by the Secretary, be applied to the purchase, rental, construction, preservation, or repair of non-self-propelled habitats, buoys, platforms, and other similar devices or structures, or to the rental of any research vessel which is used in direct support of activities under any sea grant program or project.

"(3) The total amount which may be obligated for payment pursuant to grants made to, and contracts entered into with, persons under this section within any one State in any fiscal year shall not exceed an amount equal to 15 percent of the total funds appropriated for such year pursuant to section 212.

Record retention. Regulation.

"(4) Any person who receives or utilizes any proceeds of any grant or contract under this section shall keep such records as the Secretary shall by regulation prescribe as being necessary and appropriate to facilitate effective audit and evaluation, including records which fully disclose the amount and disposition by such recipient of such proceeds, the total cost of the program or project in connection with which such proceeds were used, and the amount, if any, of such cost which was provided through other sources. Such records shall be maintained for 3 years after the completion of such a program or project. The Secretary and the Comptroller General of the United States, or any of their duly authorized representatives, shall have access, for the purpose of audit and evaluation, to any books, documents, papers, and records of receipts which, in the opinion of the Secretary or of the Comptroller General, may be related or pertinent to such grants and contracts.

Audit.

"SEC. 204. NATIONAL PROJECTS. 33 USC 1125.

"(a) IN GENERAL.—The Secretary shall identify specific national needs and problems with respect to ocean and coastal resources. The Secretary may make grants or enter into contracts under this section with respect to such needs or problems. The amount of any such grant or contract may equal 100 percent, or any lesser percent, of the total cost of the project involved.

Grants and contracts.

"(b) ELIGIBILITY AND PROCEDURE.—Any person may apply to the Secretary for a grant or contract under this section. In addition, the Secretary may invite applications with respect to specific national needs or problems identified under subsection (a). Application shall be made in such form and manner, and with such content and other submissions, as the Secretary shall by regulation prescribe. The Secretary shall act upon each such application within 6 months after the date on which all required information is received. Any grant made, or contract entered into, under this section shall be subject to the limitations and provisions set forth in section 205(d) (2) and (4) and to such other terms, conditions, and requirements as the Secretary deems necessary or appropriate.

Application.

"(c) AUTHORIZATION FOR APPROPRIATIONS.—There is authorized to be appropriated for purposes of carrying out this section not to exceed $5,000,000 for the fiscal year ending September 30, 1977. Such sums as may be appropriated pursuant to this subsection shall remain available

in section 205(d)(2) by inserting "may be applied to the short-term rental of buildings or facilities for meetings which are in direct support of any sea grant program or project and" immediately after "contract" the second time it appears therein; 33 USC 1124. 1980

by amending the first sentence of section 206(c) to read as follows: 33 USC 1125. 1978

"There are authorized to be appropriated for purposes of carrying this section not to exceed the following amounts:

"(1) $5,000,000 for each of fiscal years 1977, 1978, and 1979.

"(2) $7,000,000 for fiscal year 1980.";

in section 206(c) by inserting "out" immediately after "carrying", and by inserting the following new paragraph immediately after paragraph (2): 33 USC 1125. 1980

Not to exceed $5,000,000 for fiscal year 1981, not to exceed $6,000,000 for fiscal year 1982, and not to exceed $7,000,000 for fiscal year 1983.";

until expended. The amounts obligated to be expended for the purposes set forth in subsection (a) shall not, in any fiscal year, exceed an amount equal to 10 percent of the sums appropriated for such year pursuant to section 212.

33 USC 1126.

"SEC. 207. SEA GRANT COLLEGES AND SEA GRANT REGIONAL CONSORTIA.

"(a) DESIGNATION.—(1) The Secretary may designate—

"(A) any institution of higher education as a sea grant college; and

"(B) any association or other alliance of two or more persons (other than individuals) as a sea grant regional consortium.

"(2) No institution of higher education may be designated as a sea grant college unless the Secretary finds that such institution—

"(A) is maintaining a balanced program of research, education, training, and advisory services in fields related to ocean and coastal resources and has received financial assistance under section 205 of this title or under section 204(c) of the National Sea Grant College and Program Act of 1966;

33 USC 1124, 1123.

"(B) will act in accordance with such guidelines as are prescribed under subsection (b)(2); and

"(C) meets such other qualifications as the Secretary deems necessary or appropriate.

The designation of any institution as a sea grant college under the authority of such Act of 1966 shall, if such designation is in effect on the day before the date of the enactment of the Sea Grant Program Improvement Act of 1976, be considered to be a designation made under paragraph (1) so long as such institution complies with subparagraphs (B) and (C).

33 USC 1121 note.

Ante, p. 1961.

"(3) No association or other alliance of two or more persons may be designated as a sea grant regional consortium unless the Secretary finds that such association or alliance—

"(A) is established for the purpose of sharing expertise, research, educational facilities, or training facilities, and other capabilities in order to facilitate research, education, training, and advisory services, in any field related to ocean and coastal resources;

"(B) will encourage and follow a regional approach to solving problems or meeting needs relating to ocean and coastal resources, in cooperation with appropriate sea grant colleges, sea grant programs, and other persons in the region;

"(C) will act in accordance with such guidelines as are prescribed under subsection (b)(2); and

"(D) meets such other qualifications as the Secretary deems necessary or appropriate.

"(b) REGULATIONS.—The Secretary shall by regulation prescribe—

"(1) the qualifications required to be met under paragraphs (2)(C) and (3)(D) of subsection (a); and

"(2) guidelines relating to the activities and responsibilities of sea grant colleges and sea grant regional consortia.

Hearing.

"(c) SUSPENSION OR TERMINATION OF DESIGNATION.—The Secretary may, for cause and after an opportunity for hearing, suspend or terminate any designation under subsection (a).

33 USC 1127.

"SEC. 208. SEA GRANT FELLOWSHIPS.

"(a) IN GENERAL.—The Secretary shall support a sea grant fellowship program to provide educational and training assistance to qualified individuals at the undergraduate and graduate levels of education

in fields related to ocean and coastal resources. Such fellowships shall be awarded pursuant to guidelines established by the Secretary. Sea grant fellowships may only be awarded by sea grant colleges, sea grant regional consortia, institutions of higher education, and professional associations and institutes. Guidelines.

"(b) LIMITATION ON TOTAL FELLOWSHIP GRANTS.—The total amount which may be provided for grants under the sea grant fellowship program during any fiscal year shall not exceed an amount equal to 5 percent of the total funds appropriated for such year pursuant to section 212.

"SEC. 209. SEA GRANT REVIEW PANEL. 33 USC 1128.

"(a) ESTABLISHMENT.—There shall be established an independent committee to be known as the sea grant review panel. The panel shall, on the 60th day after the date of the enactment of the Sea Grant Program Improvement Act of 1976, supersede the sea grant advisory panel in existence before such date of enactment. *Ante*, p. 1961.

"(b) DUTIES.—The panel shall take such steps as may be necessary to review, and shall advise the Secretary, the Administrator, and the Director with respect to—

"(1) applications or proposals for, and performance under, grants and contracts awarded under sections 205 and 206;

"(2) the sea grant fellowship program;

"(3) the designation and operation of sea grant colleges and sea grant regional consortia, and the operation of sea grant programs;

"(4) the formulation and application of the planning guidelines and priorities under section 204 (a) and (c)(1); and

"(5) such other matters as the Secretary refers to the panel for review and advice.

The Secretary shall make available to the panel such information, personnel, and administrative services and assistance as it may reasonably require to carry out its duties.

"(c) MEMBERSHIP, TERMS, AND POWERS.—(1) The panel shall consist of 15 voting members who shall be appointed by the Secretary. The Director shall serve as a nonvoting member of the panel. Not less than five of the voting members of the panel shall be individuals who, by reason of knowledge, experience, or training, are especially qualified in one or more of the disciplines and fields included in marine science. The other voting members shall be individuals who, by reason of knowledge, experience, or training, are especially qualified in, or representative of, education, extension services, State government, industry, economics, planning, or any other activity which is appropriate to, and important for, any effort to enhance the understanding, assessment, development, utilization, or conservation of ocean and coastal resources. No individual is eligible to be a voting member of the panel if the individual is (A) the director of a sea grant college, sea grant regional consortium, or sea grant program; (B) an applicant for, or beneficiary (as determined by the Secretary) of, any grant or contract under section 205 or 206; or (C) a full-time officer or employee of the United States.

"(2) The term of office of a voting member of the panel shall be 3 years, except that of the original appointees, five shall be appointed for a term of 1 year, five shall be appointed for a term of 2 years, and five shall be appointed for a term of 3 years.

"(3) Any individual appointed to fill a vacancy occurring before the expiration of the term for which his or her predecessor was appointed shall be appointed only for the remainder of such term.

in section 209(c)(3) by striking the first two sentences and inserting in lieu thereof the following: "Any individual appointed to a partial or full term may be reappointed for one additional full term." 33 USC 1128.

1980

No individual may be appointed as a voting member after serving one full term as such a member. A voting member may serve after the date of the expiration of the term of office for which appointed until his or her successor has taken office, or until 90 days after such date, whichever is earlier.

Chairman, Vice Chairman.

"(4) The panel shall select one voting member to serve as the Chairman and another voting member to serve as the Vice Chairman. The Vice Chairman shall act as Chairman in the absence or incapacity of the Chairman.

Compensation. 5 USC 5332 note.

"(5) Voting members of the panel shall—

"(A) receive compensation at the daily rate for GS-18 of the General Schedule under section 5332 of title 5, United States Code, when actually engaged in the performance of duties for such panel; and

"(B) be reimbursed for actual and reasonable expenses incurred in the performance of such duties.

"(6) The panel shall meet on a biannual basis and, at any other time, at the call of the Chairman or upon the request of a majority of the voting members or of the Director.

"(7) The panel may exercise such powers as are reasonably necessary in order to carry out its duties under subsection (b).

33 USC 1129.

"SEC. 210. INTERAGENCY COOPERATION.

"Each department, agency, or other instrumentality of the Federal Government which is engaged in or concerned with, or which has authority over, matters relating to ocean and coastal resources—

"(1) may, upon a written request from the Secretary, make available, on a reimbursable basis or otherwise any personnel (with their consent and without prejudice to their position and rating), service, or facility which the Secretary deems necessary to carry out any provision of this title;

"(2) shall, upon a written request from the Secretary, furnish any available data or other information which the Secretary deems necessary to carry out any provision of this title; and

"(3) shall cooperate with the Administration and duly authorized officials thereof.

33 USC 1130. Submittal to Congress and President.

"SEC. 211. ANNUAL REPORT AND EVALUATION.

"(a) ANNUAL REPORT.—The Secretary shall submit to the Congress and the President, not later than February 15 of each year, a report on the activities of, and the outlook for, the national sea grant program.

"(b) EVALUATION.—The Director of the Office of Management and Budget and the Director of the Office of Science and Technology Policy, in the Executive Office of the President, shall have the opportunity to review each report prepared pursuant to subsection (a). Such Directors may submit, for inclusion in such report, comments and recommendations and an independent evaluation of the national sea grant program. Such material shall be transmitted to the Secretary not later than February 1 of each year, and the Secretary shall cause it to be published as a separate section in the annual report submitted pursuant to subsection (a).

33 USC 1131.

"SEC. 212. AUTHORIZATION FOR APPROPRIATIONS.

"There is authorized to be appropriated for purposes of carrying out the provisions of this title (other than section 206) not to exceed

Sec. 211(all parts): See amendment (1978) at Sec. 202(a)(3)

by amending section 211— 33 USC 1130. 1978

(A) by striking out "ANNUAL" in the section heading and inserting in lieu thereof "BIENNIAL";

(B) by amending subsection (a) to read as follows:

"(a) BIENNIAL REPORT.—The Secretary shall submit to the Congress and the President, not later than February 15, 1980, and not later than February 15 of every even-numbered year thereafter, a report on the activities of, and the outlook for, the national sea grant program."; and

Report to Congress and the President.

(C) by amending the last sentence of subsection (b) to read as follows: "Such material shall be submitted to the Secretary not later than February 1 of the year in which the report concerned is to be submitted under subsection (a), and the Secretary shall cause it to be published as a separate section in such report."

by amending the first sentence in section 212 to read as follows: 33 USC 1131. 1978

"There are authorized to be appropriated for purposes of carrying out the provisions of this title (other than section 206) not to exceed the following amounts: 33 USC 1125.

"(1) $50,000,000 for each of fiscal years 1977 and 1978.

"(2) $55,000,000 for each of fiscal years 1979 and 1980.".

in section 212 by inserting the following new paragraph immediately after paragraph (2): 33 USC 1131. 1980

"(3) Not to exceed $50,000,000 for fiscal year 1981, not to exceed $58,000,000 for fiscal year 1982, and not to exceed $65,000,000 for fiscal year 1983.".

"(4) Not to exceed $39,000,000 for fiscal year 1985, not to exceed $42,000,000 for fiscal year 1986, and not to exceed $44,000,000 for fiscal year 1987.". 1984

$50,000,000 for the fiscal year ending September 30, 1977. Such sums as may be appropriated under this section shall remain available until expended.".

SEC. 3. INTERNATIONAL COOPERATION ASSISTANCE. 33 USC 1124a.

(a) IN GENERAL.—The Secretary of Commerce (hereafter in this section referred to as the "Secretary") may enter into contracts and make grants under this section to—

(1) enhance the research and development capability of developing foreign nations with respect to ocean and coastal resources, as such term is defined in section 203 of the National Sea Grant Program Act; and

(2) promote the international exchange of information and data with respect to the assessment, development, utilization, and conservation of such resources.

(b) ELIGIBILITY AND PROCEDURE.—Any sea grant college and sea grant regional consortium (as defined in section 203 of the National Sea Grant Program Act) and any institution of higher education, laboratory, or institute (if such institution, laboratory, or institute is located within any State (as defined in such section 203)) may apply for and receive financial assistance under this section. Each grant or contract under this section shall be made pursuant to such requirements as the Secretary shall, after consultation with the Secretary of State, by regulation prescribe. Application shall be made in such form, and with such content and other submissions, as may be so required. Before approving any application for a grant or contract under this section, the Secretary shall consult with the Secretary of State. Any grant made, or contract entered into, under this section shall be subject to the limitations and provisions set forth in section 205(d) (2) and (4) of the National Sea Grant Program Act and to such other terms, conditions, and requirements as the Secretary deems necessary or appropriate. Regulation. Consultation.

(c) AUTHORIZATION FOR APPROPRIATIONS.—There is authorized to be appropriated for purposes of carrying out this section not to exceed $3,000,000 for the fiscal year ending September 30, 1977. Such sums as may be appropriated under this section shall remain available until expended.

SEC. 4. CONFORMING AND MISCELLANEOUS PROVISIONS.

(a) Section 5314 of title 5, United States Code, is amended by adding at the end thereof the following new paragraph:

"(63) Administrator, National Oceanic and Atmospheric Administration.".

(b) Section 5315 of title 5, United States Code, is amended by adding at the end thereof the following new paragraphs:

"(109) Deputy Administrator, National Oceanic and Atmospheric Administration.

"(110) Associate Administrator, National Oceanic and Atmospheric Administration.".

(c)(1) Section 2(d) of Reorganization Plan Numbered 4 of 1970 (84 Stat. 2090) is amended by striking out "Level V" and "(5 U.S.C. 5316)" and inserting in lieu thereof "Level IV" and "(5 U.S.C. 5315)", respectively. 5 USC app. II; 15 USC 1511 note.

The section heading of section 3 of the Sea Grant Program Improvement Act of 1976 (33 U.S.C. 1124a) is amended to read as follows: 1980

"SEC. 3. SEA GRANT INTERNATIONAL PROGRAM.".

Section 3 of the Sea Grant Program Improvement Act of 1976 (33 U.S.C. 1124a) is amended— 1978

(1) by striking out "National Sea Grant Program Act" each place it appears therein and inserting in lieu therof "National Sea Grant College Program Act";

(2) by amending subsection (a) (2) to read as follows:

"(2) promote the exchange among the United States and foreign nations (including, but not limited to, developing foreign nations) of information and data with respect to the assessment, development, utilization, and conservation of such resources."; and

(3) by amending the first sentence of subsection (c) to read as follows:

"There are authorized to be appropriated for purposes of carrying out this section not to exceed the following amounts:

"(1) $3,000,000 for each of fiscal years 1977, 1978, and 1979.

"(2) $5,000,000 for fiscal year 1980.".

Section 3(c) of the Sea Grant Program Improvement Act of 1976 (33 U.S.C. 1124a(c)) is amended by inserting the following new paragraph immediately after paragraph (2): 1980

"(3) Not to exceed $5,000,000 for fiscal year 1981, not to exceed $5,000,000 for fiscal year 1982, and not to exceed $5,000,000 for fiscal year 1983.".

"(4) For fiscal years 1985, 1986, and 1987, not to exceed $1,000,000, appropriated in each fiscal year pursuant to section 212 of the National Sea Grant Program Act, may be available to carry out this section." 1984

5 USC app. II.

(2) The individual serving as the Associate Administrator of the National Oceanic and Atmospheric Administration (pursuant to section 2(d) of Reorganization Plan Numbered 4 of 1970) on the date of the enactment of this Act shall continue as the Associate Administrator, notwithstanding the provisions of paragraph (1).

Approved October 8, 1976.

LEGISLATIVE HISTORY:

HOUSE REPORTS No. 94-1048 (Comm. on Merchant Marine and Fisheries) and No. 94-1556 (Comm. of Conference).
SENATE REPORTS No. 94-848 accompanying S. 3165 (Committees on Labor and Public Welfare and Commerce).
CONGRESSIONAL RECORD, Vol. 122 (1976):
May 3, considered and passed House.
June 14, considered and passed Senate, amended, in lieu of S. 3165.
Sept. 17, Senate agreed to conference report.
Sept. 23, House agreed to conference report.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 12, No. 42:
Oct. 10, Presidential statement.

LEGISLATIVE HISTORY: 1978 Amendments

HOUSE REPORT No. 95-1011 (Comm. on Merchant Marine and Fisheries).
SENATE REPORT No. 95-887 (Comm. on Commerce, Science, and Transportation) and (Comm. on Human Resources).
CONGRESSIONAL RECORD, Vol. 124 (1978):
Apr. 17, considered and passed House.
June 7, considered and passed Senate, amended.
June 29, House concurred in Senate amendment with amendments.
Sept. 25, Senate concurred in House amendments.

Approved October 7, 1978.

LEGISLATIVE HISTORY: 1980 Amendments

HOUSE REPORT No. 96-844 (Comm. on Merchant Marine and Fisheries).
SENATE REPORT No. 96-723 (Comm. on Commerce, Science, and Transportation and Comm. on Labor and Human Resources).
CONGRESSIONAL RECORD, Vol. 126 (1980):
Apr. 17, considered and passed House.
May 22, considered and passed Senate, amended.
June 5, House concurred in Senate amendment with amendments.
June 9, Senate concurred in House amendments with an amendment.
June 16, House concurred in Senate amendment.

Approved June 28, 1980.

LEGISLATIVE HISTORY: 1984 Amendments

CONGRESSIONAL RECORD, (1984)
October 4, considered and passed House.
October 10, considered and passed Senate.

Approved November 8, 1984.

10. Index

A keyword index to Sea Grant projects described in Sections 3, 4, 5, and 7 of this book.

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