

October 10, 2002

Admiral James D. Watkins, USN (Retired)
Chairman
U.S. Commission on Ocean Policy
1120 20th Street, N.W.
Suite 200 North
Washington, DC 20036-3406

Dear Admiral Watkins:

I am writing, on behalf of the Sea Grant Association, for two purposes: one, to thank you again for the opportunity to offer testimony before the U.S. Commission on Ocean Policy back on January 16, and two, to provide you with a set of summary recommendations and implementation suggestions for consideration by you and the Ocean Commission.

Our recommendations, which are enclosed, represent a synthesis of thoughts and ideas developed by the Sea Grant Association (SGA) over the past year. Specifically, they constitute a summary of pertinent information taken from (1) the Ocean Commission testimony provided by the SGA in January 2002, (2) SGA comments provided to Vice Admiral Lautenbacher, NOAA Administrator, on the NOAA Program Review Report on September 12, 2002, and (3) additional input on issues of particular interest to the Ocean Commission.

I want to thank you, on behalf of the Sea Grant Association and the network of Sea Grant College Programs, for the opportunity to participate in and assist you with the regional Commission meetings held this past year.

Again, thank you for your interest in the Sea Grant program. If you have any questions about our comments, or would like further information or elaboration, please do not hesitate to contact me.

Sincerely,

M. Richard DeVoe
President

MRD/

Enclosures

Cc: Tom Kitsos
SGA Delegates

Recommendations for Consideration by the U.S. Commission on Ocean Policy

**Provided by the
Sea Grant Association
October 10, 2002**

Executive Summary

Introduction

The Sea Grant Association (SGA) is pleased with the opportunity to offer recommendations to the U.S. Commission on Ocean Policy for its consideration. The SGA represents the combined capabilities of over 300 academic and research institutions nationwide that participate in the National Sea Grant College Program. The SGA enables these institutions to coordinate their activities, to prioritize action at the regional and national levels, and to offer a unified voice on critical coastal, ocean, and Great Lakes issues. Just as our nation's Land Grant institutions have revolutionized agriculture, so too are the Sea Grant Colleges steering our nation toward the productive and sustainable use of our coastal, marine, and Great Lakes resources, through integrated programs of scientific research, education and training, and technical assistance.

Recommendations of the SGA are organized in this document into three components:

1. Generating the "State of Knowledge" in Support of an Integrated U.S. Ocean Policy;
2. Fostering Program Integration within NOAA in Support of an Integrated U.S. Ocean Policy; and
3. Enhancing the Sea Grant Role within NOAA in Support of an Integrated U.S. Ocean Policy.

Each recommendation is followed by background and rationale statements and suggested strategies for implementation.

Recommendations "At-a-Glance"

The SGA offers the following recommendations for consideration.

The U.S. Commission on Ocean Policy should:

- 1.1. Call for the development of a detailed biogeophysical assessment of the territorial sea and the Exclusive Economic Zone along the coasts of the United States and its territories.
- 1.2. Call for the development and implementation of a national coastal and ocean resource "audit."
- 1.3. Recommend the development of a multidimensional framework for the design and implementation of the nationwide coastal ocean observing system network.

- 1.4. Recommend the development of a national research and education plan for the nation's coasts, ocean, and Great Lakes to encourage the generation of high priority science-based information and educational materials for use by resource managers, decision-makers, educators, and the public.
- 2.1. Encourage NOAA to establish a cross-cutting administrative mechanism and foster agency-wide integrated programmatic planning and implementation of its research, education, and outreach functions.
- 2.2. Encourage NOAA to integrate and enhance its educational and outreach activities in partnership with the extramural community in support of balanced use and conservation of the nation's coastal, marine, and Great Lakes resources.
- 2.3. Encourage NOAA to coordinate and, where possible, consolidate its many advisory committees, boards, and commissions.
- 3.1. Recognize and promote Sea Grant as a unique and currently underutilized university-based program that can serve all of NOAA and its diverse clientele throughout the country.
- 3.2. Urge the Administration to formally support and maintain the current mission, structure, and function of the National Sea Grant College Program (NSGCP), and that NSGCP should presently remain a part of NOAA within the U.S. Department of Commerce.
- 3.3. Recommend that Sea Grant become the nation's *primary* extramural, university-based research, education, training, and technical assistance program in support of coastal, marine, and Great Lakes resource use, management, and conservation.
- 3.4. Formally request a doubling of authorization and appropriations levels for the National Sea Grant College Program to enable the program to meet the needs and expectations of its varied constituencies.

1. Generating the “State of Knowledge” in Support of an Integrated U.S. Ocean Policy

The development and successful implementation of an integrated ocean policy for the United States will depend in large part on the development, analysis, and synthesis of information on the nature, status, and understanding of the nation’s coastal, ocean, and Great Lakes resources and on the issues and opportunities that will influence their use and conservation in the future. Possessing a sound, scientifically based “inventory” will provide policy and decision-makers with the tools they will need to ensure that critically important resources will be preserved, economically important resources will be sustainably consumed, and multiple resource uses will be accommodated.

The Sea Grant Association offers the following recommendations and suggestions in this area.

1.1. The U.S. Commission on Ocean Policy should call for the development of a detailed biogeophysical assessment of the territorial sea and the Exclusive Economic Zone along the coasts of the United States and its territories.

Background: Although “mapping” the EEZ is mentioned several times in the summaries of Working Group activities, it is not in itself identified as a key need. The need to map the ocean region of the United States has been called for many times in the past; when the U.S. declared in 1983 its sovereignty over the EEZ and its resources and when it expanded territorial sea jurisdiction to 12 miles, to mention two instances. It goes without saying that if the United States is to develop a unified coastal and ocean policy framework that includes governance, stewardship, and investment components, it must acquire detailed knowledge of the biological, geological, chemical, and physical features of the ocean regions and the resources they contain. Nevertheless, there has yet to be developed a concerted, coordinated, and funded national effort to map and assess the nation’s coastal marine and ocean regions.

Rationale: Basically, it would extremely difficult to establish and implement an ocean and coastal policy framework and management regime for the nation’s territorial sea and EEZ without detailed knowledge of their bathymetry, biological, chemical, geological, and physical characteristics. This information is critical for both existing users (e.g., fishing, recreational, and oil and gas industries) and prospective ones (e.g., near shore and offshore aquaculture, sand and gravel, mineral extraction industries), and is essential to the federal government in its role in serving as the public steward of the nation’s coastal and ocean resources and balancing competing demands. Initiating an integrated and systematic survey of the U.S. ocean environment will provide that information.

Implementation Strategy 1.1: *The SGA encourages the Commission to recommend the development of an integrated strategy, implementation plan, and timetable for “mapping” the U.S. ocean region, and identify NOAA, U.S. Navy, and the U.S. Geological Survey – Coastal and Marine Geology Program as the primary agencies to conduct the surveys.*

1.2. The U.S. Commission on Ocean Policy should call for the development and implementation of a national coastal and ocean resource “audit.”

Background: As is the case with EEZ mapping, there is no coordinated federal system to provide for or generate information on the overall environmental, economic, or socio-cultural condition of

the nation's coastal and ocean regions. Without such information, the nation cannot adequately assess (1) the "health" of the country's coastal and ocean resource base, (2) its value and contribution to the GNP of the country as a whole, nor (3) identify and, where appropriate, manage and protect the nation's important ecological, social, historic, and cultural resources. This lack of critically important information will continue to hinder the ability of the federal government to both serve as the steward for the nation's coastal and ocean resources and develop and implement a coordinated national ocean policy.

Rationale: The opportunity for designing a national coastal and ocean audit is timely, as there are under consideration or in preliminary development several initiatives that could provide the foundation upon which a comprehensive audit can be based. For instance, NOAA has begun to develop a "State of the Coast" report for the nation, researchers led by the University of Southern California are beginning to implement a National Ocean Economics Project, and a number of agencies, universities, and organizations have been engaged in the Ocean Exploration initiative. What is needed is the leadership necessary to develop a coordinated and ongoing effort that will provide the information needed to assess and monitor trends in the nation's coastal and ocean resource "stock." Taking the concept of a coastal and ocean audit and putting it into practice will require strong leadership and endorsement by the Commission.

Implementation Strategy 1.2: *The SGA encourages the Commission to consider and recommend that a national coastal and ocean environmental, economic, and socio-cultural audit be undertaken, and that it subsequently be updated every five years. NOAA should be considered as the lead agency for this effort.*

1.3. The U.S. Commission on Ocean Policy should recommend the development of a multidimensional framework for the design and implementation of the nationwide coastal ocean observing system network.

Background: As the Commission is well aware, there exist several operational coastal ocean observing systems located around the country, and quite a number more either in development or being planned. It is the role and responsibility of OCEAN.US to ensure that this loosely knit array of systems join together as a coordinated and integrated network. While proposed as the means by which information on coastal ocean conditions can be gathered for monitoring and assessment purposes, there exists great potential in expanding the scope of the observing system network to do much more. Incorporating a multi-dimensional approach into coastal ocean observing plans should be done and used as the basis for both refining existing systems and developing and implementing new systems.

Rationale: An opportunity exists to ensure that the nation receives the highest payoff from its investment in the development and implementation of a coastal ocean observing system network. The design, development, and selection of platforms, sensors, and other technologies to be deployed as part of any coastal observing system will be dictated in large part by the goals and objectives established for the system. These goals and objectives should encompass all possible applications of the system from its initiation, and should reflect the information and data needs and requirements of prospective academic, government, and industry users and the public.

Implementation Strategy 1.3.1. *The SGA encourages the Commission to recommend that an equally essential step in the development, design, and implementation of the nation's network of coastal ocean observing systems is the development of a strong outreach/feedback mechanism whereby prospective users (academia, government, industry, etc.) of coastal ocean observing*

information and data are first identified and then queried to determine their information and data needs. With appropriate funding support, the national Sea Grant Extension Program can be tasked with identifying user needs.

Implementation Strategy 1.3.2. *The SGA encourages the Commission to recommend that an essential step in the development, design, and implementation of the nation's network of coastal ocean observing systems is the preparation of operational plans that include how these systems can provide for and/or serve all the following elements: (1) monitoring, (2) assessment, (3) observation, (4) research, (5) education, (6) technology development, (7) prediction, and (8) resource management.*

1.4. The U.S. Commission on Ocean Policy should recommend the development of a national research and education plan for the nation's coasts, ocean, and Great Lakes to encourage the generation of high priority science-based information and educational materials for use by resource managers, decision-makers, educators, and the public.

Background: There are currently a host of federal departments and agencies that conduct and/or support scientific research and education programs dealing with coastal and marine resources and their uses. Also, a host of research and education plans continue to be developed while existing plans "sit on the shelf." Currently, there is no existing federal mechanism whereby these efforts can be jointly planned and undertaken in a coordinated or collaborative fashion. Additionally, many of the plans and activities do not take into account issues related to "scale." For example, how are the results of research and educational efforts undertaken at the national or regional level relevant to state and local needs and issues, the levels where most of the land use and resource management decisions are either made or applied? Further, scientists and educators from the federal government, academia, NGOs, and the private sector are all engaged in federally sponsored research and education efforts but, in many cases, there is very little collaboration among the organizations. The federal coastal and ocean science and education enterprise must be retooled to provide programmatic focus and direction, to utilize federal and non-federal expertise more efficiently, to provide the means by which scientific and educational information gets into the hands of decision-makers and users, and to encourage collaborative and cross-cutting efforts.

Rationale: The pressures on the nation's coastal and ocean resources continue to grow for many reasons. Decisions regarding the use and conservation of these resources at all levels of government are increasingly dependent on the availability and transferability of sound scientific information and a literate citizenry.

Implementation Strategy 1.4.1. *The SGA encourages the Commission to recommend a national framework upon which a coordinated coastal and ocean research and education agenda can be developed. This framework would consist of the identification of (1) the most pressing information needs that can be addressed through federally sponsored research and education, (2) the federal role in supporting and coordinating research and education efforts across agencies and in delivering results to target constituencies, (3) the means of engagement of intellectual resources found in the federal government, at the nation's universities, and elsewhere, (4) needs for research and education information at multiple scales (federal, regional, state, local), and (5) financial and intellectual capital that would be required to undertake these activities.*

Implementation Strategy 1.4.2. *The SGA encourages the Commission to review and incorporate, as appropriate, the topics and priorities developed by the leadership, staff, and*

partners of the national Sea Grant network (of universities and laboratories) into its recommendations for research and education on coastal and ocean issues and opportunities. Priorities for research and outreach have been developed for aquaculture; fisheries; seafood science and technology; ecosystems and habitats; coastal natural hazards; coastal communities and economies; the urban coast; marine biotechnology; ocean and coastal technology; and education and human resources. [See Appendix I for the topical white papers, or view them at www.seagrant.wisc.edu/communications/national/Theme_Teams/one-pager_links.html.]

Implementation Strategy 1.4.3. *The SGA encourages the Commission to consider adopting the Sea Grant Extension Program as the primary means by which priority information and data needs can be identified and scientific information generated at federal, state, and university laboratories can be translated and delivered to federal and state resource management agencies, municipalities, business and industry, public and private schools, the interested public, and others, given the means to do so.*

Implementation Strategy 1.4.4. *The SGA encourages the Commission to explore the feasibility of establishing a coastal and ocean research and education extramural cross-cutting framework as a short-term method to focus attention and resources on priority needs and to encourage collaborative efforts among federal, state, and university scientists and educators. The existing National Ocean Research Leadership Council (NORLC) is an example of a mechanism that might be expanded or mimicked to address broader ocean, coastal, and Great Lakes research and outreach needs and opportunities, but should be expanded to include state, university, and constituent representation.*

Implementation Strategy 1.4.5. *For the long-term, the SGA encourages the Commission to recommend the establishment of a permanent mechanism by which the disparate units of the federal government that focus on coastal and ocean research and education can be brought together. While recognizing that the establishment of, say, a formal U.S. Department of the Oceans may be difficult to achieve, a similar such mechanism should seriously be considered by the Commission.*

2. Fostering Program Integration within NOAA in Support of an Integrated U.S. Ocean Policy

The role of the National Oceanic and Atmospheric Administration (NOAA) as the nation's primary "oceans" agency places it at the nexus of any discussion of a re-evaluation of the nation's ocean policy framework. Created as one outcome of the work of the Stratton Commission in the late 1960s, NOAA essentially remains an amalgamation of numerous agencies, programs, and offices that have yet to be fully assimilated into one "whole." NOAA has undergone a number of external and internal evaluations and reorganizations over the last 30 years, and has recently completed yet another internal program review upon which policy options for program integration and possible reorganization are currently being evaluated.

The Sea Grant Association thus offers the following recommendations regarding NOAA as the nation's primary "oceans" agency in the context of its current self-evaluation.

2.1. The U.S. Commission on Ocean Policy should encourage NOAA to establish a cross-cutting administrative mechanism and foster agency-wide integrated programmatic planning and implementation of its research, education, and outreach functions.

Background: Of the issues identified by NOAA's Program Review Team in its internal review, the need for integration and cross-cutting of NOAA's research, education, and extension enterprises stands out. Currently, these three functions are dispersed throughout the agency, with no mechanism to ensure shared priority setting or program execution. Additionally, NOAA proposes to commit 50% of any new research funds to the extramural community.

Rationale: Establishing a Program Planning and Integration line office presents NOAA with an excellent opportunity to integrate strategic planning and implementation both within and across all NOAA components and missions, including research, education, and extension initiatives. To be successful, this office must be located between the Office of the Administrator and across the five program Assistant Administrators to serve as a cross-cutting hub. The lead Program Manager for NOAA research and outreach should be housed in the Program Planning and Integration cross-cutting office. This office should seek to raise the stature of NOAA's extramural funding efforts in research and outreach and establish standards and outcomes that are a model for engagement of the best available talent found in the nation's universities. In addition, NOAA should formally apply the model used by agencies such as NSF and NIH to involve the extramural-university community in workshops and other forums to discuss and generate NOAA priorities for research AND education AND extension in key programmatic areas. This would ensure that NOAA's programmatic priorities accurately reflect both the current state-of-knowledge of coastal, marine, and Great Lakes resource issues and the real needs of NOAA's constituencies, and would vest the extramural community in seeing that the priorities are addressed.

Implementation Strategy 2.1.1. *The SGA encourages the Commission to recommend that NOAA's proposed Line Office for Program Planning and Integration be realigned to cut across rather than parallel the five established line offices, and that NOAA's extramural research, education, and extension programs, including Sea Grant, be placed within the proposed LO for Program Planning and Integration.*

Implementation Strategy 2.1.2. *The SGA encourages the Commission to urge NOAA to enhance its engagement of the extramural community in establishing its research, education, and extension priorities and action agendas.*

2.2. The U.S. Commission on Ocean Policy should encourage NOAA to integrate and enhance its educational and outreach activities in partnership with the extramural community in support of balanced use and conservation of the nation's coastal, marine, and Great Lakes resources.

Background: Interaction and regular contact with external constituencies contribute to NOAA's identification of critical coastal, marine, and Great Lakes issues and to its effectiveness in delivering information and products to its "client" base. Numerous studies¹ have recognized the NOAA-university partnership as one of the principal means to connect with these constituencies.

Rationale: The structure and function of the National Sea Grant College Program can serve as a key component in NOAA's education and extension strategy, and Sea Grant should be given the challenge, responsibility, and resources to assist in identifying constituent needs and transferring research findings and general information generated throughout NOAA to the appropriate user base.

Implementation Strategy 2.2: *Effective education and extension programming is critical to NOAA's mission and must be identified as core missions for NOAA and the U.S. Department of Commerce. Sea Grant, with additional resources, can assist NOAA in enhancing its educational and extension efforts.*

2.3. The U.S. Commission on Ocean Policy should encourage NOAA to coordinate and, where possible, consolidate its many advisory committees, boards, and commissions.

Background: Currently, NOAA and its line offices engage a variety of advisory mechanisms to oversee the development and operations of their programs. For example, there is the NOAA Science Advisory Board that serves the NOAA Administrator's Office, and the National Sea Grant Review Panel, a FACA panel authorized by legislation, to oversee the operation of the National Sea Grant College Program. Multiple advisory groups have the potential to contradict and confound, as well as waste human and financial resources. They are also countercurrent to the concept of one NOAA, rather than five or more NOAA "parts." The issue of advisory panels is only partially addressed by the NOAA Program Review, which recommends that membership on NOAA's Science Advisory Board be modified to include a diversity of expertise, experience, and perspectives.

Rationale: NOAA should expand the definition of its primary advisory board to embrace and support the research, education, and extension components of its mission. NOAA should also specifically define the charge and role of its "advisory" structures and clearly establish their relationship to NOAA's management structure. There should be only one NOAA-wide advisory

¹ National Research Council's 1994 review of the National Sea Grant College Program; NASULGC Board on Oceans and Atmosphere 2001 white paper on NOAA in the 21st Century; President's Council on Ocean Exploration (2001); Sea Grant Review Panel 2001 report *A Mandate to Engage Coastal Users*; and NOAA & Academic Partnership Building Conference Report of 2001.

board so as to minimize the potential for mixed and possibly contradictory messages coming from external “experts.”

Implementation Strategy 2.3. *NOAA should consider establishing an agency-wide Advisory Board that reflects the breadth of both its missions and the constituencies it serves. Existing (and new) sub-agency (Line Office and Program level) advisory panels should perhaps be organized as “extensions” of the NOAA Advisory Board, with appropriate Advisory Board representation, leadership, and guidance, to provide for consistency and effective communication throughout the agency.*

3. Enhancing the Sea Grant Role within NOAA in Support of an Integrated U.S. Ocean Policy

The National Sea Grant College Program was created in 1966. Sea Grant was created to mimic the land-grant model specifically to “focus a broad array of academic talent on issues related to the sea.” In just 35 years Sea Grant has created a remarkable track record. Sea Grant conducts priority-driven research, transfers scientific results to the public, provides educational opportunities from K-12 to graduate degrees, and conducts successful outreach programs. Sea Grant is a partnership among academia, government, and the private sector. It uses a combination of research, education and extension. It focuses on maximizing the economic, environmental, and social potential of the nation’s coastal, marine, and Great Lakes resources. Sea Grant peer-reviewed science is the key to generating intellectual capital. Sea Grant serves a broad constituency. Sea Grant solves national problems and creates national opportunities. Sea Grant is “Science Serving America’s Coasts.”

The Sea Grant Association continues to encourage NOAA to invest in programs with a proven track record of success. The Sea Grant enterprise can and should be empowered to meet the needs of both NOAA and its constituencies through an expansion of its role and responsibilities and the provision of additional resources.

Congress has placed Land Grant and Sea Grant programs in the appropriate stewardship agencies; that is, the Department of Agriculture, which supports agricultural research and education programs in Land-Grant universities, and the National Oceanic and Atmospheric Administration (NOAA), which supports the National Sea Grant College Program and its network of some 300 universities. However, to date, Sea Grant universities have not achieved the synergy with NOAA that has been achieved by Land-Grant universities with USDA (and other agencies), and consequently has been unable to reach its full potential to serve the needs of the nation’s coasts, oceans, and Great Lakes.

The Sea Grant Association offers the following recommendations to address the question: How can the National Sea Grant College Program be empowered to meet the needs of NOAA and the nation, and the increasing demands for information and services coming from multiple constituencies?

3.1. The U.S. Commission on Ocean Policy should recognize and promote Sea Grant as a unique and currently underutilized university-based program that can serve all of NOAA and its diverse clientele throughout the country.

Background: Sea Grant is a unique partnership between federal, university, state, and private sector interests. As such, the Sea Grant network can significantly contribute to NOAA initiatives on climate, human resource development, and watershed dynamics, all of which have nationwide importance and applicability. To affirm the importance of the ocean to the very existence of all living organisms — including those that live in inland states — Sea Grant funding should be substantially increased to accommodate Sea Grant network growth in all 50 U.S. states. Because there is a progressive path for a university to become a Sea Grant College — single project → coherent project → institutional program → Sea Grant College — funding increases could be phased in over time. *Currently, however, the National Sea Grant College Program (NSGCP) Network is an underutilized NOAA and national asset.*

Rationale: Sea Grant, like Land Grant, is inclusive in its mandate, even though it is currently perceived as exclusive to only coastal and Great Lakes states. Balanced use and conservation of marine and coastal resources is a national priority and NOAA is the lead federal agency with the mission to achieve this goal. Enhanced ocean literacy across this nation's population is critical for NOAA to be successful — further reinforcing the notion of Sea Grant involvement in all 50 states. Sea Grant is an established, well-respected state-based program that can serve as the nation's conduit to the states and their citizenry.

SGA firmly believes that excellence in the National Sea Grant College Program network has been strengthened through the adoption of a rigorous and well-defined program evaluation and improvement process. The Sea Grant peer review process occurs initially during biennial project selection at the university level and is carried out by the Sea Grant Program management teams distributed throughout the network of universities. The peer review process employed for this distributed review is directly analogous to that carried out by NSF, both of which draw from a national pool of peer reviewers. This distributed management concept provides many opportunities for Sea Grant programs to leverage the federal investment with support from non-federal partners that invest real cash in the Sea Grant enterprise. In addition, Sea Grant solicitations for national strategic initiatives are also peer-reviewed using an NSF-like model.

Implementation Strategy 3.1. *The SGA requests that the Commission recognize Sea Grant as a model program for engaging the extramural community in the nation's coastal and ocean programs, and recommend to NOAA that Sea Grant be designated the "go-to" agency for its extramural research and outreach functions.*

3.2. The U.S. Commission on Ocean Policy should urge the Administration to formally support and maintain the current mission, structure, and function of the National Sea Grant College Program (NSGCP), and that NSGCP should remain a part of NOAA within the U.S. Department of Commerce.

Background: The current Administration has proposed the transfer of funding for the National Sea Grant College Program from NOAA to the National Science Foundation beginning in FY03. This would eliminate the strong state and university-based nature of this successful program, terminate its outreach function, and destroy its effective transfer of new scientific knowledge to coastal citizens, industries, and governments. Reauthorization legislation currently under consideration by the U.S. Congress (HR3389) for the National Sea Grant College Program is pending in Congress. This bill would continue the program for five years based on its current structure, conduct, and performance, and maintain its presence within NOAA. The SGA believes that no change should be considered in mission, structure, and function of the Sea Grant program, and the location of the National Sea Grant College Program.

Rationale: Congress passed Public Law 105-160 in 1998 to authorize the National Sea Grant College Program through FY2003. This legislation was passed with the unanimous consent of Congress. Over 100 members of the House of Representatives and over 20 members of the Senate co-sponsored the legislation. The bi-partisan support for this legislation continued Sea Grant as a part of NOAA within the U.S. Department of Commerce. Sea Grant, moreover, has linked more closely with other NOAA offices to increase the accountability, effectiveness, and efficiencies of its and all of NOAA's programs.

Sea Grant's university base has enabled it to be a partner with NOAA (and before that NSF), and with other federal resource and environmental units, state and local governments, business and industry, and conservation groups. For Sea Grant to be successful it requires a host in government that allows for partnerships among academia, the private sector and government, that allows for the combined use of research, education and outreach, and that focuses on education, the economy and the coastal environment. It also must be positioned in that host unit at an adequately high position to enhance its effectiveness and efficiency. No purely government program has the depth and breadth of partnerships that exist in Sea Grant.

Implementation Strategy 3.2. *The SGA encourages the Commission to (a) endorse HR3389, a bill to reauthorize the National Sea Grant College program, (b) urge the U.S. Congress to pass HR3389 prior to adjournment this year, and (c) recommend to the Administration and OMB that the integrity and mission of Sea Grant be maintained.*

3.3. Sea Grant should become the nation's *primary* university-based, extramural research, education, training, and technical assistance program in support of coastal, marine, and Great Lakes resource use, management, and conservation.

Background: NOAA has historically been concerned that the strong state and local connections that are the foundation of the Sea Grant Program threaten its influence over the program. As a result, NOAA has often looked to other structures and programs to accomplish tasks that could more efficiently fall within the Sea Grant purview. Sea Grant's network should be perceived for what it truly represents, an excellent resource to the federal government, the Congress, and this nation's citizens in helping meet their coastal, marine, and Great Lakes objectives. Sea Grant is successful because it combines the functions of quality peer reviewed research with fact-based public education.

Rationale: Sea Grant has been successful in addressing common property resource issues because it has close ties and partnerships with federal, regional, and local governments and with many affected constituencies. Sea Grant has access to the best intellectual capital in the nation because of its university base, and has brought innovative approaches to longstanding issues. Without its issue orientation, its peer-reviewed science, and its established and trusted ties to business, government, and citizen constituencies, Sea Grant could not be successful. To be successful, Sea Grant needs the commitment, financial resources, and a host agency that understands that, especially for issues involving both the development and conservation of public resources. Many of the marine and coastal issues facing the nation are affected by decisions that are made nationally, regionally, and locally. The impacts of these decisions many times reach across state borders; thus, there is a strong national interest.

Implementation Strategy 3.3. *The SGA encourages the Commission to recommend that ensure Sea Grant receives both the resources from and status within the federal government to ensure that the success of the Sea Grant program not just measured within the context of its own agency mission, but also in its success in contributing to the national agenda as expressed in legislation shared by other agencies.*

3.4. Authorization and appropriations levels for the National Sea Grant College Program should be significantly increased to enable the program to meet the needs and expectations of its varied constituencies.

Background: The issues to be addressed in coastal, marine, and Great Lakes resource management are immense and the investment in Sea Grant has not been commensurate with the demands for science-based information created by increased growth in coastal population and development. Yet the 1994 National Research Council (NRC) review of the National Sea Grant College Program pointed out that Sea Grant has been virtually the only source of funding in the U.S. for marine policy research and a major contributor to the fields of marine aquaculture, coastal and estuarine research, marine fisheries management, seafood safety, marine biotechnology, marine engineering, and coastal technology development. And this list is not exhaustive.

Several independent studies have concluded that Sea Grant has not realized its potential because of limited funding. As far back as 1981, the Heritage Foundation evaluated the Department of Commerce and concluded: *“Sea Grant has an impressive record of success, primarily because it is based largely on local priorities and needs ... Sea Grant funding should be increased 10 percent per year in real terms for the next five years.”* In its 1994 review of the National Sea Grant College Program, the NRC was emphatic in stating: *“A steady increase in funding is necessary if the program’s potential contributions to the Nation’s economic and environmental health are to be realized.”* The Board on Oceans and Atmosphere (BOA) of the National Association of State Universities and Land Grant Colleges (NASULGC) echoed these findings when it stated in 2000: *“The Sea Grant Program represents NOAA’s largest university-based research, extension and education activities. This program represents a unique opportunity for the Agency to engage constituencies that will be increasingly important to its evolving mission. We would urge that the...Administration develop an agenda to specifically utilize and expand the resource base of this program so as to better engage university capabilities in helping the Agency fulfill its responsibilities.”*

Rationale: Sea Grant is built on the Land Grant model, its highly successful counterpart. Although 54% of the U. S. population lives on the coast, funding for Sea Grant is only 3% of equivalent federal funding for university Land Grant programs. Sea Grant’s enabling legislation envisioned other federal agencies accessing university expertise through the Sea Grant administrative structure, but Sea Grant’s “pass-through” capabilities have been underutilized by other agencies. Funding limitations have contributed significantly to the difficulty of creating strong interagency partnerships.

The general case for growth is compelling, but despite an unprecedented high demand for coastal and ocean science and information and Sea Grant’s unique ability to provide solutions to coastal problems, funding has not kept pace with demand for services. In fact, the Sea Grant budget has not kept pace with inflation over the last two decades, much less expanded to meet the wealth of new challenges and opportunities that face our country. Sea Grant’s appropriations are over 20 percent below the buying power of its 1980 appropriation. From fiscal year 1986 to fiscal year 1999, Sea Grant’s program-wide staff size declined 25 percent.

Sea Grant is at heart a science-based program that engages the university community through partnership in providing consistently high-quality and relevant research, ranging from highly focused projects that develop innovative solutions for immediate and pressing needs to more forward-looking activities that anticipate the needs of society five to ten years hence. Over the past few years, the review process has been streamlined and improved to increase the ability of Sea Grant to support research projects most critical to mission objectives. However, each of our state and national competitions continues to receive many times more highly-rated projects than could possibly be supported. For example, the 1999 fisheries habitat research competition received requests for almost 20 times the available funds, and the requests for the aquaculture

competition were about 50 times the available funds. Clearly the capacity is there for Sea Grant to provide much more useful science-based information than current funding levels allow.

Finally, as science becomes increasingly more complex, professional outreach staff are needed more than ever to synthesize and promulgate needed information. With its established extension network, Sea Grant is uniquely positioned to be the two-way conduit between the providers and users of information. Indeed, Sea Grant's greatest asset may be the trust that has been developed and nurtured through 35 years as an "honest broker" of scientific information. Sea Grant's science is credible and its outreach staff is trusted because Sea Grant is university-based, neutral, and objective. Yet, an external review of the Sea Grant Extension Program conducted in 2000 concluded that Sea Grant's current work force of 300 extension specialists "is insufficient to address adequately the issues raised along the extensive reaches of the nation's coastlines."

Congress has recognized the continued success of Sea Grant and in December 2000 introduced H.R.3389 to reauthorize the program at significantly higher levels for an additional five years. Sea Grant has not achieved significant increases in appropriations like other science programs -- for example, in the National Science Foundation. However, it appears that Congress and the federal government are both recognizing that inadequate funding is a problem, and are taking steps to support the National Sea Grant College Program at an elevated level. This bill substantially increases the authorized level of appropriations for Sea Grant and consolidates several university-based NOAA programs under Sea Grant as a way to achieve increased efficiencies, and enhances the effectiveness and application of the nation's coastal, marine, and Great Lakes research and outreach programs.

Implementation Strategy 3.4. *The SGA encourages the Commission to recommend to the U.S. Congress and the Administration that funding for the National Sea Grant College Program be doubled within five years, commensurate with the recommendations of the National Research Council and NASULGC, for three purposes: (a) to enhance the Sea Grant network's existing capabilities in generating and delivering science-based information to its constituencies, (b) to expand Sea Grant's role throughout the country, and (b) to adequately address nation's most pressing coastal, ocean, and Great Lakes resource issues and opportunities.*

Implementation Strategy #3.5. *The SGA encourages the Commission to call on NOAA to offer competitive funding opportunities to Sea Grant College Programs in order to restore and enhance their capabilities to deliver services and assistance to their constituencies. Furthermore, SGA encourages NOAA to provide maximum flexibility in the use of extramural grant funding to derive full "value-added" in leveraging matching funds and in optimizing the use of the enormous talent and expertise found in our nation's universities.*

APPENDIX I:

SEA GRANT TOPICAL WHITE PAPERS ON:

**MARINE AND AQUATIC SCIENCE LITERACY:
EDUCATING THE 21ST CENTURY WORKFORCE**

SCIENCE SUPPORTING SUSTAINABLE MARINE AQUACULTURE

**RESEARCH AND OUTREACH ADDRESSING
THE NATION'S FISHERIES PROBLEMS**

**HEALTHY COASTAL ECOSYSTEMS
FOR A HEALTHY ECONOMY**

**SCIENCE HELPING COASTAL COMMUNITIES
AND ECONOMIES BUILD A SUSTAINABLE FUTURE**

URBAN COASTS FACE MULTIPLE CHALLENGES

**REDUCING THE NATION'S VULNERABILITY
TO COASTAL NATURAL HAZARDS**

**RESEARCH AND OUTREACH IN MARINE BIOTECHNOLOGY:
SCIENCE PROTECTING AND CREATING NEW VALUE FROM THE SEA**

THE DIGITAL OCEAN: OUR OCEANS ON A MICROCHIP



SCIENCE SERVING AMERICA'S COASTS

MARINE AND AQUATIC SCIENCE LITERACY: EDUCATING THE 21ST CENTURY WORKFORCE

Virtually every serious study of national goals for the new millennium underscores the critical importance of education to national prosperity. In order to sustain a growing economy, we must also be stewards of the natural environment upon which all life depends. To that end, having a scientifically literate, environmentally responsible population is necessary for the United States to remain competitive in the world economy while conserving its natural resources. The challenges facing this country require instilling environmental values, behaviors and literacy in the decision-making public while developing a highly skilled, technologically capable workforce.

Educating the 21st century workforce toward literacy in the marine and aquatic sciences is integral to both the educational and scientific missions of the National Sea Grant College Program. From Sea Grant's inception, innovative and effective marine and aquatic education programs have produced a record of successes that spans three decades. The network of Sea Grant educators has provided valuable leadership in marine and aquatic science education activities throughout this country. Sea Grant education efforts have contributed to improving marine and aquatic science literacy by enhancing education among formal K-12, undergraduate and graduate students, and informal sessions with both children and adults. As educators, our challenge is to ensure an educational process that imparts an enhanced awareness and understanding of the environment by all citizens. We are thereby promoting increased value in marine and aquatic science education by the American public as being integral to national security, economic development and the overall quality of life for everyone.

Focusing on K-12 Schools

For the American population to become more scientifically literate, increased emphases must be placed on engaging students in the activity and nature of science. As members of the future workforce experience for themselves the excitement and empowerment of scientific discovery, they will more readily participate in scientific endeavors and value the role of marine and aquatic science in their lives. Since local situations vary, no single scenario characterizes K-12 marine and aquatic education efforts, but Sea Grant educators regularly contribute to curriculum development, teacher education and professional development, programs for school-aged students, and educational research. Through such local and regional efforts, positive national impacts have been realized.

Producing Environmentally Literate Professionals

The advent of new viewpoints, vantages and perspectives is one of the most important challenges to higher education. In addition to gaining scientific knowledge and research skills, students need to engage interdisciplinary and multidisciplinary perspectives, to use multiple contexts in solving problems, and to communicate complex ideas in group settings. Fostering these important skills requires a diversification of learning opportunities at the college or university level. To accomplish this goal, a suite of opportunities and programs exists throughout the Sea Grant network. Sea Grant supports a wide range of experiential internships, fellowships, team-based research courses and traditional research assistantships

that serve to broaden the expertise of both undergraduate and graduate students. Sea Grant has provided substantial support to educating our nation's future marine scientists and environmental professionals by giving selected graduate students the opportunity to develop their research and analytical skills by assisting scientists with Sea Grant research and education projects. These students are then prepared to assume prominent positions where they impact directly on the continued responsible use, sustainable development, and conservation of marine and aquatic resources.

Educating in Informal Settings

As the coastal population continues its rapid increase in the coming decades, so will conflicts over the use of and access to this country's coasts and marine and aquatic resources. One way of alleviating these conflicts is through informal education of the public. Sea Grant educators, in collaboration with a wide array of museums, aquaria and environmental education facilities, deliver marine science information to the public through lifelong learning experiences, such as workshops, field trips, lectures, Internet usage, and television and radio broadcasts. These programs are designed to foster environmental literacy and encourage responsible use and conservation of fragile marine and aquatic resources.

Reaching Out to Interested Adults

Outreach education activities for the public and private sectors are conducted by an extension program consisting of an interactive network of specialists and field agents who transfer information and research results to the marine and aquatic community, and a communications program comprised of a cadre of writers, editors and media specialists who create a wide variety of printed and electronic information products. The backbone of Sea Grant's outreach education effort has always been the ability to help clients use knowledge and research results through a broad multidisciplinary approach including the elements of outreach education, technology transfer and communications. In developing and implementing outreach education programs, outreach professionals serve as an intellectual resource and partner with many local, state and federal agencies, businesses and industries. These professionals assume a variety of roles (e.g., facilitator, catalyst, educator and/or coordinator) in helping the public and private sector find solutions to marine and aquatic problems by linking together the capabilities, skills, and knowledge of academia, government and industry.

Envisioning the Future

Sea Grant's vision for education is simply stated: To provide national leadership in the development of well-prepared professionals who understand marine and aquatic science and research, and to be a leader in enhancing marine literacy from "cradle to grave." That said, this country has a long way to go to produce both an informed citizenry, one that is environmentally and scientifically literate, and a sufficient cadre of technical, policy and managerial professionals that can ensure a sustainable future. Sea Grant, by legislative mandate, is in the education business and will do its part to support a strong education base. That role will be increasingly important as demand for marine and aquatic education increases.

As a national organization, Sea Grant has certain inherent strengths necessary to be a key player in developing that critical education base. With a long-term funding base, a strong regional infrastructure and a commitment to education, Sea Grant can make the long-term investments and provide the necessary continuity to ensure useful outcomes.

We have entered an era in which the educational agenda is essential to national survival. Sea Grant needs to consider education more explicitly in its strategic thinking; develop innovative, imaginative approaches and technologies for the delivery of education; consistently assess education efforts to ensure accomplishment of project objectives; strengthen its case for sufficient resources to accomplish the task;

engage in partnerships with other science education stakeholders; and work more closely with other educators in more proactive, productive and focused collaborations. Such activities could result in extensive and ongoing support for current and future teachers as they develop their scientific skills, interesting and engaging scientific opportunities for school-aged students of all cultural and ethnic origins both in and outside of the traditional classroom, and continued professional development of future scientists, policymakers and resource managers.

<http://www.SGA.seagrant.org/ThemeTeams>



SCIENCE SERVING AMERICA'S COASTS

SCIENCE SUPPORTING SUSTAINABLE MARINE AQUACULTURE

Sea Grant will be at the forefront of efforts to grow the U.S. aquaculture industry through an integrated program of research, education and technology transfer focused on key scientific, engineering, environmental and socioeconomic issues and opportunities that currently inhibit this emerging industry.

Defining the Challenge

A host of challenges define the need to bolster marine aquaculture. For example, this nation:

- Faces a seafood trade deficit amounting to \$7 billion annually.
- Imports more than 60 percent of the fish and shellfish it consumes.
- Endures collapses of some of the country's more important fisheries, forcing commercial fishermen and seafood processors out of business.
- Benefits from aquaculture's potential to supply up to 25 percent of all seafood consumed by its citizens within the next 20 years, and to provide the seed for rebuilding of some fishery stocks.
- Suffers from an underdeveloped marine aquaculture industry, which — accounting for only 15 percent of total domestic aquaculture production — lags far behind its well-developed freshwater aquaculture industry.
- Represents a growing multimillion-dollar market for marine aquarium fishes— a ready outlet for cultured organisms that can relieve fishing pressure on wild stocks, especially in coral reef habitats.
- Bears the burden of a U.S. marine aquaculture industry whose expansion is constrained by its complex technology, diversity of species, multiple user conflicts, environmental and ecological concerns, and a fragmented institutional and regulatory system. Such constraints prevent traditional coastal aquaculture from expanding to reach its potential, and they block the application of new and innovative approaches to marine aquaculture in the nearshore.
- Faces the major challenge of a marine aquaculture industry that will grow only if (1) it addresses social and environmental constraints for nearshore areas, and (2) develops and applies new technologies to establish viable offshore and/or shore-based recirculating culture systems.

Pushing for Results

The National Sea Grant College Program — a university-based, multidisciplinary research, education and extension network committed to the balanced use and conservation of marine resources — is poised to help the nation meet these challenges. Sea Grant programs in all coastal and Great Lakes states are well positioned to address the needs and responsibilities of the marine aquaculture community, including responsible environmental approaches, through integrated aquaculture research and development efforts. Sea Grant can marshal the necessary talent including biologists, engineers, sociologists, market analysts, legal experts, and economists. Sea Grant and its allies will focus on the short-term needs confronting coastal marine aquaculture as well as the long-term needs for developing recirculating systems, enhancement protocols, and offshore aquaculture based upon environmentally sustainable practices and approaches for the production of food and ornamental species.

In fact, a 1999 national COMPASS initiative invited by the Office of Science, Technology and Policy

recommended that a substantial increase in federal funding is needed to achieve the nation's goals in marine aquaculture.

Defining an Agenda — Priorities for Action

Culture System Technology Development: Marine aquaculture operations will involve three distinct environments: the nearshore/coastal region; the Exclusive Economic Zone seafloor; and the open ocean surface and water column. Utilization of each environment presents unique system engineering and technological challenges.

Nutrition and Feeds: Research and development efforts must evaluate feed components in relation to organism growth and final product quality, as well as the stability of formulated rations and alternative protein sources.

Genetics of Cultured Species: Research must identify gene complexes responsible for reproduction, growth, disease resistance and other desirable traits so that state-of-the-art genetic manipulations can be applied to marine species.

Health and Disease: We must better understand the immune systems of marine organisms and the potential for the production of vaccines in finfish and shellfish. A great need exists for improved diagnostic capabilities for aquatic pathogens and parasites, new therapeutants, and streamlining the approval process for applying therapeutants in aquaculture.

Stock Enhancement: The potential for assisting the rebuilding of collapsed wild fish stocks through the use of aquacultured fish must be fully explored.

Public Policy and Law: Agencies involved in developing, implementing, and enforcing aquaculture policies must partner with environmentalists, universities, industry, and citizens in a comprehensive program to establish a viable coastal and offshore marine aquaculture industry based upon a sound understanding of the ecosystem, the economy and the particular needs of marine aquaculture. Sea Grant's access to university-based intellectual capital plus its strong links to coastal communities gives it a unique opportunity to assemble expertise to address:

- Conflicts among all users of coastal and marine resources potentially affected by marine aquaculture;
- The need for environmentally sensitive and science-based regulation, including the careful siting, operation and monitoring of coastal and offshore facilities;
- Use of exotic species in aquaculture, and protection from undesired introduction of these species into local waters;
- Leasing requirements and fees for such new business ventures; and
- Navigational considerations regarding existing shipping lanes and the needs of public navigation and safety.

Socioeconomic Issues: Marine aquaculture has been hampered by the lack of a coordinated effort among stakeholders to achieve successful commercial development in a socially and environmentally sensitive manner. Sea Grant can integrate expertise from universities, agencies and the private sector to:

- Address scientific, engineering, and socioeconomic needs;
- Assess and propose technologies and practices to protect the environment;
- Form partnerships with private industry to transfer technology, design market strategies, and develop spin-off industries;
- Provide marketing and technical expertise for new or prospective entrepreneurs; and

- Enhance scientific literacy in the nation's schools, by using aquaculture as a teaching tool.

Reaping the Benefits

Through its long-standing leadership in aquaculture and its partnership with university-based researchers, policymakers at all levels of government, environmental advocates, aquaculture professionals, and coastal communities, Sea Grant is poised to catalyze efforts to:

- Increase the value of domestic aquaculture production from \$900 million to \$5 billion by 2025;
- Offset the current \$7 billion annual U.S. trade deficit in seafood through increased domestic production from marine aquaculture;
- Raise per capita consumption above the current 15 pounds per annum through increased the availability of domestically produced seafood in the U.S. market place;
- Rebuild wild fisheries stocks through enhancement programs;
- Ensure the sustainability of marine aquaculture;
- Increase annual U.S. exports of aquaculture goods and services;
- Spur job creation in both the production and processing of fishery products, thereby revitalizing fishing communities devastated by collapsing fisheries industries.

<http://www.SGA.seagrant.org/ThemeTeam>



SCIENCE SERVING AMERICA'S COASTS

RESEARCH AND OUTREACH ADDRESSING THE NATION'S FISHERIES PROBLEMS

Many of our nation's marine and Great Lakes fisheries are in trouble. Sea Grant researchers and outreach specialists are part of the solution—they identify, analyze, and help solve problems in fisheries. Sea Grant has identified the following research and outreach actions as top priorities to revitalize and maintain our fisheries.

Sea Grant will work on these problems in collaboration with the National Marine Fisheries Service, state and regional fisheries agencies, and the recreational fishing sector.

Partnering to Improve Fisheries Management

America's fisheries are under extreme stress from many sources, and new management approaches must be found to cope with the difficult challenges.

With myriad relationships among university, government, and industry researchers, Sea Grant is uniquely situated to promote cooperative research on subjects critical to decisions being made by fisheries managers. Topics include stock assessment, habitat and ecosystem health, environmental contamination, area management strategies, fish biology and behavior, climate change, management institutions, conflict resolution, and others.

Sea Grant's outreach specialists translate and transfer useful research findings to stakeholders. Located in coastal communities, Sea Grant extension personnel enjoy cooperative working relationships with recreational, commercial, and subsistence fishing interests. This unique front-line presence will allow Sea Grant to facilitate local problem solving and guide experiments in community-based management.

Taking Stock

Some marine and freshwater fishes are commercially harvested, others are protected or not harvested for economic reasons. But all stocks are connected in the ecosystem, and all should be conserved.

To make the best decisions, fishery managers must have a reasonable idea of how many fish comprise each population, the rates at which they grow, reproduce, and die, and how many can be harvested under various scenarios of regulatory measures and fishing pressure.

Sea Grant researchers will collaborate with National Marine Fisheries Service (NMFS) scientists to carry out studies on population dynamics. And through the Sea Grant/NMFS Joint Graduate Fellowship Program in Population Dynamics, more stock assessment scientists will be produced to alleviate a critical shortage of trained personnel in this field.

Caring for the People

Changes in fisheries affect society. It is important that fisheries managers know how their decisions might affect people who depend on fishery resources. When changes affect people, it is equally important to help them cope.

Working cooperatively with government agencies and stakeholders, Sea Grant will provide fisheries managers with the socioeconomic data and insight into social and management institutions that are necessary to manage fisheries in a way that minimizes the negative effects their decisions will have on people. And through career training guidance, outreach personnel will help people adjust to changes that profoundly affect their lives.

Who's Where Doing What?

Fisheries managers must know how many fish are in the water, where they are located, how different species interact with each other and their habitats, and how changes in the environment affect the animals.

Sea Grant researchers and outreach specialists will work with fishermen and other concerned parties to test new sampling technologies and pioneer analytical procedures that will lead to more accurate estimates of distribution and abundance of fish and invertebrates, broaden understanding of how the animals interact with their environments and what habitats are best for different species, and how changes in the environment affect fisheries.

Adding Without Subtracting

Sea Grant researchers, in collaboration with other scientists, will explore ways to ensure that stocked animals do not affect the genetic diversity of natural populations. The researchers will determine how many cultured animals can be added to an area without adversely affecting other naturally occurring organisms of the same or different species. They will assess how fish released from aquaculture facilities interact with other species in the wild and determine how extensively hatchery fish interbreed with their wild cohorts. Researchers also will study how to minimize effects of aquaculture wastes on water quality, and how market competition between cultured fish and wild-caught fish affect the seafood industry.

Homes for Homeless

Human activities can degrade fisheries habitat, and natural environmental changes affect habitat in other ways. But little is known about what kinds and quality of habitat fish and invertebrates require throughout their lives, how habitat affects fishery production, and how human activities and natural environmental changes affect habitats.

To help fill the knowledge gaps, Sea Grant scientists will synthesize what is known about estuarine and marine habitats and their importance to the animals that depend upon them, examine how human activities and natural hazards and environmental change affect fisheries, and find effective ways to restore and enhance degraded habitat.

Balancing Needs with Technology

Through well-informed decision-making, fisheries managers strive to conserve stocks, reduce waste, and get more value from the harvest. Managers also try to balance the needs of recreational, commercial, and subsistence harvesters.

Sea Grant scientists and outreach specialists will work with fishermen and managers to invent tools and techniques that reduce unintentional capture of sea life during fishing activities and develop new seafood

products from target species to maximize value and yield and reduce waste. Sea Grant also will conduct research to discover how fishing gear affects habitat.

To help reduce conflicts among different users, Sea Grant experts will generate and share information on such topics as catch-and-release programs.

Recognizing Reasons, Predicting Effects

Fisheries oceanography is the science of understanding and predicting the effects of ocean and atmospheric processes on marine ecosystems. It demands the integration of many scientific disciplines and is critical to good fisheries management.

Sea Grant researchers will partner with government scientists to develop techniques to detect and forecast climate and ecosystem (regime) changes that occur in ocean basins over decades. They will examine how these changes affect all levels of sea life, from marine bacteria at the bottom of the food chain, to marine mammals near the top of the food chain. This work will help managers and scientists more accurately predict “domino effect” changes in ecosystems.

Great Lakes Fisheries

The Great Lakes hold about 20 percent of the world supply of fresh water and about 95 percent of the U.S. supply. The Lake Erie commercial fishery is the largest freshwater commercial fishery in the world, and the Great Lakes support large recreational fisheries. Well informed management is critical in this highly populated and environmentally sensitive region. Sea Grant researchers will develop ecosystem models to improve Great Lakes management techniques; find ways to cope with aquatic nuisance species; monitor and mitigate effects of contaminants and educate the public about them; and assess and identify ways to prevent loss of habitat.

<http://www.SGA.seagrant.org/ThemeTeams>



SCIENCE SERVING AMERICA'S COASTS

HEALTHY COASTAL ECOSYSTEMS FOR A HEALTHY ECONOMY

Coastal areas host some of the most ancient, complex and productive ecosystems on Earth. They have the potential to supply two-thirds of the world's seafood. Coral reefs, like tropical rainforests, support some of the most diverse assemblages of species on Earth – a vast potential source of valuable biochemical products. Wetlands protect coastal water quality and ecosystem health by filtering out nutrients and other pollutants.

The United States' 95,000-mile coast is among the longest for any nation on Earth. Coastal areas provide essential habitat for 75% of U.S. commercial landings of fish and shellfish. Coastal ecosystems are also critical habitat for numerous species of recreational fishes, waterfowl, migratory birds, marine mammals and sea turtles. A healthy coastal economy depends on healthy coastal ecosystems.

More than half of the U.S. population lives within 50 miles of the coast, and this population is growing at a much faster rate than inland. This rapid urbanization of our coasts has destroyed a significant amount of coastal wetlands, degraded coastal water quality, and severely stressed coastal ecosystems.

Sea Grant has a unique capability to bring the nation's best minds to bear on coastal habitat and ecosystem issues. It offers an integrated program of education, research, and technical assistance that promotes the wise use of natural resources by coastal communities. Sea Grant's interest in coastal ecosystems focuses on two broad areas:

- Minimizing the impacts of human-caused change to coastal ecosystems, and
- Developing and implementing methods of restoring damaged coastal habitats.

Reducing Stresses on Coastal Ecosystems

Excessive inputs of nutrients and toxic pollutants from the Mississippi River watershed are blamed for a 7,000-square-mile "Dead Zone" in the Gulf of Mexico. Dangerously high concentrations of nitrogen in coastal waters are blamed for outbreaks of new waterborne pathogens. Wetland losses have contributed to the over-fertilization of coastal waters and the growth of harmful algal blooms (HABs).

Sea Grant has been a leader in research and outreach regarding the public health and economic impacts of *Pfiesteria*, brown tides and other HABs; the root causes of the Gulf "Dead Zone"; the impacts of metropolitan sewage outflows on coastal waters; and the causes and effects of toxic chemical contamination of oysters, mussels and Great Lakes fish. Sea Grant has the experience and expertise needed to make significant contributions toward resolving these and many other coastal ecosystem and public health issues nationwide.

Invasive Species

A major threat to the health and survival of all coastal ecosystems is the introduction of exotic species via the ballast water of transoceanic ships and other means. Foreign invaders like the green crab, zebra

mussel and Australian jellyfish have displaced native species and diminished biodiversity, resulting in huge economic impacts and fundamental disruptions of coastal and Great Lakes ecosystems.

Sea Grant was among the first to respond to the zebra mussel invasion of the Great Lakes in the 1980s and the recent Australian jellyfish invasion of the Gulf of Mexico. Sea Grant created integrated, multi-state programs of research, outreach and education, and increased public awareness of the rising rate of “biopollution” by foreign species through conferences, information clearinghouses, newsletters, and Web sites (www.sgnis.org).

Coastal Watersheds

Upland land and water uses play major roles in determining the quality of coastal ecosystems and habitats. Effective management of coastal ecosystems requires a better understanding of the complex set of mechanisms and pathways by which upland land and water uses influence coastal waters.

Sea Grant investigators engage coastal communities to realize common goals of sustainable watersheds nationwide. Sea Grant develops the science-based information needed to predict the effects of watershed land and water use on coastal ecosystems and habitats. These include innovative applications of remote sensing, Geographic Information Systems and other novel technologies needed for a comprehensive national coastal watershed monitoring and impact-prediction system. Sea Grant has led the transfer of these technologies to local communities.

Conserving and Restoring Coastal Habitats

Nearly half of the nation’s coastal wetlands have been lost, and wetland losses in some states exceed 90 percent. Gulf Coast states have the largest proportion of remaining coastal wetlands in the nation – totaling just 17,000 square miles – yet these are also disappearing rapidly due to coastal development pressures. Other vital habitats such as beaches, dunes, seagrasses, coral reefs and oyster reefs face similar pressures.

Loss and deterioration of coastal habitat, especially estuaries and wetlands, has dramatically affected U.S. fishery stocks. Landings of estuarine-dependent fishes are down, and the shellfishing industry is at historically low levels. Salmon in the Pacific Northwest have declined significantly due to alterations to watershed habitat. The genetic diversity of many marine species is very low, increasing the probabilities of disease and extinction.

The identification of critical fish spawning grounds and nursery habitats is a hallmark of Sea Grant research nationwide, providing vital information for the designation of future marine protected areas. Sea Grant scientists also have studied the effects of commercial fishing on coastal habitats and how to ameliorate the adverse impacts of dredging.

Sea Grant empowers coastal communities to undertake well-planned coastal development that preserves and helps restore coastal habitats. Sea Grant partners with private and public entities to promote wetlands banking, rehabilitate brownfields, stabilize and restore beaches, establish marine protected areas, and use dredged materials to enhance fish and wildlife habitat. Sea Grant can contribute substantially to implementing the Coastal Wetland Planning, Protection & Restoration Act; Coastal Zone Management Act; the Estuarine Restoration Act, and other vital coastal conservation and management legislation.

Building on a Legacy of Success

Through its unique integration of research, education and outreach, Sea Grant has an enviable record of

success in providing policymakers and the public with useful science-based information for conserving and restoring critical coastal ecosystems. Through its established relationship with more than 3,000 faculty, staff, and students at over 300 universities nationwide, Sea Grant is exceptionally qualified to lead an expanded national effort that brings academia, government and the private sector together to protect and restore America's critical coastal ecosystems and habitats.

The Sea Grant program has a demonstrated capability to reduce the impacts of human-induced change on the structure and function of coastal ecosystems and to restore these critical habitats for future generations of Americans.

<http://www.SGA.seagrant.org/ThemeTeams>



SCIENCE SERVING AMERICA'S COASTS

SCIENCE HELPING COASTAL COMMUNITIES AND ECONOMIES BUILD A SUSTAINABLE FUTURE

Coastal communities depend on healthy ecosystems for their economic survival. However, population growth, increasing tourism and coastal development threaten the natural resource amenities that are the main economic engines for coastal regions of the United States. Balancing of economic growth and coastal resource quality is the critical issue for all the nation's coastal communities and requires a thorough understanding of a community's coastal resources, or natural capital, plus a commitment to sustainability principles. Bridging the gaps of information and coordination between the many coastal stakeholders is daunting but essential to realizing the full economic potential and environmental integrity of our coastal resources. Sea Grant, through its fundamental underpinning of university-based, interdisciplinary research and with its science-based outreach education, is uniquely positioned to continue its leadership role in helping coastal communities make progress towards sustainable development. The National Sea Grant Program has a network in place to address the national need in all coastal and Great Lakes states. Information and techniques developed in one state or region can be used broadly throughout the national network. The partnership between Sea Grant and the coastal and Great Lakes states is an excellent example of meshing federal and state programs to solve national problems or address national issues. The Sea Grant network will expand its research and outreach efforts with community leaders, decision-makers, user groups and governmental partners to improve leadership and planning capacities in the following areas:

Strengthening Coastal Planning

Evaluating Natural Capital: Sound coastal planning requires reversing the systematic undervaluation of coastal resources and amenities, often understood broadly as “natural capital.” Valuable goods and services – such as fisheries, recreation, waste assimilation, erosion, flood control and biological diversity – flow from our natural coastal systems. The inter-connectivity between the economy and the environment must be understood if the protection of coastal ecosystems and the requirements of economic development are to be balanced. Sea Grant will help communities examine their natural resources and support research to quantify the economic values derived from these coastal natural resources. A recent example of this approach is Sea Grant's successful *Lake Erie Beach Valuation Project*, a partnership with the Lake Erie Protection Fund that helped the state target infrastructure investments more effectively based on a better understanding of the value of its beaches.

Educating Coastal Planners: Sea Grant research is focused on expanding the scientific understanding of the function, biodiversity and economic importance of our coasts. Sea Grant is working to transfer this rapidly growing body of knowledge to coastal decision-makers and to train coastal leaders in the use of science-based tools. A successful example is the *Shoreline/Coastal Planners Group*, facilitated by Sea Grant and implemented in the Pacific Northwest. It provides science-based, coastal management tools to assist local planners in better managing coastal and estuarine areas. These professional development programs, planned by state and local planners and Sea Grant, will address the region's complex coastal management challenges.

Stimulating Integrated Coastal Management

Constructing Indicators of Sustainable Development: The concept of sustainable development arose from the pressures economic growth often puts on natural resources. However, a blueprint for sustainability is a yet-to-be-realized goal. Successful coastal management must look at the economic and social forces that impact and are impacted by the quality of the coastal environment. Coastal communities need to construct economic, environmental and social indicators that track sustainability in order to measure progress toward sustainable development. Sea Grant will expand its work with community planners to design indicators that appropriately represent the community's character and provide a framework for measuring its successes. Sea Grant's Aquidneck Island Partnership exemplifies how Sea Grant helps coastal communities pursue their vision of sustainable development. Through collaborative planning, adjoining towns worked to link economic development, transportation, open space planning and coastal resource conservation to achieve a balance between economic development and environmental well-being while maintaining the island's unique character and quality of life.

Developing Decision Support Systems: Sea Grant will continue providing decision-support tools to help decision-makers utilize the vast array of information available to communities. A recently successful example, "NEMO" (Nonpoint Education for Municipal Officials), is a partnership between Sea Grant and USDA's Cooperative Extension Program. This national program uses remote sensing and Geographic Information Systems technology to educate local officials about the impacts of land-use change on coastal water quality. Spatial decision support systems are critical to Sea Grant's Urban Boating Bay Water Management Program in Florida. This successful program encourages a self-regulatory approach and boater education to manage boat-congested waterways, promote stewardship and maintain a quality recreational environment.

Supporting Community and Economic Development

Building Leadership: Sea Grant will train community planners, business leaders and citizens to use science-based tools more effectively in the decision-making process. For example, Sea Grant's *Communities In Transition Program* provides research and outreach to fishing families undergoing difficult economic and social times because of a declining fisheries industry. The program provides techniques to deal with financial and emotional stress and training to pursue alternative economic opportunities.

Revitalizing Communities: Smaller coastal communities have endured declines in their economic bases, especially in such resource-dependent industries as fisheries. They have also had to face complex environmental regulation, such as the Endangered Species Act. Sea Grant works to help smaller communities make smart choices about development and protection of the quality of coastal life. For example, Sea Grant has forged a partnership with communities in Washington and Oregon to create waterfronts that provide better public access and preserve their rich maritime heritage. Many smaller coastal communities are evaluating options for revitalizing depressed economies. Sea Grant's tourism program focuses on helping communities develop tourism and nature-based recreation to offset economic declines in other areas.

Achieving Results

Ultimately, Sea Grant's Coastal Communities Theme is about assisting coastal communities in protecting their environmental amenities, strengthening their economies and improving their quality of life. There is no "cookbook" approach to community planning. Rather, each community must make decisions in ways that best engender their own unique environmental, social and economic perspective. This is the challenge to Sea Grant — to provide science-based information and innovative tools that encourage successful

community-based environmental protection and sustainable community development. Sea Grant, building on its record of scientific research and science-based outreach and working in partnership with communities, can help sustain the nation's coastal resources and secure the vitality of coastal communities for generations to come.

<http://www.SGA.seagrant.org/ThemeTeams>



SCIENCE SERVING AMERICA'S COASTS

URBAN COASTS FACE MULTIPLE CHALLENGES

As the 21st century opens, more than 54 percent of the U.S. population is concentrated in coastal areas accounting for only 10 percent of the country's land mass. Economic growth since World War II has sparked increased urbanization of coastal areas — with corresponding rises in pollution and environmental degradation.

In an urban setting, a shoreline has significant appeal, shown in the demand for recreational, business and residential developments near the water. Communities and states must balance economic and environmental values, manage the impacts of nutrient runoff and waste disposal, and consider needs for transportation, recreation and commerce — while maintaining the integrity of coastal ecosystems that provide critical habitat and nursery areas for countless species. When based on solid scientific data, these crucial decisions can have positive implications for the nation's economy and environment.

Resolving Urban Dilemmas

From gene probes that track harmful algae to satellite technology that monitors coastal changes, the results of Sea Grant projects demonstrate expertise in sound-science solutions relevant to difficult local and national policy decisions.

In 30 programs around the country, Sea Grant combines research and outreach to help residents, business leaders and government officials cope with urban issues that accrue in coastal cities — water quality, beach access, and planning, among others. The rapid transfer of research and new technologies makes Sea Grant's outreach capabilities valuable to coastal communities. For example, sea level rise models developed by Sea Grant for low-lying Ventura County, California, communities are the basis for local land-use plans. The same models are being used in coastal Maine to assess effects on residents and businesses, and to develop appropriate mitigation and planning strategies.

As an honest broker, Sea Grant shares information and facilitates open discussions nationwide — defining immediate and potential problems, assessing risks, and helping to develop action plans. While Sea Grant has outlined various pressures on urban coasts in the next decade — including aging infrastructures, loss and change in ocean-related industries, potable water technology and transportation needs — three areas require immediate attention.

Reducing Nonpoint Pollution

Diverse urban pollutants degrade watersheds across the country, sending contaminants and excessive nutrients into bays and the coastal ocean. Yet, nonpoint sources are difficult to identify or control.

In Hawaii, a Sea Grant project to trace the flux of heavy metals in nearshore waters sparked additional research by the U.S. Geological Survey to evaluate the effect of land use on water quality. In Louisiana, Sea Grant is working with state officials to remove heavy metals from runoff that now pours directly into estuaries from highway bridges and an extensive causeway system.

In a comprehensive study of nonpoint source pollution in Southern California's Santa Monica Bay, Sea Grant researchers mapped the stormwater plume, identifying the toxic elements posing threats to human and marine life. Local officials and stormwater managers in the City and County of Los Angeles are using this information to reduce the effects of nonpoint runoff on public beaches and marine ecosystems.

Sea Grant encourages cooperation within watersheds and provides updated data and scientific information to business/industry leaders, local government officials and landowners, who can then collaborate on comprehensive strategies to reduce runoff.

Immediate needs are varied. Urban watersheds should be mapped to define sources of biological and chemical contaminants. Specific pollutants — metals, pathogens and nutrients — must be tracked in urban runoff. The role of wetlands and other natural means to reduce runoff effects on streams, bays and nearshore waters must be explored. Sea Grant researchers also can develop models that assess the impact of proposed mitigation efforts.

Enhancing Ports and Harbors

The vitality of American commerce depends upon the nation's 150 deepwater commercial seaports — and diverse coastal marinas and harbors — that struggle with environmental quality amid pressures for expanded service. Ports and local harbors are often dredged to deepen channels, improve navigation and increase capacity, but expansions may threaten adjacent fragile wetlands or compete with fishing, development and community needs.

While clean sediments may be beneficial for beach nourishment and coastal development, a greater challenge is disposal of sediments containing metals, PCBs, DDT, and petroleum-derived hydrocarbons. These contaminants can be released during dredging and disposal. Sea Grant experts served on a Boston Harbor technical advisory team that recommended burying sediments in underwater trenches. The Massachusetts Port Authority and the U.S. Army Corps of Engineers have adopted this new isolation process for use in projects around the country.

Many of the nation's more than 500 ports provide diverse — and sometimes incompatible — services, from handling container and bulk cargo shipments to accommodating small-craft and tourism vessels. For nearly 30 years, the Pacific Coast Congress of Harbormasters and Port Managers has called upon Sea Grant researchers and extension staff to develop "best management practices." Through MarinaNet, Sea Grant assists professional marina associations and manufacturers to conduct sound economic research for environmentally sustainable ports and marinas.

Port managers throughout the nation call upon Sea Grant to help improve infrastructure yet preserve wetlands. Sea Grant scientists evaluate ecology and water quality in major urban ports, offering risk-assessment and modeling processes to predict cumulative impacts. Sea Grant port specialists continue to look at ports on a national scale, working with industry and government officials on environmental, navigational and economic issues.

Managing Coastal Resources

Sea Grant is a leader in bringing various interests to the table to tackle critical coastal planning issues. In Connecticut, regional water officials used Sea Grant's satellite-based analysis to identify lands to be acquired or otherwise restricted to low-intensity uses — thus reducing runoff and avoiding the expense of new filtration systems. In North Carolina's fast-growing coastal counties, developers, landowners and local officials will learn principles of shoreline erosion, water quality and coastal planning through a

series of Sea Grant guides commissioned by state officials.

Coastal policymakers and resource managers face increasing conflicts over existing and proposed uses of coastal space and resources. Accurate, unbiased scientific data will help managers nationwide to prioritize the allocation of scarce coastal resources.

Moving Forward

Sea Grant leads the nation in identifying and solving the problems — and in recognizing the opportunities — along our urban coasts. Sea Grant’s federal/state partnership matches multidisciplinary research with public education and outreach, making it uniquely capable of providing resource managers, users and policymakers with understandable, scientific explanations of natural processes, and the value and risks involved in activities and change.

These efforts help resolve significant threats to valuable resources along the urban coast — and many of these lessons can be applied to waterfront development and redevelopment across the country.

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SCIENCE SERVING AMERICA'S COASTS

REDUCING THE NATION'S VULNERABILITY TO COASTAL NATURAL HAZARDS

“To enhance preparedness and reduce losses of human life, property and environmental resources from coastal natural hazards”

U.S. coastlines are at risk from coastal natural hazards — the winds, waves and floods generated by hurricanes and other major storms, the physical impacts caused by earthquakes and tsunamis, and the threats to coastal development due to short- and long-term shoreline change. Risks to life and property from these hazards will increase as coastal population expands from 110 million people today to an estimated 177 million by the year 2010. Over the last few decades, property losses from coastal disasters have skyrocketed, reaching more than \$150 billion in the 1990s. This upward trend is likely to continue as investments in vulnerable coastal property increase rapidly.

Coastal natural hazard risks are compounded by sea level rise, land subsidence, unfamiliarity of coastal residents with local hazards, and an increasingly valuable building stock along the nation's coastline. These observations underscore the need for a dedicated national effort to reduce the economic, social, and environmental costs of natural hazards. Research and outreach programs are needed to help states and localities create an aware and prepared citizenry capable of employing the most effective means to reduce these risks. The nation's Sea Grant College Program and its existing networks of universities, laboratories, and outreach programs contribute considerable expertise and capability to the national coastal natural hazards mitigation effort.

Reducing the Loss of Life and Property

The goal of the Sea Grant Coastal Natural Hazards Initiative is to enhance preparedness and reduce losses of human life, property and environmental resources from coastal natural hazards in the United States. Sea Grant is united in this objective with many public and private interests, including NOAA's National Ocean Service and National Weather Service, Federal Emergency Management Agency, U.S. Geological Survey, Institute for Business and Home Safety, and U.S. Army Corps of Engineers. Sea Grant's strong connections with its universities and coastal constituencies, and its capabilities in the areas of basic and applied multidisciplinary research, education and technology transfer, enable it to contribute critical information and assistance to the national effort. Overall, Sea Grant will foster efforts to:

- Develop new technologies for remediation and disaster prevention
- Develop methodologies and techniques for risk assessment and cost-benefit analysis
- Generate methods for restoration of natural habitats (e.g., barrier islands, dunes, beaches, marshes) that play an important role in minimizing damage from coastal hazards
- Establish a clearinghouse of university-generated information on coastal hazard events and mitigation strategies
- Transfer information and technologies to coastal constituents on the predicted risks, expected impacts and effective methods for pre-event preparation and post-event recovery
- Develop and transfer economic evaluation techniques to state and local officials seeking to develop

more effective mitigation, evacuation and recovery plans.

Weather-related Hazards

Over the past 20 years, 44 weather-related disasters with overall damage costs exceeding \$1 billion each struck the United States. Thirty-eight of these occurred during the 1988-1999 period with total damage costs exceeding \$170 billion. Insurance companies paid out more than \$91.8 billion in losses from weather-related natural disasters in the 1990s, close to four times the weather-related claims settled during the 1980s. Even so, some \$2 trillion in insured property currently lies within 30 kilometers of the Atlantic coast alone, exposed to the threat of hazard damage. Sea Grant will support efforts to:

- Develop hazard-resistant retrofit alternatives for existing buildings and structures,
- Evaluate and improve mitigation tools and techniques related to building construction and land use,
- Develop, refine and demonstrate community risk and vulnerability assessment methods and standards, leading to improved methods for cost-benefit analysis for use by local officials,
- Provide information for use in developing more effective building codes, and
- Improve hurricane management for ports and harbors.

Earthquakes and Tsunamis

Earthquakes and tsunamis are infrequent but very dangerous natural hazards that threaten the coasts and inland waters of California, Oregon, Washington, Alaska, Hawaii, and territories in the Pacific region, as well as Puerto Rico and the Virgin Islands in the Caribbean. The Cascadia Subduction Zone (CSZ) just offshore in the Pacific Northwest and the Aleutian Seismic Zone are of particular concern, given the potential there for very large, destructive events. U.S. seismologists put the probability of a major Alaskan earthquake of magnitude 7.4 or greater in the next decade at 84 percent. Along the CSZ, the probability of a magnitude 8-9 event is 10 to 20 percent in the next 50 years. Tsunamis generated by such events will reach coastlines in as few as 15 minutes. Sea Grant, through public and private partnerships, will:

- Reconstruct historical earthquake/tsunami events and impacts through examination of the geological record,
- Contribute to more timely and more accurate tsunami warnings and prediction of post-event flooding potential,
- Evaluate potential economic, social, and environmental impacts and costs of earthquakes, tsunamis, other coseismic hazards, and of evacuation and recovery strategies, and
- Develop tools to assist port and harbor communities in assessing earthquake/tsunami risk, vulnerability, and mitigation options.

Shoreline Change

Nationwide, coastal erosion is responsible for approximately \$500 million per year in property loss to coastal property owners, including damage to structures and loss of land. To mitigate coastal erosion, the federal government spends an average of \$150 million every year on beach nourishment and other shoreline erosion control measures. Despite these efforts, over the next 60 years, erosion may claim one out of four houses within 500 feet of the U.S. shoreline. Experts predict increasing sea level rise this century, accelerating coastal erosion and property loss. Sea Grant activities will:

- Improve shoreline mapping and change analysis methodologies,
- Document and evaluate the influence of the regional and local geological framework on current sedimentary processes,

- Examine beach and coastal ocean processes, particularly to establish sand “budgets,”
- Identify and evaluate sustainable erosion control techniques and technologies that take into account environmental considerations,
- Improve understanding and assessments of the relationship between shoreline change and environmental effects, and
- Assist local governments and developers in incorporating water availability limitations, erosion rates and setbacks, and coastal building codes into development activities.

Partnering for Success

Sea Grant will join with federal and state agencies, coastal communities, and the private sector to accurately assess the threats to the coast from natural hazards, generate and modify technologies to minimize damage, and develop education and public awareness initiatives for and transfer research information from the nation’s universities to all those who live, work and play along the nation’s coastlines. Through a proactive partnership effort, property damage and loss of life can be reduced, saving the federal and state governments, taxpayers, business and industry, and the insurance community billions of dollars annually.

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SCIENCE SERVING AMERICA'S COASTS

RESEARCH AND OUTREACH IN MARINE BIOTECHNOLOGY: SCIENCE PROTECTING AND CREATING NEW VALUE FROM THE SEA

Biotechnology offers great promise as a tool to develop solutions from the sea. Consider that:

- More than 80 percent of the earth's living organisms are found only in aquatic ecosystems, and we know little about their biochemical characteristics. Our challenge as a nation is to discover the life-enhancing and lifesaving qualities these unique organisms possess.
- Approximately 40 percent of coastal waters are currently unfit for swimming because of bacteria and pollutants. Our challenge is to develop the biological technologies needed to identify sources of ecological stress and develop strategies to protect coastal resources.
- Understanding the dynamics of fish populations and the impact of disease is essential to manage resources. Our challenge is to develop molecular technologies that will allow scientists and managers to differentiate populations and address emerging diseases to protect fishery and ecological resources.
- Seafood-borne illness impacts public health and coastal economies. Our challenge is to use molecular technology to develop rapid diagnostic assays that ensure the safety of the seafood we eat and the vitality of the seafood industry.

Meeting the Challenge

The biotechnology revolution has created enormous opportunities for research and economic development. The worldwide market for biotechnology-based therapeutic products alone may reach \$24 billion in 2005. While studies that extend biological technologies to the marine environment are few, they hold great promise. Marine plants, animals and microorganisms have evolved in complex ecosystems and produce many unique biochemicals. These marine natural products have demonstrated potential to treat diseases such as cancer and inflammatory disorders and may prove effective against HIV. Microorganisms from extreme oceanic environments, such as thermal vents and polar regions, have provided industry with "extremozymes," which have commercial applications at extreme hot and cold temperatures. Studies of the molecular control for silicon production in marine diatoms have promising applications in the emerging field of nanofabrication. The economic potential for marine products and processes is immense.

These same technologies offer equally important opportunities in the environmental arena. The next generation of technology for monitoring of biological processes, remediation of pollutants and conversion of wastes will all be linked to these new biological technologies. Current applications of molecular technology have already affected how ocean and coastal problems are managed and given us new ways to identify ecological stress in target organisms. Molecular biology has provided environmental managers, seafood processors and the aquaculture industry with an accessible toolbox that enables them to make better decisions on critical resource and economic issues.

Building on a Record of Achievement

Sea Grant's sustained investment in marine biotechnology has placed it at the forefront of the field.

Success is evident in a number of key areas:

- Pseudopterosin, an anti-inflammatory agent isolated from a marine gorgonian, has a market value of \$3-4 million per year.
- Four marine natural products are currently in clinical trials, with a potential market value of more than \$1 billion.
- Application of the polymerase chain reaction (PCR)-now enables public health officials to simultaneously identify multiple microbial pathogens— including *Vibrio* and *Salmonella* — in oyster tissue, in a single rapid assay.
- Contaminant-degrading microbes and metal-trapping algae are enhancing environmental remediation.
- DNA fingerprints and an enhanced understanding of reproductive strategies are contributing to the management of key fisheries.
- Molecular probes for harmful algal bloom-forming species are enabling managers to better predict potential health risks.
- Development of molecular biological tools to assess the effects of contaminants like endocrine disruptors is progressing rapidly.

Collectively, these advances provide substantive examples of the power and potential of biotechnology.

Mobilizing Sea Grant's Unique Resources

Sea Grant will invest in marine biotechnology to catalyze advances in marine and coastal science. If we are to reach the potential offered by these biological technologies, it is imperative that we engage current practitioners and train new researchers to take advantage of the opportunities at hand. Any effort must be coupled closely to outreach and extension activities that educate stakeholders in coastal communities nationwide.

Investing for the Future

Sea Grant investments in innovative science and emerging technologies will produce strong returns. These investments will be coordinated with outreach and communication efforts designed to generate an understanding of the potential of marine biotechnology and develop links between scientists and stakeholders, including managers, industry and the general public. The exploration of unique marine environments and new applications provide exciting educational opportunities for teachers and students alike. Our goal is to de-mystify biological technologies and the scientific process that underlies them and focus attention on the exciting new opportunities created. Key areas for investment include:

Marine Natural Products: The tools of molecular and cellular biology, chemistry, pharmacology and ecology will be used to discover and evaluate innovative natural products found in marine organisms. Attention will be focused upon unique coastal and marine environments, such as anaerobic regions of estuaries and lakes, deep-sea vents, coral reefs and arctic waters. Marshes, wetlands and even contaminant-stressed environments provide fertile grounds for novel organisms and their products. Projects will develop technologies to assure production of sufficient material for use as pharmaceuticals and in industrial applications.

Biomolecular Processes Discovery: Research focused on the unique mechanisms used by marine organisms to generate elaborate mineralized and bio-molecular structures is essential. Understanding the emerging areas of chemical signaling and signal transduction are important to enhance our knowledge of bioluminescence, biofouling, biocorrosion, biofilm function and symbiosis. These studies will be used to develop antifouling and anticorrosion materials as well as create an understanding of how microbes colonize surfaces.

Marine Environmental Biotechnology: Sensitive and accurate means of predicting impacts of stressors on marine organisms are needed to strengthen indices of coastal ecosystem health. Sea Grant will encourage the development of novel biosensors, genome enabled technologies such as microarrays and their application to real-time monitoring technologies and will link them to engineering and remote sensing initiatives. This research will lead to the development of effective bioremediation strategies. These will be supported by the use of molecular biology as well as innovative “green technologies” that employ biological systems engineering focused upon remediation of polluted sites.

Marine Resource Management: New tools to characterize diversity of economically important species at the molecular-genetic level are essential for fisheries managers. Sea Grant will promote studies that identify larvae or provide fine-scale delineation of key stocks, and will support applications of molecular techniques to help understand and quantify ecosystem processes. Research will spur the identification and treatment of emerging diseases in economically important stocks and ecosystems, thus improving options available to resource managers.

Seafood Safety and Processing: The development of molecular assays for human pathogens and aquatic organisms is vital, as is research offering new ways to identify public health issues in seafood processing. Sea Grant will help scientists and others identify clear linkages between technology development and HACCP guidelines. In addition, Sea Grant will promote the application of biological and biochemical technologies to develop value-added products and economically viable uses for wastes.

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SCIENCE SERVING AMERICA'S COASTS

THE DIGITAL OCEAN: OUR OCEANS ON A MICROCHIP

Imagine placing the oceans on a microchip. In a fashion, the Digital Ocean Program is setting out to do this, by developing methods to create extensive digital representations, or models, of ocean resources and phenomena. With such models, we will be able to translate chemical, biological, and physical data into tools that will help us learn how best to use and tend our resources. The Digital Ocean—identified as one of three multimillion-dollar, multi-agency undertakings under Sea Grant's COMPASS (Coordinated Marine Programs to Assess and Sustain the Seas) proposal—builds on work pioneered by Sea Grant in the areas of autonomous underwater vehicles (AUVs), modeling, mobile platforms, robots, sensors and more. These existing technologies, coupled with developing ones to gather, analyze and make data widely available, hold much promise.

Focusing on Coastal Areas

Today, more than 50 percent of all Americans live in coastal areas; that figure is expected to jump to 75 percent by 2025. The Digital Ocean Program can offer coastal zone applications to address the increasing demands posed by these concentrations. Current U.S. facilities are demonstrating that the technology exists to collect real-time ocean data and readily share it via the Internet. In addition, Sea Grant's major contributions in the Autonomous Ocean Sampling Network Prototype show that a network of AUVs working with distributed acoustic and point sensors can achieve spatially adaptive sampling.

The first stage here will be to develop tools to assimilate data from distributed observatories, or even individual networked ocean sensors. The second stage will be to connect this assimilated data with the various existing computer models of ocean processes.

Examples of potential benefits abound. Fisheries management would benefit from the ability to quickly and easily test population models using data for Atlantic and Pacific salmon—or any other species. A nearly real-time comparison of species trends across the country would be a new tool for fisheries policy development. Similarly, models using assimilated water quality databases along a coastline or from neighboring watersheds would be of great value to regional authorities.

Particular topics of interest include wireless telemetry, better fish stock assessment tools, and intra-instrument communication so that any deployed sensor can become part of a vast network feeding data into a national database.

Supporting Offshore Oil Industry

The Digital Oceans concept also presents ample opportunities for supporting the offshore oil industry. The trend toward subsea wells—some 1,000 more are expected by 2005—illustrates industry expansion into deep water and suggests the timeliness of our support of deepwater oil exploration, maintenance and safety. Recent fluctuations in oil prices make it clear that supporting our domestic oil industry is of vital interest. By using our strong contacts with the oil industry, we could help create a new industry that contributes directly to Sea Grant's National Strategic Objective of economic leadership.

Specific applications in this area include exploration and survey, and inspection and intervention. Improving the endurance and telemetry capabilities of current AUVs will allow researchers to deploy a small fleet of survey vehicles from one support ship, thereby collecting data more efficiently. That data, in turn, could be funneled into a comprehensive Digital Oceans database that the offshore industry could use to make major decisions regarding pipeline routes and platform locations—thereby improving safety, decreasing environmental impact, and substantially lowering costs.

In the area of inspection and intervention, the important technologies will be sensors, telemetry, and management and control software focused on the region immediately surrounding an offshore structure or pipeline. Properly equipped AUVs could be permanently docked in these areas, vastly improving efficiency and safety.

Preparing for Hurricanes

One of the most exciting anticipated applications is in the area of monitoring and models for extreme events, particularly hurricanes. U.S. financial losses due to hurricanes were estimated at more than \$53 billion in the last decade. Although hurricane-related deaths in the U.S. have greatly decreased, other countries still suffer heavy losses. This is largely because they lack the satellites, aircraft and ground-based radar used to provide warnings in the United States. Ocean-based hurricane observation systems could greatly increase forecasting abilities and significantly decrease the number of deaths and economic loss.

In addition, the coupled nature of the ocean and the atmosphere provides further rationale for increasing the ocean-based study of hurricanes. Sea Grant's parent organization, the National Oceanic Atmospheric Administration (NOAA), supports extensive atmospheric monitoring aimed primarily at weather prediction. Examining hurricanes from an ocean perspective rather than a solely atmospheric one is of great importance.

One Digital Ocean research topic involves the development of new *in situ* sensors capable of being used in a hurricane. AUVs might be modified to study the water column beneath hurricanes, and new drifting sensors might be developed to ride through a hurricane. A second area of investigation is the use of acoustic systems to provide greater spatial coverage of the ocean. Preliminary research indicates that hurricanes and other ocean storms may have distinctive acoustic signatures, which could be tracked over great distances. Additional research in this area is highly recommended. In addition, earthquake monitoring and underwater volcanic activity could also prove fruitful areas of research. Unlike the hurricane research, which is almost virgin territory, this sort of research has already been proposed by the National Science Foundation.

Creating Tools for Tomorrow

These are just three areas in which The Digital Ocean Program can make significant advances if allocated funding. As a university-based organization, Sea Grant is uniquely poised to tap into rich, intellectual resources and to partner research, education, and outreach. By creating banks of information via models and other means, we will be creating invaluable tools for interrogation by scientists, policy makers, fisheries managers, and coastal managers who will in turn be better equipped to make the everyday decisions essential to their jobs and the healthy sustainment both of our economic and ocean resources.

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