NOAA's National Sea Grant College Program

Fiscal Year 1994 Program Guidance

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
December 1993

Contents

National Sea Grant College Program
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Introduction

Purpose

This statement is prepared in anticipation of proposal receipt and review for Fiscal Year 1994 funding. The intent is to uniformly provide the Sea Grant network, and others, with guidance from the National Sea Grant Office (NSGO) staff. It is not implied that only efforts in areas stated to be of highest priority will be supported, but it is intended that dissemination of this guidance will skew the distribution toward such areas.

Background

Expansion of knowledge for its own sake is not adequate reason for Sea Grant support. Focus should be on increasing the value of public benefits from basic research leading to the development and use of marine resources. Proposed efforts will continue to be subjected to a three-tiered review process at the national level (extramural written peer review, on-site review, and review by the NSGO staff.) No proposal project in research, education, or advisory fields will be considered for funding unless the rationale (and programmatic values), methods (project protocol), and a prospective use (user relationships) are considered suitable. Proposed activities should have sufficient intellectual content to make them appropriate university functions.

Networking, either within or among campuses or institutional programs, continues to be encouraged. Meeting some of the current coastal and ocean challenges will require fiscal, intellectual, and operational resources not available to any single program. In such cases, use of the concept of networking is clearly indicated. Consequently, the NSGO is placing greater emphasis on networking among institutional programs whenever appropriate to meet the programmatic guidance below. Staff at the NSGO are available for consultation, assistance, and coordination.

Regional Marine Research

Regional Marine Research Plans have been under development for the past two years in accordance with the new Regional Marine Research Program (RMRP). At the time of this writing, two plans have already been approved. This guidance has taken into account those plans, and the essential complementarity of the two programs, Sea Grant and RMRP.

Technology and Commercial Development

Ocean Engineering

High Priority:

- In the development of efficient aquaculture production systems, engineering support appears to be one of the weak links. In particular, advances in the computer sciences, including artificial intelligence, should be utilized in more efficient design and control of systems. Water quality control and transfer and mixing processes are other key areas.
- The competitiveness of the U.S. fishing industry can be increased by focusing on the efficiency of the harvesting operation. Engineering studies should include gear development, propulsion, and hull design, for example.
- The safety and economics of working in the marine environment and conducting research can be enhanced with the use of unmanned vehicles. This technology is in its infancy and deserves added attention. In particular, with regard to autonomous vehicles, research should include design of appropriate missions for "single purpose" vehicles to take advantage of the best of current technology and to fit within current limitations; development of new sensors with low power and space requirements; extension of present power and communication limits; development of advanced artificial intelligence concepts to expand the ability to learn from the environment and control the vehicle; and development of methods to accomplish progressively more complex mechanical work functions.
- Most materials are subject to accelerated deterioration in the marine environment. Maintenance, repair, and replacement are costly. Particularly important are fundamental studies of metal corrosion and the use and degradation of non-metallic and/or composite materials.
- The assessment of the remaining useful life of aging structures and extending the life through appropriate repairs is a developing focus of activities within Sea Grant; this is strongly encouraged. The problems involved in our decaying infrastructure have received insufficient attention in the past.

Low Priority:

- Routine engineering design or commercial practices.
- Increased sophistication of a hydrodynamic or other mathematical model for its own sake.
- Collection of geographically specific information for advising particular groups (without special justification).

Marine Transportation

High Priority:

- In collaboration with NOAA's Coast and Geodetic Survey, there is a need for Sea Grant institution(s) to provide a robust and defensible method for setting hydrographic survey priorities:
  - Develop a general model or procedure which can be used to assess navigation risks and vulnerability in waterways, approaches, harbors, etc.
  - Identify all areas and regions, such as waterways, approaches, and harbors that are reasonable candidates for future survey operations. Define a data base structure which represents these areas and regions.
  - Design and implement a program to populate the data base.
  - Perform analyses and demonstrate the system, showing how survey priorities can be derived.
- Evaluate changing conditions (such as technology change, major international political and economic events, major financial developments, changes in trade patterns, and changes in capital markets) in terms of their effects on port management and productivity.
- Determine the types of information needed for decisionmaking and particularly the kinds of data bases needed to meet the market forecast information requirements of smaller ports.

- Examine the factors that determine port growth, including internal and external factors.
- Examine the role of ports in economic development.
- Define appropriate environmental controls for the prevention of catastrophic accidents in ports and harbors and explore mechanisms for environmental mitigation, including arbitration or mediation.
- Determine the impact of various forms of user fees on larger and smaller ports.
- Explore the training needs of the port industry at all levels.

Marine Economics

The goals of the Sea Grant Marine Economics Program are to:

- enhance the competitive position of marine resource-based businesses in order to sustain economic growth and job creation in the long term;
- increase the economic and societal benefit derived from the nation's marine resources and environmental assets; and
- improve the efficient allocation of marine resources, especially through the use of economic incentives and market-based solutions.

Research should focus on understanding the underlying economic prerequisites and conditions needed to meet these goals. Research proposals must offer to make a significant contribution both to solving practical problems and to economics scholarship. Interdisciplinary efforts with other social sciences, the natural sciences, engineering, and law are strongly encouraged. Priority research areas are identified and discussed below.

Sea Grant Business Initiative

The Sea Grant network, through a series of workshops and planning meetings, has made a renewed commitment to supporting research and advisory programs related to the long-term economic development, growth, and competitiveness of marine sector businesses, such as:

Aquaculture
Commercial Fisheries
Marine Trades
Seabed Mining
Offshore Energy
Ports and Harbors
Water-borne Transportation
Marine Biotechnology
Coastal Recreation and Tourism
Oceanographic Services

Industry studies of productivity and economic performance, business trends and practices, technological change, the impact of trade or environmental policy, and the effects of demographic change or resource regulation on these industries are high priority research areas. (See *Economic Competitiveness and the Coastal Environment: Towards the 21st Century*, The National Sea Grant College Network, 1993.)

Economic Valuation of Marine and Coastal Resources

The estimation of benefits derived from marine resources, especially non-market values, identified with marine recreation, wetlands, habitat preservation, endangered species, biodiversity, and environmental quality—is an appropriate research area. Analyses of resource values of ecological systems is extremely important, and provide an excellent opportunity for economists and ecologists to work together to integrate their quite different approaches to analyzing economic development.

Recent efforts to elucidate the concept of sustainable economic development, and the Clinton Administration's announced intent to move toward "Green" national income accounting measures to track the economy's use of natural and environmental resources, makes research on valuing marine resources a strong priority.

Coastal Ocean Management

Land and water use conflicts, habitat loss, water quality degradation, and increased waste loadings are severe problems in coastal areas. Remediation of these effects and their cumulative impacts on marine resources present important economic research needs. The ocean disposal of wastes and hazardous materials, the problems of marine debris, and the design of economic incentives for pollution abatement and environmental improvements continue to be important areas of study.

Fisheries Management

The design of efficient market mechanisms to allocate fishery resources and minimize industry dislocations is the most critical problem in fisheries management today. Research is required to analyze how fishing behavior would respond to individual harvesting rights vs. fishery-wide quotas; to measure the benefits and costs and the distributional impacts of regulatory regimes; and to improve empirical techniques to measure the value of fish stocks in alternative uses, including the rebuilding of stocks.

Routine economic baseline studies in support of fisheries management are low priority. However, there is a tremendous need for economists to communicate with fishery managers and industry members about fundamental socioeconomic concepts applicable to the management and allocation of fish stocks. In the process, economists gain the insight that comes from the questioning of underlying assumptions, analytical paradigms, and research results.

Property Rights in Ocean Space

There is continued need for clarification of ocean property rights across the whole spectrum of marine resource development activities. If ocean property rights are not satisfactorily defined, incentives for technological advancement are lessened. The familiar debates on over-fishing, coastal waterfront development, beach access, pollution discharge into estuaries, ocean dumping, aquaculture leasing, sea level rise, and seabed mining claims exemplify property rights issues in the oceans. Sea Grant wants to develop a research program built around the concept of property rights in ocean space. It would be multidisciplinary and include economic, legal, social, historical, and political research on ocean property rights related to resource use.

Recreation and Tourism

Recreation and tourism activities are important uses of Great Lakes and ocean resources. Sea Grant's support of research and advisory service programs in this area follows from the importance of this sector to the national economy and to the economic base of coastal communities across the nation. Interdisciplinary approaches—involving economists, sociologists, psychologists, geographers, lawyers, engineers, natural scientists, diving and safety experts, and others—are encouraged.

High Priority Areas:

Recreation and Tourism Economic Development

Research aimed at providing better planning and analytical tools for use by communities and small businesses considering investment in coastal recreation and tourism development is very important, given the need to make efficient use of limited fiscal resources. The segment of tourism markets which focus on environmental tourism are of special importance.

Valuation of Marine and Coastal Resources

The economic and social benefits derived from coastal recreation and tourism are significant. Development of conceptual models and empirical methods for valuing marine resources allocated to these purposes must remain in the forefront of this research.

Access to Coastal Recreation Opportunities

Coastal recreation opportunities depend upon the public having access to the shoreline and adjoining waters. Research that addresses the technical, legal, or socioeconomic changes needed to broaden recreation opportunities and to remove barriers is important. This might include, for example, research on boating access

that addresses small harbor design, marina management, and pollution control; urban recreation research that focuses on waterfront revitalization; sport angling enhancement looking at the design of fish aggregation devices, artificial reefs, catch and release programs; or the study of beach access and congestion as it effects the quality of beach recreation.

Resource Scarcity and User Conflicts

Recreation and tourism issues are often tied to areas such as fisheries or coastal zone management, water quality and pollution control, and transportation, among others. For example, claims to fish resources are voiced by competing user groups such as sports, subsistence, and commercial fishermen or environmental groups. Here, recreation research might be part of the broader resource use question. Another example is where conflicts arise from multiple-use of coastal resources such as with shoreline development or the leasing of water rights for aquaculture.

Low Priority:

Routine Analysis of Baseline Recreation Data

Sea Grant does not have the resources for, nor should it be intellectually inclined toward, the collection and routine analysis of recreation data for the many regions or participant groups wanting such information. Research aimed at providing a descriptive picture, inventory, or economic baseline of recreation and tourism activities are low priority. Alternate ways of responding to these needs should be found, perhaps with financial support from the industry or state.

Living Resources

Aquaculture

General

It is becoming apparent that aquaculture for certain species in North America is going to be more intensive. Therefore, added emphasis needs to be placed on the development of cost-efficient intensive systems. This will require more attention to engineering problems, computer monitoring and control, and comparative economics of different systems. Nursery systems utilizing recirculating water and conservation of heat need to be developed to interface with open pond situations that can be used during warmer months. Baseline information needs to be set on water quality requirements by species for closed system conditions. It is also time to start looking at engineering technology for offshore culture of selected species.

Now that many of the problems of life history have been solved for key species, there is a shift in interest toward more basic physiological and endocrinological studies. This is to be encouraged so better control of reproduction, environmental adaptation, and growth can be obtained. However, applied studies with shorter-term payoffs are still appropriate.

High priority is given to research directed toward improving the potential for commercial aquaculture operations involving marine or Great Lakes species that are economically viable or nearly so. Those species highest on the list of priorities for this year include: hybrid striped bass, marine shrimp, marine finfish (grouper, mahimahi, snapper, redfish), salmon, freshwater finfish of the Great Lakes, hard clams, oysters, and mussels.

Aquaculture research on non-marine organisms (those that do not occur naturally in the Great Lakes, oceans, or brackish water during any part of their life cycle) is low priority, especially those for which the Department of Agriculture or Interior has assumed responsibility.

Specific Research Areas:

Aquaculture Permits, Regulations, and Policy

This area of research is moved forward in importance, and the issue should be addressed in every state expecting aquacultural development to occur. Research is needed that will provide states with information that can be used in developing appropriate policies and regulations pertaining to aquaculture. At the very least, advisory agents and specialists should have at their disposal guidelines on how states handle aquaculture permits, regulations, and policy. Advisory personnel should be fully familiar with the regulations of their particular state and should keep abreast of activities in other states.

Genetics and Selective Breeding

Research is needed to understand the basic genetic makeup of the organisms in culture sufficient to determine the potential for improvement of the species and to identify the most promising methods for making these improvements. Special emphasis needs to be placed on producing faster growing and disease-resistant strains of commercially important species.

There is also a need to determine the effects of hatchery-produced aquatic species on the wild populations into which they are introduced.

Physiology and Endocrinology

Understanding endocrine effects on physiology and growth of aquatic animals is becoming increasingly more important for commercial operations. The chemical composition of active hormones in aquatic animals needs to be characterized.

Environmental Requirements

As the environments in which aquatic animals are raised continue to be modified, it is essential to know the optimum environmental requirements for specific species. In addition, the complex interactions that occur in open pond culture must be understood in order to control production under those conditions. The carrying capacity of the natural environment for cultured marine organisms needs to be better defined. A new area for 1994 is to determine the effect of the microbial community on hatchery and pond culture success. Recent advances in Japan have indicated that hatchery environments can be improved through proper condi-

tioning with beneficial bacteria.

The combination of aquaculture activities in any particular area needs to be assessed as a whole system. In other words, there is a need to know the complementary effects of growing fish, algae, and filter feeders in the same area in order to reduce the impact of aquaculture on the environment.

Nutrition and Feed Development

Studies leading to more cost-effective artificial diets for crustaceans and finfish are needed. Recent analyses of European aquaculture have shown that aquaculture, particularly of crustaceans and finfish, will become limited by the availability of fish meal. Present aquacultural feeds are taking fish protein from trash fish and converting it into higher-quality protein for human consumption. However, in many parts of the world, the original fish protein could be used directly for human consumption rather than being fed to a higher trophic level fish with the concomitant loss of efficiency. This limitation needs to be overcome by looking at biotechnology to provide new ways to mass produce proteins suitable for inclusion in aquaculture diets. More efficient methods for production of higher-quality natural diets and development of better feeding procedures are needed for cultured animals. Improved understanding of the nutritional requirements for specific life stages for hard clams, oysters, marine fish, saltwater shrimp, and salmon is also high priority.

Pathology and Disease Control

Determination of the causes of major disease-related mortalities in culture systems, and the development and testing of procedures and substances to prevent or control these mortalities are assigned a high priority for oysters, marine finfish, salmon and shrimp. Disease poses no constraint at this time for mussels, clams, and freshwater shrimp; thus, work of this type on those animals is low priority.

Fisheries

General

High priority is given to research that aids in solving managerial and conservation problems confronting U.S. commercial and recreational fisheries or that advances the state of knowledge in fisheries science.

High priority research includes:

- Improving the capability for predicting short- and long-term population status;
- Identifying and quantitatively describing the processes and mechanisms controlling natural variability in population abundance;
- Quantifying the functional relation between habitat characteristics and quality with fish and shellfish productivity;
- Developing means for restoring and enhancing depleted species and stocks of fish and shellfish;
- Developing methods and means to reduce the capture of non-targeted species and life stages and/or the degradation of benthic habitat;
- Developing improved means to quantitatively sample all life stages of fish and shellfish in close to "real time;" and
- Designing and evaluating management schemes aimed at improving the efficient and equitable allocation of fisheries resources among competing users.

Although high priority is given to the research objectives listed, the following topics should be given particular attention during the next three years.

Population and Community Modeling

The activity level in modeling has diminished over the past four years. Although low priority will be given to studies that simply apply well-known population models to various fisheries, high priority is given to developing new models, evaluating the assumptions of commonly used population models, and incorporating results of recruitment research into population and community

models. Efforts in multispecies fisheries models are also encouraged.

Recruitment Fisheries Oceanography

Highest priority is given to the development of comprehensive, multidiscipline ocean experiments focused on ocean systems. Excellent opportunities exist to develop studies in association with or complementary to NOAA's Fisheries Oceanography Cooperative Investigation (FOCI) in the Gulf of Alaska and the Bering Sea, the South Atlantic Bight Recruitment Experiment (SABRE) off the Atlantic Coast between North Carolina and central Florida, and with the Georges Bank Ecosystem Study of the coast of New England. Additional opportunities exist in developing research that is complementary to the National Science Foundation/NOAA Global Ecosystems Dynamics (GLOBEC) field study in the area of Georges Bank.

Restoring and Enhancing Exploited Stocks Through Hybridization and Genetic Engineering

A great deal of research activity is being pursued throughout the country to develop hybrids and genetically-improved fish that can be used for aquaculture and in stock enhancement and restoration programs. Research on the consequences of the accidental or intentional release of improved fish on wild populations is of the highest priority. Such investigation should include social and economic components, as well as biologic components before being supported.

Gear Studies

Research on fishing and sampling gear has been very scarce despite the large number of problems associated with harvesting and sampling. The highest priority is assigned to research aimed at estimating and assessing the impacts associated with bycatch and on developing novel and innovative approaches to selectively and efficiently harvest fish and shellfish. High priority is also given to research on sampling gear for larval and particularly juvenile stages. Emphasis should be placed on sampling gear that facilitates sample processing and speeds up processing time. In addition, studies are encouraged that investigate the effects of gear on habitat.

Marine Biotechnology

General

Marine biotechnology can be broadly defined as the use of marine organisms or their components to provide products and services—products such as polymers and pharmaceutical compounds, services such as control of biofouling and biocorrosion or sensitive measurement with biosensors. Sea Grant's research to provide the scientific basis for technical developments in this field can be considered in the categories described below. Making research in these categories relevant to the use of marine organisms or their components in high technology may require efforts in engineering and investigation of fundamental physical, chemical, and biological phenomena. Interdisciplinary planning may benefit or be essential to such endeavors. Usually, however, planning in academic research proceeds within single disciplines and has resulted in the call by some scientific philosophers to bridge the gaps among the chemical, biological, and engineering sciences. In addition to exploiting opportunities for interdisciplinary approaches where appropriate, proposals and projects should be oriented both to advancing science and to providing the basis for developments in high technology.

Bio-organic Chemistry

The study of the structure and function of primary and secondary metabolites of marine organisms is important because these metabolites have potential for application in medicine, medical research, agriculture, and the chemical industry. What is their role in nature? What insight can they provide to such issues as allelopathy, ecological relationships, biosynthesis, chemical communication, and biochemical aspects of symbiosis?

Few scientists interested in marine bioactive substances have turned their attention to aqueous extracts, enzymes, other bioactive macromolecules, or to marine bacteria, fungi, yeasts, and microalgae as subjects of study. Along with traditional topics in study of natural products, these neglected topics represent areas of opportunity for marine research.

Isolating, identifying, and determining function and properties of enzymes responsible for unusual biosyn-

theses and unique processes constitute a research direction of potential importance. Research on metabolic pathways leading to substances of real or potential commercial importance, like the alginates in algae, could provide part of the basis for improving technology. The nitrogen-fixing thermophilic bacteria in particular, and thermophilic bacteria in general, as well as non-photosynthetic sulfur bacteria from marine environments, may be promising subjects for fundamental studies that could provide the basis for their application in industrial processes. For example, enzymes from organisms that function at high temperature could be useful in chemical processing. Of high priority is exploratory research on algae, including single-cell algae, to develop a basic understanding of their biochemistry and metabolism and to determine their content of useful chemicals such as enzymes, pigments, vitamins, other fine chemicals, or feedstocks for the chemical industry.

Cellular and Molecular Processes Relating to Bioactivity

Because many metabolites are difficult to obtain in large quantity, high priority is assigned to development of bioassays that require only small quantities of test substance. Development and use of bioassays that define new or uncommon mechanisms or sites of physiological or pharmacological action are especially important. Defining pharmacophores through molecular structure, synthesis, and computer modeling is viewed as a productive route to advancing science and technology. Characterizing structural features that result from interaction of a bioactive compound and its receptor is viewed as vital to describing novel characteristics of a natural product and its inherent bioactivity, and important to providing a basis for designer drugs. Low priority is assigned to generalized screening for antibiotic properties unless it is geared to providing leads to substances with activity of significance in the context of products already in use.

Cell Culture, Bioreaction, and Bioprocessing

Opportunities in this underdeveloped category include studies on basic physiology and nutrition of marine microorganisms and cells of higher organisms to set the stage for their use in controlled systems for producing commercial substances. Cell culture could provide a technique useful in studying the basic physiology and nutrition of organisms. It could be useful for determining natural regulation of secondary metabolism. Of special interest is understanding nutritional and environmental controls on metabolism (especially secondary metabolism), determining mutual biochemical effects of symbionts on production of metabolites, and determining factors that promote production of useful materials. Also important are studies on use and adaption of microorganisms in bioreactors to detoxify industrial effluents and wastes, and studies of bioprocesses that may have industrial application such as in waste processing. Research in this category could provide the science for developing photo-bioreactors which could be used in exploiting the biosynthetic capabilities of photosynthetic organisms. Such developments could depend also on advancements in biochemical engineering. Bioreactor design, materials selection, product separation and purification, and instrumentation would be among the important engineering issues.

Biofouling, Biocorrosion, and Biosensors

Biofouling and biocorrosion in the marine environment are extremely costly forms of deterioration. Increasingly stringent environmental regulation is making traditional methods of controlling or ameliorating these processes difficult. Thus, environmentally sound methods for preventing or controlling these complex processes are needed. These methods likely will derive from fundamental information gained from studying the mechanisms of these processes.

Progress in rapidly evolving fields like biotechnology and medicine is often limited by inadequacies in measurement technology. Biosensors promise to meet some important measurement needs for drugs, metabolites and other biomolecules. (Biosensors use an immobilized biological material, even a living material, in contact with a transducer to convert biochemical signals into quantifiable electrical signals.[1]) Thus, marine organisms could play an increasingly important role in biotechnology because of their biochemical components that could be exploited in developing biosensor technology.

[1]After Belli, S.L. and Rechnitz, G.A., 1988, Biosensors based on native chemoreceptors, *Fresenius Anal. Chem.* 331:439-447.

Molecular Genetics of Algae

Blue-green algae, now designated cyanobacteria, are the only algae that have been genetically modified by molecular techniques. Because a wide spectrum of both micro- and macroalgae from marine environments is useful or potentially useful in commerce or medicine, there is a strong rationale for developing information and molecular techniques that eventually can be used to alter the genetic traits of algae for desirable purposes. Thus, research focusing on (a) determining mechanisms by which gene expression is regulated in marine algae, and (b) developing methods by which foreign genes and additional copies of natural genes can be added to the genome of algae is considered important.

Molecular Genetics of Fishes and Invertebrates

The U.S. imbalance of trade in seafood products makes up a significant part of the total trade deficit. Aquaculture is considered one route to ameliorating this problem. Some aspects of aquaculture are technologically sophisticated, especially in Japan and Scandinavia, but little progress has been made in genetic engineering of aquacultural species for improved performance in controlled culture. Because this is an important goal, research focusing on developing fundamental information and techniques for modifying genetic traits of marine fishes, mollusks, and crustaceans is important.

A spectrum of marine invertebrates and microorganisms has been shown to produce bioactive substances and other biochemicals of importance or potential importance in pharmacology, research, and the chemical industry. While chemical synthesis will be the route to commercial production of most chemical products, some are too complex for synthesis. Thus, production from living systems could be a viable route as it is with many antibiotics. Developing molecular technology for modifying genetic traits of invertebrates and marine microorganisms could be important to technology in the long term. For most types of marine organisms, research in molecular biology, including DNA technology, at a fundamental level will be required before practical application of these sciences can be reasonably attempted. Of special interest is (a) determining the mechanisms by which gene expression is controlled, (b) developing techniques for introducing fish growth genes into microorganisms to provide the basis for large-scale production, and (c) developing techniques for introducing foreign DNA to or amplifying native DNA in the genome.

Marine Biomaterials

Although the polysaccharides of a variety of macroalgae have been studied and a few are produced commercially, the study of marine organisms generally as sources of useful polymers has been neglected. Almost no research has focused on polymers of microalgae, other microorganisms, or animals. Biopolymers display chirality (left- or right-handedness) and for this reason may have useful properties different from petroleum-derived polymers which do not have this property. The advantages offered by hydrogen bonding and controlled crystallinity in natural polymers will provide control of physical and chemical properties that may make possible production of chemicals with sophistication transcending the capabilities of petrochemicals. Also, of interest is defining properties of marine biomaterials, developing methods for manipulating materials into new forms, and producing modified prototype materials.

Seafood Science and Technology

General

Of high priority are research projects that address the problems which prevent delivery of fresh and frozen domestic seafood products of high microbiological and organoleptic quality to consumers in the United States and foreign countries. The research may encompass development of concepts for new products that could create new domestic markets; allow U.S. fishery resources, including underutilized species, to be used in traditional foreign markets; and enhance productivity by providing uses for food- or feed-grade materials currently wasted in processing. Other work relevant to these problems may include efforts to improve practices in handling, processing, transporting,

and storing fish and fishery products so that safe food of consistent high quality can be expected from the industry. Of equal importance is research directed toward development of generic techniques for improving efficiency in processing which can and should include engineering approaches.

Some areas of concern, relating to research and extension, that were included in a 1988 report of the U.S. General Accounting Office, *Seafood Safety: Seriousness of Problems and Efforts to Protect Consumers*, are the following:

- the need to develop better tests to measure microbiological contamination in shellfish-growing waters and in shellfish stock,
- the need for a better indicator of viral contamination in shellfish,
- the need to create a greater public awareness of the potential health risks associated with consuming raw or undercooked molluskan shellfish,
- the need for more consumer education in general about seafood handling and preparation, (mishandling of seafood and improper cooking are regarded as major causes of seafood-borne illness), and
- the need for more research to better understand chemical contamination in seafood and its implications for human health.

Molecular techniques, including DNA technology, may be especially appropriate for addressing the need for better assays for food pathogens and toxins and for organisms responsible for degrading product quality.

Product Safety

Research addressing issues of seafood safety is important. Of particular concern are problems arising from contamination of seafood with pathogenic bacteria, viruses, and chemical contaminants, including natural toxins. Development of rapid and economical tests which could prevent commercial trade in contaminated products is important. Development of decontamination procedures is also important. Establishing the ecological basis for sensibly managing fisheries to lower risk of contamination may also be a desirable approach to solving problems.

A new issue of particular seriousness is the natural toxin, domoic acid, that causes amnesiac shellfish poison (ASP). Domoic acid is an insidious, neuroexcitatory, non-protein amino acid. ASP was characterized for the first time in late 1987. In November and December of that year, it made 153 persons ill in Canada; 93 experienced gastrointestinal distress only and 58 reported, in addition, neurological symptoms including confusion, loss of short-term memory, seizures, and coma. ASP directly and indirectly killed five persons. ASP was traced to the diatom *Nitschia pungens*. The effect of this toxin on humans is still being studied. ASP is present in U.S. waters, including those of the West Coast, and Maine closed two harvest areas because of it. Obviously, ASP and the oceanographic controls on size and density of *Nitschia* populations are topics of high priority for research.

Processing Wastes

One of the important issues confronting seafood processors is increasingly stringent regulation of quality of effluents. Consequently, research directed at alleviating this growing problem is important. A wide range of approaches is appropriate—from development of methods for decreasing volumes of effluents to development of useful products from waste materials and development of new, inexpensive biological or physical methods for making effluents conform to regulatory standards.

Nutrition

Sea Grant research in seafood science has included studies on microconstituents of seafood and on its nutritional quality. Work of this type is still appropriate if it is justified on the basis of its relevance to well-defined problems or opportunities relating to health or safety. Opportunities to investigate and document seafood's contribution to good health are extant. For example, fish oils are thought to improve cardiovascular health, but a fundamental understanding of their nutritional and biochemical modes of action is lacking. In some quarters, there has been concern about bioavailability, especially of inorganic constituents. Studies that will develop reliable information on

bioavailability in many cases require the use of human subjects and careful controls. Experiments of this type are expensive and, if undertaken through Sea Grant, should be on the basis of highly significant problems or opportunities in development of resources. Of low priority is work directed toward cataloging concentrations of chemical constituents of seafood without a justification based on specific problems or opportunities.

Basic Studies

Research in seafood and technology is or can be directly relevant to realizing opportunities for significant expansion and improvement of the U.S. fishing industry and concomitant reduction of the national deficit in foreign trade. Because much of this research is applied and can be quickly and directly transferred to industry, heavy emphasis is put on interaction and cooperation with industry and outreach specialists as well as with the technological laboratories of NOAA's National Marine Fisheries Service which are also engaged in research of this type. It is recognized, however, that appropriate studies may be basic in nature. For example, to solve certain problems in seafood quality, it would be logical and cost-effective to first develop a fundamental understanding of the factors that affect the organoleptic quality of seafood, and then to apply this knowledge to specific problems.

Environmental Studies

The complex nature of modern marine environmental issues calls for research extending beyond traditional, descriptive studies of local ecosystems. Instead, investigations must focus on fundamental ecological processes that regulate ecosystem structure and function and on the response of ecosystems to natural variability and anthropogenic change. The ultimate goal of such research is the development of a detailed, quantitative understanding of ecosystem response that will permit timely and accurate environmental prediction and mitigation of undesirable effects.

The NOAA Strategic Plan includes as one of its key program elements the need to "promote healthy coastal ecosystems by ensuring that economic development in U.S. coastal ecosystems is managed in ways that maintain biodiversity and long-term productivity for sustained use." High priority will be given by Sea Grant to research that helps achieve this goal. Of particular interest is the development of approaches to assess and predict the effects of multiple stresses on coastal ecosystems, their associated watersheds, and their living marine resources, so that management can be carried out effectively and on the appropriate scale.

Six broad topics are identified as focal points for Sea Grant environmental research during FY 1994: primary production and nutrient dynamics; trophic dynamics; habitat dynamics and utilization; toxicants and other materials that pose threats to the well-being of marine organisms and ecosystems; human health concerns; and applications. Specific guidance for each topic is provided later in this section.

As general guidance, high priority will be given to environmental studies that address critical environmental problems on a national or regional basis. In this regard, multidisciplinary and inter-institutional studies are strongly encouraged. Research undertaken in support of other NOAA elements is also encouraged. Low priority will be given to environmental characterizations, monitoring, and "baseline" studies.

Nutrient and Carbon Dynamics

Studies pertaining to estuarine and coastal issues including the regulation of primary production, nutrient effects, nutrient dynamics, and eutrophication are of major interest to Sea Grant. Topics of high priority include:

- The relative importance of riverine, terrestrial, atmospheric, and oceanic sources of nutrients and carbon in shaping estuarine and coastal production.
- Alterations in the productivity and biodiversity of estuarine and coastal ecosystems in response to natural and anthropogenic environmental changes.
- The impact of the eutrophication of rivers and estuaries on nutrient and carbon cycling on the continental shelves.

Trophic Dynamics

High finfish or shellfish (secondary) production in coastal and estuarine waters is often associated with high primary production, but the relationship is not consistent or well understood. Among the priority areas to be addressed are:

- The linkages between primary production and living marine resources, and the way those linkages are affected by anthropogenic stresses and natural variability, especially interannual variability in weather patterns.
- The identification of key species in estuarine and coastal food webs and the elucidation of their roles in modulating secondary production.

Habitat Utilization and Dynamics

Sea Grant is concerned with understanding both the processes that shape marine communities over time and space and with the importance of specific habitats to the well-being of living marine resources. Special emphasis is placed on estuarine and wetland habitats because of their proximity to centers of human population, their use by society for multiple, often conflicting purposes, and their roles as spawning grounds and nursery areas for economically valuable species of finfish and shellfish.

Priority research areas are:

- To determine the ecological interdependence of the habitats in a given watershed, including, for ex-

ample, the seasonal and age-specific patterns of habitat utilization by key living resources, and the advective exchange of materials (e.g., nutrients, sediments, and larval stages) among estuarine and associated upland habitats.

- To measure the variation in habitat quality in space (locally, regionally, and geographically) and time (seasonally and interannually) in response to both natural and anthropogenic stresses (e.g., changes in hydrology, sediment loading, and eutrophication).
- To improve techniques for restoring and creating wetland and estuarine habitats, emphasizing the use of biotechnology where appropriate.
- To develop population and community level indices of habitat quality that reflect the ability of habitats to support living marine resources in order to improve the ability to evaluate the success of habitat restoration and mitigation activities.
- To address the issue of nonindigenous species introductions including prevention, control, and mitigation of their environmental and economic impacts.

As the importance of biodiversity has been acknowledged in the coastal and marine environment, the lack of trained taxonomic specialists has become a serious impediment to the research community's ability to address the issue. In light of Sea Grant's responsibilities for graduate education, innovative research projects that include training students to become taxonomic specialists, while at the same time improving understanding of the role of biodiversity in coastal ecosystems, will be considered a high priority.

Toxicants and Other Ecosystem Threats

A continued need exists to examine the physical, chemical, and biological pathways of toxicants in the aquatic environment. A need also exists to understand the effects of toxicants on valued living marine resources and on the ecosystems required for their support.

Research on the following topics is of priority interest:

- The processes that control the transport, fate, and bioavailability of toxicants in the marine and Great Lakes environment.
- The effects of toxicants at the population and community levels. This includes investigations of contaminant-induced alterations in reproductive ability, growth, and disease incidence, and studies of effects on critical life-history stages. Investigations of the physiological and biochemical mechanisms by which organisms detoxify or metabolize pollutants are of high priority only if such studies are undertaken as part of a larger investigation of population- or community-level effects.
- The implications of toxic substances on the functioning of coastal and estuarine habitats/ecosystems.
- The interactions of pollutants and natural stresses in organisms.

Human Health

Sea Grant environmental research has always been focused toward understanding factors that can adversely affect human health. The presence of pollution-derived toxic materials in the edible tissues of fish and shellfish is of concern. A need exists for a better understanding of the dynamics of pathogenic bacteria and viruses in the marine environment, including sources, transport, survivability, and rates of uptake and depuration by shellfish. Blooms of noxious and toxic algae in coastal and estuarine waters pose threats to the health of humans and to coastal living marine resources as well as aquaculture. A need exists for a better understanding of the causes of toxic algal blooms and for the development of methods to predict the onset, duration, and severity of such blooms.

Priority research interests include:

- Development of rapid, specific, and sensitive detection methods for bacteria and viruses in the environment.
- Understanding harmful algal blooms causes; the development of techniques to predict their occurrence, severity, and duration; and the control of harmful algal blooms and mitigation of their effects.

Applications

A major objective of Sea Grant environmental research is the development of information, equipment, and procedures to enhance society's ability to wisely use its marine resources. For example, several Sea Grant programs have initiated efforts to use remote sensing—specifically satellite imagery—as a source of data for environmental interpretations. Geographic Information Systems (GIS) are also being used to combine results from studies of habitat function and habitat spatial relationships with extant and projected demographic and impact-related data bases.

Priority research topics include:

- The application of environmental technology to support sustainable development in the coastal zone through the development of new products and processes that reduce or eliminate the environmental impacts of existing and new industries and businesses.
- Reformulating water-, land-, and waste-management practices; subsequent changes in nutrient, sediment, pathogen, and toxicant loadings; and the likely environmental implications of such changes.
- Evaluating environmental management practices to determine whether specific governance strategies have greater likelihoods for success, in association with the priorities of the National Sea Grant Office's Human Resources Division.
- Development and testing of novel equipment and procedures for gathering or analyzing environmental data, particularly if specific users are identified, and if evidence is presented of in-kind or actual support from projected users.
- The development of remote sensing and GIS capabilities within the Sea Grant network; cooperation among investigators from several Sea Grant programs may be especially appropriate.

In contrast, low-priority is assigned to requests for the long-term support of research facilities or monitoring programs.

Coastal and Ocean Processes

General

The Sea Grant Coastal and Ocean Processes Program supports fundamental and applied research on the physical and geological processes influencing the quantity and quality of coastal resources. Additional support is provided for developing engineering tools and numerical models useful in predicting the effects of natural and man-induced changes to natural systems and management of the resource base. This guidance addresses the need for quantitative understanding of fundamental hydrodynamic and sedimentary processes—understanding which must be obtained before significant advancements can be made in related subject areas.

In recent years, the impacts of natural phenomena (e.g. storms, hurricanes, long-term change) on man's activities along the coast have been increasingly costly. Millions of dollars of waterfront real estate are lost each year to shoreline erosion, and property damage from coastal storms is equally as costly. Sediments deposited in navigation channels and harbors require hundreds of millions of dollars of dredging each year to insure the safe and efficient passage of waterborne commerce. These problems are being exacerbated by an ever-increasing demand for coastal resources and rapid development of coastal areas.

Solutions to such problems depend upon knowledgeable decisions by scientists, engineers, and managers. Good decisions not only require quantitative understanding of the processes, but also demand accurate models for predicting the impacts of natural and man-made changes. However, within the surf zone and nearshore waters, the interactions between waves, currents, sediment and the sea bed are extremely complex, spanning time scales ranging from seconds to millennia and occurring in a region of significant wave nonlinearity and relatively high turbulence. Because of this complexity, and a past inability to make accurate field measurements, knowledge of the fundamental physics of the coastal ocean remains rather rudimentary. Consequently, existing numerical models are generally crude, and engineering design relies as much

on experience and judgment as on quantitative tools.

Recent scientific and technological advancements make this an opportune time to undertake fundamental research on coastal hydrodynamic and sediment transport processes. Although the ultimate goal is to predict physical changes to nearshore environments based on time-dependent dynamical models, the behavior of complex, large-scale nearshore regions on time scales of months to years can only be understood if the physical processes of smaller, simpler systems over much shorter time scales are modeled correctly. Therefore, an ordered sequence of process-oriented experiments is envisioned to investigate forcing/response mechanisms over a wide range of time and space scales. Existing models of the physics of fluid motion and particle transport should be used to define experimental needs, and results should be used to verify models and develop and test new relationships. High priority research topics discussed in this guidance relate to: wind waves, long waves, sediment transport, coastal storm hazards, sea level rise, and instrument development and are discussed below.

Incident Wave Processes: Turbulence

The temporal and spatial distribution of high velocity, high frequency turbulence is important to sediment motion initiation and transport. The intensity of turbulence produced may eventually be predictable given knowledge of the incident wave characteristics. However, the precise mechanisms of energy transfer to turbulence and sediment interactions with turbulent fluctuations are unknown.

Research needs include studies of:

- Turbulence generation at both the sea surface (wave breaking) and the sea bed (bottom boundary layer).
- The role of turbulent fluctuations in the initiation of sediment motion and in the maintenance of suspended sediment concentrations via eddy diffusion.
- The general role of fluid accelerations (large with high frequency turbulent motions) in sediment suspension.

Incident Wave Shoaling and Breaking

The shoaling and breaking of surface gravity waves is a much studied problem in nearshore processes, and there is a large body of literature dealing with the idealized situation of a normally incident, monochromatic wave train propagating on a uniformly sloping beach. The linear wave theory-based expressions for radiation stress, energy density, and energy flux developed by Longuet-Higgins and Stewart (1960) have proven qualitatively correct, and most features of the shoaling wave field are relatively well known. Conditions for the onset of breaking of this particularly simple wave type, and the shoreward decay of the resulting bore, have also been studied extensively in the laboratory. However, relatively little data exist for field conditions.

Research needs include:

- Generalization of refraction-diffraction equations to a directionally spread, weakly nonlinear, random sea.
- Development of a spectral, random wave model for bore propagation in the surf zone with capabilities to predict turbulence levels and nonlinear moments of the velocity field, including the effects of infragravity waves and complex bathymetry.
- Field verification of the above models.
- Further quantification of breaker characteristics, including the importance of wave plunging on sediment suspension.
- Wave processes over soft, muddy bottoms.

Infragravity Waves (also referred to as surf beat and edge waves)

Long-period water level fluctuations in the surf zone are an order of magnitude or more greater than the period of the incident wind waves. Recent field experiments have significantly improved knowledge of infragravity waves and confirmed their importance to nearshore fluid and sediment motions. In addition to exhibiting standing wave structure in the cross-shore direction, infragravity wave energy at the shoreline

(which is important in controlling wave run-up characteristics) was found to increase with increasing incident band energy outside the surf zone. In fact, within the surf zone, incident wave heights are reduced by breaking, while the amplitudes of nonbreaking infragravity waves increase. Finally, some indications have been found that on a barred profile, resonant interactions between infragravity waves and the bathymetry could lead to amplification of discrete infragravity wave frequencies. No conclusive linkage has been found, however, between bar crest position and peak-frequency infragravity waves.

Research needs include:

- Incident to infragravity energy transfer processes.
- Infragravity wave effects on beach and surf zone sediment transport.
- Tuning of infragravity waves by nearshore morphology.
- Parameterization of infragravity energy dissipation.

Wave-Induced Nearshore Currents

Quantitative models for the dynamics of nearshore currents driven by incident waves utilize the concept of "radiation stress," the depth integrated excess momentum flux owing to the presence of waves. In a spatially non-uniform wave field, as occurs during wave shoaling and breaking, gradients in the radiation stress result in a steady force. The cross-shore component of this force drives bottom return flow and other cross-shore currents and produces changes in the mean sea surface elevation, i.e. set-up. The longshore component, non-zero when waves approach the coast obliquely, drives steady longshore currents. However, monochromatic (single frequency) wave models applied to a naturally occurring random sea yield only crude parameterizations of the physics of longshore currents. Random waves are an essential element of realistic longshore current models.

Research needs include:

- Developing and verifying, in the field, random wave models for steady wave-driven currents on complex bathymetry.
- Quantifying the energy and momentum transfer processes of a breaking, broad-banded wave field that generate longshore currents.
- Determining the temporal and spatial variability of the vertical structure of velocity within the wave and current boundary layers under various wave and bottom conditions.
- Quantifying rip current hydrodynamics and sediment transport processes.

Tidal and Wind-Induced Currents

The traditional concept of purely wave-induced surf zone currents is often inadequate to describe longshore and cross-shore current behavior. In fact, shelf-wide tidal and wind-driven flows extend to the shoreline and in some cases may be stronger than wave-driven flows. Onshore winds may produce localized setup of water against the coast, resulting in a seaward directed flow near the bottom. Conversely, offshore winds drive surface waters away from the coast producing onshore near-bottom flows. The direct contribution of surface wind stress is very important to longshore flows on shallow, gently sloping shorefaces such as in the Great Lakes. In certain areas, tidal currents dominate shoreface sediment transport.

Research needs include:

- Quantifying the relative contributions of winds, waves, and tides to longshore and cross-shore currents through field experiments of surf zone and shelf-wide observations of tidal and wind-driven flows.
- Determining the vertical structure of velocity within wave and current boundary layers.
- Developing models of tide- and wind-forced nearshore currents and sediment transport.

Sediment Response to Physical Forcing

Recent fast response measurements of fluid flows and suspended sediment concentration profiles in the surf zone, and limited application of numerical models incorporating time-dependent turbulent diffusion

concepts have begun to provide new insights into sediment transport in the wave-dominated environment. These insights include the role of infragravity energy in driving sediment motions in the inner surf zone; boundary shear stress estimates from wave-current shear flows; and the coupling between cross-shore oscillatory velocities and the total suspended load and cross-shore particle flux. Preliminary results clearly suggest the importance of time-dependent boundary layer modeling and field experiments.

Research needs include:

- Determining suspended and bedload transport dependence on sediment size, density, and shape.
- Quantifying the effect of bed roughness on oscillatory boundary layers.
- Suspended and bedload effects on bed shear stress.
- Turbulent transfer mechanics associated with combined wave-current boundary layers.
- Characteristics and behavior of bed-forms under combined wave and current flows.

Coastal Storm Hazards and Sea Level Rise

There are a number of problems associated with coastal storm hazards and sea level rise that could be addressed effectively with relatively small, focused research efforts.

There is a need for storm surge and wave height measurements in developed areas during a hurricane. The ability to model storm surges has improved considerably in the last 20 years, unfortunately it is very difficult to measure and interpret wave heights and still water levels around buildings. This problem means that models are probably poorly calibrated in the most critical areas.

A number of dune erosion models are now available but it is not clear if one model is better than another, or for what circumstances one model might be preferred over another. Further, it would be very advantageous to have an erosion model that included breached dunes with overwash.

The current rate of sea level rise along the U.S. coast is quite variable. Estimates of future rates are extremely variable and controversial. Still, there is little question that sea level is rising, and this trend will have a profound influence on coastal processes, coastal engineering, and coastal zone management. Sea level rise works with the increasing pressure to develop the shoreline to place irreconcilable demands on coastal areas. However, with only controversial estimates it is difficult to develop plans that have a broad base of support. What is needed is at least a conceptual model that could guide society in determining what shoreline will be defended and what shoreline will be abandoned.

Research that could reduce the uncertainties in sea level rise would be very valuable, but will be difficult to achieve given the intrinsic complexity of the phenomena. Another approach is, given realistic bounds on the uncertainties of the projections, to develop prudent responses to the problem. This later approach seems practical and clearly suggests a probabilistic approach with input from a number of disciplines.

There are, of course, many small pieces in the puzzle of how to respond to sea level rise, which, if improved, would contribute a great deal to developing realistic plans. The increased erosion rates for shorelines and dunes, the decreasing effectiveness of beach nourishment, and the degradation of performance of coastal structures are all expected effects of higher water levels and examples of research areas which could productively complement a big picture research effort.

Research needs include:

- Storm surge and wave height measurements in developed areas.
- Critical evaluation and improvement of dune erosion models.
- Confidence limits for rates of sea level rise.
- Cost-effective responses to sea level rise.
- Effectiveness of shoreline defenses against increasing water levels.
- Response of wetlands to sea level rise.
- Extent to which Great Lakes experience can be applied to saltwater coast.

Instrumentation and Technology Development

Recent developments in acoustical and optical technologies suggest that it is feasible to measure both fluid velocity and sediment flux in the nearshore zone with high spatial and temporal resolution. High resolution measurements are essential in view of large vertical gradients in flow and sediment concentrations. Acoustic Doppler current meters have worked well in inlets and coastal waters outside the surf zone. Development of similar instruments for the highly energetic surf environment would provide valuable research tools.

An additional requirement exists for a remotely-operated or *in situ* high-resolution surf zone bathymetric mapping system. Rapid and substantial changes in shoreline position and nearshore bathymetry during storms require frequent surveys if changes in large-scale sedimentary features such as bars and troughs are to be accurately monitored. Ongoing development of shallow-water multi-beam surveys offers a potential means to map areas outside the surf zone, but systems capable of operation in turbulent and aerated environments will be needed for inshore sites.

Continued development of remote sensing techniques, highly desirable for their capability to obtain rapid measurements over large areas, offers promise for measurements of coastal variables and bathymetry.

Human Resources

Marine Advisory/Extension Services

This section discusses topical areas on which advisory service staffs might concentrate. Recognizing that state priorities are pertinent to the development of sound programs, Marine Advisory Services (MAS) should also increase regional and national and even international talent-sharing and program development. Coordinating activities with other local and regional NOAA offices such as the National Ocean Service and the National Marine Fisheries Service, where appropriate, should continue. Developing programs in technology diffusion, product quality improvements, entrepreneurship, and sustainable resource managers are appropriate to NOAA and Department of Commerce long-term goals.

Special Attention: Continuing reference should be made to the report, *Sea Grant Marine Advisory Service: Making Waves in the 21st Century*, and consideration given to implementation of ideas in that report which seem appropriate to long-range increases in efficiency of institutional MAS programs.

Coastal Business and Economic Development

Americans are rapidly moving to the nation's coasts. Estimates of citizens living within 100 miles of the coast (including the Great Lakes) by the year 2000 range as high as 70 percent. This will place increasing demand on marine resources, for both personal and community livelihoods and recreational opportunities. There is great potential for increased infrastructure and development of business opportunities to meet this demand. MAS programs are encouraged to provide guidance to decisionmakers and leaders concerning the appropriate development of this potential through proper planning and support for business and economic development, while, at the same time, assuring appropriate environmental and resource considerations. Programs are also encouraged to provide entrepreneurial guidance and technical information relative to development of appropriate coastal business opportunities. These opportunities range over the entire spectrum of resource issues, from aquaculture to urban waterfront development to underwater preserves. Quantitative documentation of accomplishments (i.e. economic benefits and job creation) is extremely important.

Coastal Zone Management (CZM)

Most states now have CZM plans in place which provide guidance for development strategies along the coastline. Competition along the coastal zone for water-dependent and water-independent uses continues to expand. With increasing development along the coasts, demands grow for better pollution control strategies and for maintenance of the ecological integrity of coastal wetlands. The potential for long-term sea level rise and the problem of fluctuating water levels in the Great Lakes require using the most advanced thinking and technology. Oil spill response planning and hurricane preparedness are issues of growing public concern. Programs aimed at community leaders and users to focus on environmental management issues in the decisionmaking process are of great potential and value.

Conflict Resolution

Multiple use of marine resources is causing increasing conflict among user groups. Examples include controversies over fishing gear, oil and gas development in fishing areas, tribal fisheries, access, resource allocation, protected species, and many others. It is appropriate for marine advisory personnel to enter such controversies from a neutral position to explore ways to open communication, gain mutual understanding of all sides of the issues, and provide a forum for compromise, negotiation, and mediation by other professionals. While extreme care must be taken in tiptoeing through these issues, positive results can have a big payoff in terms of resource management, and in many cases, MAS is the only entity capable of creating these forums because of its neutral, educational position.

Fisheries

Commercial and recreational fisheries remain a significant element of most MAS programs. Each program tends to emphasize different elements of the fishing industry based on local needs and staff resources. The programs are basically successful and should be continued in this format.

Working relationships with fisheries agencies are seen as desirable in planning and implementing educa-

tional programs. It is critical that Sea Grant management maintain a nonadvocacy role that provides objective and balanced educational information and avoids program relationships that may be interpreted as slanted regulatory or enforcement oriented. Specific topics of concern include gear conflicts and development, such as with the Turtle Excluder Device and bycatch issues, gear and fuel efficiency, and management of fishing as a business, among many others. Social aspects of fisheries management (e.g. minority group influences, novel management approaches such as the Individual Transferable Quota system and refuges, access, and economic dislocation) are of increasing importance.

Fishery extension activities carried out for the sole purpose of increasing efficiency of taking already fully exploited stocks will not be favorably received, but applied population-level research in support of management decisions is an appropriate extension activity, if it is adequately peer reviewed. Look to Sea Grant director leadership and guidance in regional council meetings to address mutual cooperative programs and information transfer activities. Interaction with management groups such as regional councils or commissions should be for the purpose of providing technical advice only.

Recreational fisheries are a major economic and management consideration in most parts of the country, and they soon will be in all parts. Support of business infrastructure development which in turn supports recreational fisheries is important as is educating sport fishermen about fisheries management and viability of fishery resources.

Seafood Technology

One of the major opportunities in seafood technology is improving the quality and safety of seafood products being delivered to the consumer. This opportunity primarily involves the fresh seafood market but can also include frozen, processed, and packaged products. One of the major problems inhibiting greater use of U.S. domestically harvested fish is the widespread inability to produce fresh fish of adequate quality with sufficient shelf life for use in most major retail outlets in inland and coastal states. Advisory services can play a significant role in improving the quality of the product delivered to the consumer. Program consideration includes the total market channel, from catch to the consumer's table, but priority will be placed on shipboard and processing sectors. Advisory service programs directed at sanitation and handling of the catch are needed to improve the shelf life of fresh products and the quality of processed, packaged and frozen products. Improving seafood quality may also help expand the export of seafood products. In addition, the apparent proliferation of toxic algal blooms has affected seafood safety, primarily of shellfish, and public attitudes toward seafood safety. Programs addressing this issue, as well as seafood inspection and Hazard Analysis Critical Control Points training, are very appropriate.

These approaches also apply to aquaculture products, including development of value-added components to the marketplace.

Disposal of processing waste and plant effluent is becoming an increasing concern, and development and transfer of new and improved technology are important. Also, of increasing importance to the economic viability of the processing industry is development of byproduct recovery and utilization systems as an integral strategy to improve effluent water quality.

Aquaculture

The continued development of aquaculture in the U.S. will be aided by technical assistance provided through advisory services. An effort to assist development of viable aquaculture enterprises through technology transfer and business and marketing education is of high priority. Aid in the development of export markets for cultural products is appropriate. Economic analyses of production level projects are needed by financial institutions to provide entrepreneurial backing. These programs are particularly adaptable to regional programming approaches.

Ports and Marine Transportation

Sea Grant is interested in increasing technology transfer and application to ports and marine transportation industries. Several advisory service programs have found such efforts productive. Sea Grant programs and their advisory components are encouraged to review

port and marine transportation facilities and industries within their regions to determine if useful advisory services could be developed, perhaps, in regional collaboration. Reviewing past Sea Grant-sponsored port conference proceedings may help identify possible research and advisory service outreach activities that may have widespread applicability. With the signing of MARPOL and its implementation, ports and harbors still need considerable help in meeting the requirements for collection and disposal of non-biodegradable debris from vessels. Priority should be given to working with small isolated ports which may not have the needed information and the resources.

Education and In-Service Training of MAS Personnel

In-service educational opportunities are essential for advisory staff to keep abreast of the changes in their field of expertise. For advisory programs to operate efficiently, the staff must be alert to improvements in operational techniques and program expertise. Each program should address this issue to ensure there are adequate training opportunities. Regional and national training opportunities should be fostered.

The rapid movement of citizens toward the coast was noted above. Many of these people come from inland areas, and while a coastal life style is their interest, they know little about the complexity and vulnerability of the marine environment. Educational programs to encourage these coastal residents to be good stewards of the coastal community are encouraged.

Safety

MAS programs are encouraged to emphasize safety in all elements of programming. Safety awareness and knowledge will make the marine environment safer for those who live, work, and/or play within the confines of marine and Great Lakes resources. Program areas include, among others, diving safety, boating safety, industrial safety, hurricane preparedness, and general public safety involving life and/or property in coastal areas. Recognizing that promoting safety is a universally-shared responsibility and that many safety programs and safety providers exist outside Sea Grant, emphasis should be placed on increasing regional and national talent-sharing and program development.

Pollution and Global Change

Marine debris is a form of pollution of rising concern and one for which a national public education campaign might be particularly effective. Global climate change and the resultant long-term effect on sea levels can be linked to atmospheric changes and contamination. Sea level rise has major adverse connotations for coastal communities and should be factored into long-term coastal planning efforts. Advisory efforts to begin to address these issues are appropriate.

Aspects of pollution and environmental (habitat) problems permeate almost every aspect of advisory service programs. Rather than being treated as a separate category, these problems should be linked to specific programs within existing parts of individual advisory programs and Sea Grant research efforts.

Regional Activities

Programs are urged to continue regional interactions for programming, resource and personnel sharing, training and other activities which can be enhanced by cooperative efforts. Several recent success stories testify to the merit of this approach.

Setting Priorities

All issues discussed above have significance to the national Sea Grant effort if addressed in ways that maximize results. Relative merit will thus be evaluated by significance of past performance; potential effect on behaviors, economic impact, and/or resource management and decisionmaking; novel approaches to leveraging resources; approaches to maximizing program impact (ie. appropriate choice of target audience to maximize magnification, effectiveness at stimulating educational activities beyond local/state boundaries, etc.) and the relative merits of program proposals as judged against the published criteria of the Joint Modified Procedures Committee (ie. Rationale, Outreach Quality, Innovativeness, Programmatic Justification, User Relationships, Relationship to National Office Priorities, Past Record of Accomplishment, Use of Available Talent, and Identification of Milestones.)

Communications

Communications projects should aim to expand public awareness of Sea Grant research, education and training, and advisory/extension activities. Highest priority should be given to communications projects which disseminate, in a cost-effective manner, the results of Sea Grant research, education, and advisory/extension efforts to the scientific community, user groups, the media, and the general public. Communications projects should strive to create a better understanding of Sea Grant accomplishments and benefits and to promote an awareness of ocean and Great Lakes issues.

Communication projects vary in staff size, funding, and emphases; however, certain functions must be performed before other activities are undertaken. These priority functions include:

- The dissemination in efficiently produced formats of Sea Grant research, education, and advisory/extension information to the scientific community, user groups (such as fishermen and coastal planners), the media and the general public. Mailing lists should be analyzed and revised so that proper target audiences are reached. Particular thought should be given to exactly who the priority audiences are for a particular program and why these groups take priority. In some programs, there may be a few large audiences such as commercial fishermen or resource managers, while, in others, there may be a variety of different audiences. In addition to directing communications efforts at special constituencies, it is important to remember that Sea Grant is also committed to ensuring a marine literate public, and some effort must be given to reaching the general public through the use of the mass media.
- The provision of communications expertise and advice to all components of Sea Grant—management, advisory/extension staff, researchers, and educators. Close ties must be maintained with advisory/extension staff who themselves are often involved in communications activities. The burgeoning use of both desktop publishing and video capabilities requires that communicators coordinate with all appropriate parties to identify potential audiences and to ensure product quality.
- The evaluation of communication efforts, with documentation of results to indicate that programs are meeting needs and helping to effectuate change. For instance, issuing news releases on research results is encouraged, but, besides providing details on the number of releases issued, can any ensuing media pick-up be demonstrated? Providing information on the size of print runs for various reports is expected, but is there any evidence that audiences are reading, using or benefiting from these reports? Any such evaluative information should be presented in communications proposals.
- The submission of all appropriate publications to the National Sea Grant Depository. While the overall record for submission of journal reprints has improved, closer attention needs to be given to ensuring that all relevant advisory/extension and education publications are also reaching the Depository. With the production of the nationally distributed *Sea Grant Abstracts* quarterly, the need is even greater now for all required materials to be submitted to the Depository.
- The preparation of annual or biennial reports. However, the National Sea Grant Office does not require these annual/biennial reports if individual Sea Grant programs submit satisfactory completion reports within six months of the completion date of projects.

Following are other observations that should be of value as communicators plan their efforts for 1994:

- Sharing available resources and working on cooperative projects to increase public awareness of Sea Grant are certainly encouraged. Adapting already existing publications in the network for use regionally or in one's own program and participating in joint exhibits at major conferences are ways in which communications programs can further spread the Sea Grant story.

- Given that good visual aids can make an impact on audiences, communicators are encouraged to expand their photographic and color slide collections to show scientists, educators, and marine advisory/extension personnel in action, investigating scientific problems and educating and advising constituents.
- Communicators should seize opportunities to describe accomplishments of individual programs within the broader context of the Sea Grant network. Such products as news releases and feature articles could be written to incorporate related work at other Sea Grant programs.
- Obtaining the most mileage out of already existing communication products in order to achieve a multiplier effect is desirable. For instance, a news release announcing research results to the print media could be adapted (shortened to a few paragraphs) for use by the broadcast media. State agencies, such as departments of natural resources or of tourism, often have publications that could use relevant Sea Grant articles.
- Another technique would involve placing Sea Grant personnel on radio and television programs in order to provide Sea Grant information to a wider audience. This latter technique of media placement suggests using already existing broadcast outlets; it does not mean hiring, during tight fiscal times, additional new staff in the broadcast area.

For further thoughts on communications, reference should be made to the report *Sea Grant Communications: Reaching Out in the 21st Century.* A special focus task force on communications, jointly convened by the NOAA Sea Grant Director and the Chair of the Council of Sea Grant Directors, presented this report at Sea Grant Week '91. This report and two others, prepared by task forces on advisory services and on education, should be consulted for information that could prove useful for long-range planning.

Marine Policy and Social Sciences

Human and policy dimensions of natural resource management are of growing importance due to increasing population growth and use of coastal areas. In addition, there is increasing recognition of the need for sociocultural insights for resource management. No longer can environmental issues be solved through research in natural and physical science alone. The human and policy aspects of environmental issues must be considered.

The goal of the Marine Policy and Social Sciences Program is to provide relevant information for the wise use of coastal and marine resources. Sea Grant is interested in solving problems and contributing to decisions that have national relevance and that advance theory and methodology. Projects may involve collection, synthesis and analysis of data for policy and evaluation, analyses of social change and of management options for natural resources, suggestions for alternative institutional arrangements, and socioeconomic impact studies. However, case studies that monitor sociocultural impacts with no theoretical generalizability, and input-output analyses that are case-specific are not appropriate.

The application and accessibility of the results of social science and marine policy research rely on clear strategies for user involvement, and such strategies should be clearly identified in proposals. Investigators are urged to involve user groups, extension agents, and resource management agencies in the project to facilitate use of results.

The following research areas merit attention. Because these research topics are problem-focused, they offer an opportunity for cross-discipline perspectives. Researchers should be aware of work in related areas and use the Sea Grant network to identify related efforts when developing their projects.

Coastal Growth Management and Multiple Use Dilemmas

Coastal growth management is not anti-development, but stems from the idea that new development can be channeled into areas able to accommodate it with

minimal environmental risk and maximum fiscal savings and social results. Wetlands, flood plains, erosion-susceptible areas, and other coastal areas at risk face growing demands for use. Intergovernmental management opportunities, incentives, and penalties need to be considered to cope with growing challenges in the coastal zone. Hand-in-hand with coastal growth are conflicts over use by multiple parties. Research that adds to the ability to resolve conflicts among recreationalists, local communities, fishing interests, and other parties is an important mission for social science.

Fisheries

Fisheries continues to be of interest, especially when building on previous studies and providing comparable or supplementary information in a coordinated fashion.

There is a rapidly expanding interest in information on the social and economic aspects of limited access or effort limitations. More information is needed on the ways that individually assigned privileges affect recreational and commercial fisheries. Consequently, the following topics are high priority:

- Comparative studies of institutional design and implementation for individual quotas (IQs) and other limited access regimes.
- Identification of the causes and consequences of the patterns of individual permit or quota transfers.
- Identification of the effects of initial allocation on the distribution of benefits, and research into the related issue of who should have rights to the initial allotment.
- Investigation of the interrelationship between bycatch issues and individual quotas. How have fishermen and managers dealt with bycatch?

Information is needed on inshore fisheries and subsistence fishing. The extent and nature of subsistence fishing and petty-commodity fishing is not well documented, and NOAA's National Marine Fisheries Service has not been able to fund research in this area. It is likely that hundreds of thousands of families supplement their diet and incomes by fishing in sounds, bays, and estuaries. States that consider fishing licenses or bag limits may affect livelihood of families who depend on this strategy.

Commercial fishing is imperiled in many coastal areas where there is increasing population growth and changing land use. The effects of gradual marginalization of fishing as a livelihood in areas under pressure, and trends in labor, migration, economic viability, and socio-structural adaptations to increasing marginalization of commercial fishing need to be described.

Conflict over the use and management of fisheries resources is likely to escalate due to stock depletion, increasing numbers of recreational fishermen, and environmental regulations. Resolving these conflicts or mediating them in constructive ways is very important for the future of fisheries and for avoiding lengthy court battles. Theoretical and practical advances in the area of conflict management are encouraged.

Aquaculture

The aquaculture industry has the potential to revolutionize the seafood industry and to affect consumers of seafood. Advances for several species have brought technical and economic constraints under control. Yet, more information is needed on the social and policy aspects of aquaculture development. It is important to assess how the development of aquacultured species will affect the structure of the commercial seafood industry, from producers to distribution and pricing. Who are the prospective investors—small entrepreneurs, corporations, agriculturalists—and what are the social and cultural constraints that affect adoption? Will aquaculture development foster conflict with commercial fishermen and coastal property owners and how might this be resolved? On the policy side, there is a wide range of problems to address. Potential aquaculturists complain about the difficulty in obtaining leases, licensing, and permits from states. Whether and how to consolidate the permit and license process or how the permitting process can be facilitated should be examined. What public management options are there for integrating aquaculture uses with the increasing demand for coastal areas for competing purposes? It is important to know how local interests can be involved in aquaculture operations to reduce conflict and provide economic stability.

Marine Biotechnology Policy/ Exotic Species Issues

As new genetically engineered organisms and natural chemical products push forward the edge of established regulatory regimes, the unique policy issues that will be raised by developments in marine biotechnology need to be addressed. Is the current regulatory framework adequate to deal with the emerging issues? What is the proper federal role? Is there a role for state and local governments? With the recent decision to grant patents for genetically engineered animals, it is important to assess long-term structural implications for the aquaculture industry.

The colonization of the Great Lakes region by the exotic zebra mussel has raised similar scientific, policy and socioeconomic questions. Because of the likelihood of other introductions of exotic species, from algae to invertebrates, it is valuable to assess the regulatory and policy options as well as the economic and social effects they may have.

Global Climate Change

The human consequences of global climate change could be enormous. The National Sea Grant Office (NSGO) coordinates with NOAA's global change research program regarding the human dimensions of global change. NOAA's Office of Global Programs has identified "Human Dimensions of Global Change" as a program element for FY 94. Funding for this program, however, is dependent on FY 94 appropriations. Given this uncertainty, NSGO will entertain proposals in the human dimensions of global change for very specific topics. Research should focus on regional domestic issues in coastal areas.

A sea-level change of one meter over 100 years is a conservative estimate. It is important to know how state and local governments should, and would, cope with the loss of valuable recreational areas, eroding property tax bases and the inundation of harbors, bridges, and roads, and how the private sector will deal with the loss of valuable coastal property. Creative ways must be found to deal with changes in resource management—with an increase in sea level, for example, one of the first resources to suffer may be coastal ground water due to saltwater intrusion of potable water supplies. It is important to assess how the positive and negative effects will be distributed across the social and economic fabric of coastal regions. For example, how will these changes affect industries dependent on marine and coastal areas? From a public policy perspective, are there creative ways to harness the changes?

Coastal Economic Development

Trends in coastal economic development are spurred by changing demographic and lifestyle demands. Retirees and owners of second homes are choosing coastal communities as residences of choice. At the same time, there are pressures for coastal tourism development, both public (recreational boating/fishing facilities) and private (resorts, marinas). Many coastal communities face choices about growth management because opportunities for employment and financial returns are forcing the issues of multiple use of resources and of rapid social change. The processes of social change and the social and cultural effects of different strategies for economic development in communities and regions need to be understood. In addition, it is important to know which alternative strategies for communities will allow local interests to be involved to reduce economic dislocation and legal conflict and to provide long-term economic stability.

Interpretations of Coastal Demographic Trends

With the release of 1990 U.S. census data over the next several years, it is important to analyze what these data mean for coastal communities and industries. Analyses are encourage that are linked with theory and public policy issues such as natural hazards, fisheries management, and nonpoint source pollution and which are not solely statistical enumerations or case studies.

A related demographic and land use issue is to identify and quantify anthropogenic impacts on nearshore coastal areas. The effect of land use on estuarine water quality is an important issue. Land use patterns contribute to water quality in different ways—sediment, nitrogen, phosphorus, PCBs, etc. Given past experience with estuaries and surrounding land use changes, quantitative models could be developed to

predict the effects of development or changing land use patterns on estuaries which have not yet become "developed" in order to anticipate environmental and social problems.

Communicating Risk

Because of the presence of toxic chemicals in Great Lakes waters, there is some risk to humans who consume fish. Sea Grant has funded research into the processes of establishing fish advisories and communicating risk to coastal users. The results have been promising and may be useful for other coastal hazards such as shellfish advisories or siting of construction in hazard-prone areas. The proposals should focus on communicating risk to coastal clientele and should advance knowledge about communication theory while at the same time provide information useful to extension agents, federal or state agencies, or other coastal user groups. Proposals should be complementary to work previously funded or currently underway.

Education and Training

The *1992 Guidance* document announced a new educational effort for the Sea Grant network. Funded by the National Science Foundation (NSF), the project, "Interpreting Current Research on Global Environmental Issues for Middle School Teachers and Their Students," is being done cooperatively with the Gulf Coast Research Laboratory (GCRL). Its focus is a middle-school teacher enhancement program on understanding global marine environmental issues. The principal investigator is Dr. Sharon H. Walker, a Sea Grant marine education specialist and an administrator of GCRL's J. L. Scott Marine Education Center and Aquarium in Biloxi, Mississippi.

To date, four sets of intensive courses have been held for middle school teachers. FY 1994 will be the last year of the GCRL grant. Teachers have received training in four areas: declining biodiversity, overpopulation, marine and estuarine pollution, and climate change. As part of the overall plan to enhance middle school teachers' capabilities to teach about global change, complementary proposals from other regions in the Sea Grant network will be submitted to NSF to fund training courses. This year, under leadership from Vicki Osis, the Pacific Northwest was able to initiate teacher training in global change. The network will continue to seek funding for courses in the Mid-Atlantic region and the Great Lakes.

Principles and Priorities

The present and future role of Sea Grant is stated in the Sea Grant long-range educational white paper *Sea Grant, Society and Marine Education: Shaping the Future*. The broad educational goals clearly spelled out in the document are as follows:

Teachers and scientists must work together cooperatively to find ways to teach science as it is practiced—with wonder and excitement—in order to attract and retain more students in scientific careers. Sea Grant provides the foundation for that cooperation. Undergirding Sea Grant education efforts is a Congressional mandate to conduct marine research, technology transfer, and education and training. The researchers, outreach specialists, and educators working to fulfill the Sea Grant mission are resources for accomplishing stated educational goals through the following plan of action:

Sea Grant should:

- educate and train preservice and inservice teachers through a continuation of exemplary informal workshops and through graduate and undergraduate courses as developed, piloted, and refined within the Sea Grant network. Teaching teachers is a national priority;
- draw on network expertise to augment efforts, through these workshops and courses, to develop or improve and disseminate stimulating instructional materials that can be used for specific audiences in formal and informal educational settings;
- capitalize on the allure of the ocean and its inhabitants to increase scientific literacy, to retain students in scientific disciplines, and to attract young people to marine and aquatic science;
- provide leadership in evaluating and incorporating the use of specific new electronic communications

technologies into formal and informal teaching strategies to meet Sea Grant's educational objectives. Satellite systems, for example, now exist that beam curricula directly into classrooms, and Sea Grant marine educators are developing programs for these systems;

- present scientific concepts involved in marine and aquatic environments to broad public audiences through informal, "hands-on" activities. This strategy will foster an expanded public awareness and understanding of marine and aquatic environments, and of the role of oceans and inland seas in the global environment;
- target assistantships and fellowships toward specific professional opportunities in areas where shortages of scientific personnel are predicted;
- adapt elements of proven Sea Grant programs to attract and retain minorities and women in the sciences; and
- where possible, link Sea Grant resources with other agencies involved in marine science education.

These goals should provide the basis for all future educational proposals submitted to the National Office. Each proposal should state what goal(s) it is addressing. Proposals should also include the rationale for the project, the process or mechanisms by which it will be carried out, and provisions for insuring that teachers introduce curricular materials to their students or colleagues to "multiply" the results of their learning and training. Proposals should include procedures for monitoring the progress and evaluating the results of the education project.

Policy

For evaluation purposes, no continued education grant should go over four years without a review of progress made and benefits obtained. Therefore, after four years, a new proposal would be expected.

Ocean Law and Policy

Research Projects

Legal research projects must demonstrate a significant benefit to potential users and should reflect user involvement in the development of proposals. Projects which consider generic issues of significance to a broad range of users or group of states or a region and provide for appropriate dissemination of results will receive high priority. Interdisciplinary studies also will receive high priority.

Projects involving almost any area of marine law can have the requisite degree of practical benefit and significance. Therefore, those that appear to be particularly timely will receive high priority include studies that:

- Identify significant legal obstacles to the development of aquaculture and provide concrete suggestions for removing them.
- Identify specific issues that result from use conflicts in the coastal public trust lands and waters and examine concrete proposal for managing these conflicts. However, studies that generally review well-known use conflicts and simply catalogue relevant laws and regulations will not be given priority.
- Pursue innovative legal approaches to controlling the effects of acid rain in estuarine management.

Sea Grant recognizes the value in appropriate cases of holding conferences and symposia to discuss legal issues, but normally will give higher priority to projects that involve original research and problem solving.

Sea Grant continues to stress that legal research projects must demonstrate a significant benefit to potential users. Proposals which do not specifically address user involvement in the development of the proposal and a clear user interest in the dissemination of results are not likely to be funded.

Educational Activities

In general, Sea Grant believes that the current marine-oriented legal programs train an adequate number of marine legal specialists. Therefore, proposals to develop new programs or significantly expand the capacity of existing programs to train additional specialists are discouraged.

Many research projects will provide side benefits in terms of educating law students undertaking them. Providing these benefits is encouraged but will not be a basis for funding a research project that doesn't qualify on its own merit.

Many funded educational activities may be more properly characterized as advisory services—providing practical, day-to-day information to users of coastal and ocean resources and to policy makers responsible for these resources.

Advisory Services

Legal advisory services can be an effective way to translate original research into practical use and, conversely, to identify legal issues that merit further research. The National Sea Grant Office will give high priority to proposals that combine research and advisory efforts.

Requests for legal advisory services should demonstrate a particular need on the part of other Sea Grant elements, local or state officials, or coastal use groups for such services. This need may be demonstrated by citing past experience and/or describing future projects in which the users are expected to become involved, and the general types of legal problems which can be anticipated as a result. Services may be provided directly or in conjunction with and as support to other advisory service activities.

Highest priority will be given to proposals that identify relatively specific legal needs of a particular group or groups and can describe proposed methods of addressing these needs, e.g., publication of a newsletter, holding seminars, conducting limited research or defining a research project and referring it to a Sea Grant law school. Priority also will be given to proposals which:

- demonstrate a past pattern of useful services and indicate why this pattern is likely to continue; and
- provide results useful beyond the immediate group or area generating the need for services and provide for dissemination of these results.

Proposers may be required to demonstrate that a particular project is not appropriate for referral to local practicing attorneys.

Non-Living Resources

Marine Geological Resources

General

Development of marine geologic resources, as with the exploration of any resource, must be approached systematically. The decision to utilize a particular geologic resource, although primarily based on economics, must take into account environmental considerations. The commercial feasibility of developing a given geologic resource will depend on the delineation, extent, and quality of the resource, its usability and beneficiation requirements, production costs, market value, and rules and regulations.

Priority should be assigned to research that will identify scientific questions that must be addressed in order to assess potential additional sources for economically viable minerals or materials, as identified by Congress or the Administration.

Projects integrated with related engineering, environmental, or economic studies are appropriate. Such integration could be accomplished on one campus, in one university system, or in institutions throughout the Sea Grant network.

High priority should be accorded:

1) To assure, through adequate research on marine geologic resources in the public domain, that data essential to decisionmaking and management in the public interest are available, along with data to encourage the rapid commercialization of such resources. For example:

- Research on the environmental impacts of deep seabed mining.
- Adequate research on marine geologic resources in the Exclusive Economic Zone (EEZ) to provide data necessary for rational decisionmaking and management.

2) Evaluation of scientific questions relating to the formation, distribution, commercial potential, exploitation, or environmental impact for recovery of marine resources. For example:

- Improved understanding of the physical, chemical, and biological processes that will lead to knowledge necessary to evaluate the distribution of mineral resources.
- Economics of potential mineral resources within the EEZ.

3) To develop innovative exploration or research technologies; alternative methods and systems for mining, beneficiating, and processing of marine minerals resources; and systems for monitoring effects of extraction on the environment. For example:

- Utilization of new research technologies to assess the processes of mineral formation at or beneath the seafloor.
- Development of a suite of monitoring techniques that accurately sense change in the marine environment from extraction activities, and which can be conducted in an efficient and cost-effective manner.
- Refinement of development of mineral exploration and prospecting technology that conserves time and energy and that has direct application and benefit to private industry.
- Adaption of new computer technology and statistical methods to enhance or manipulate data for improved environmental interpretation or resource assessment.

Recently discovered phenomena of venting (both hot and cold) are now increasingly seen to be a global phenomena, active over thousands of kilometers of the seafloor. The significance of these phenomena upon the seafloor, the oceans, and the atmosphere has not yet been quantified, but some evidence and hypotheses indicate major significance over varying scales of time and space. In so far as the study of these phenomena helps to quantify the significant geological elements of the process and thus the United States' wise development and use of the oceans' resources, then that study is appropriate Sea Grant research and is considered a priority topic.

Low priority is assigned to research projects directed at resources for which generic questions related

to assessment of the resource, the technology for exploration and recovery, environmental effects, and economics generally have been answered. For example:

- Resource research, assessment and economics of manganese nodules on the deep seafloor.
- Marine sand and gravel resources (except in the Arctic environment).
- "How to" design research for most local needs.

Undersea Research and Diving Safety and Physiology

The National Undersea Research Program (NURP) composed of NOAA's Office of Undersea Research (OUR) and its network of National Undersea Research Centers (NURC) is unique among federal funding agencies in its support of shallow submersibles, remotely operated vehicles, surface-supported diving systems, and sea floor habitats. Recent research indicates the importance of these systems in conducting precise, detailed *in situ* sampling and observations. Without these systems, precise positioning and microsampling of the water column, the sediment water interface or the benthos are, if not impossible, most difficult. The National Sea Grant College Program endorses the application for use of these OUR systems in the conduct of Sea Grant-supported research in the above or other subject areas. In particular, use of these systems is encouraged in studies of fisheries/habitat relationships and effects of gear on habitat and bottom communities.

Diving Safety and Physiology

The emphasis on studies that improve the safety and performance of divers remains constant and includes efforts that benefit the entire diving community including: recreational, scientific, and commercial. The decompression schedules available, composition of the breathing gas, oxygen toxicity, inert gas narcosis, sensitivity to carbon dioxide, and onset and growth of bubbles in the body all limit in some way our ability to work safely and effectively in the oceans and on the seafloor.

Accordingly, high priority should be placed on research into the following:

- Operations procedures including decompression tables, excursion tables from saturation and treatment tables.
- Safety; certification/training standards, information on diving-related accidents, and diving-accident management.
- Medical aspects; treatment of diving-related accidents, hyperbaric/emergency equipment, procedures for diving in remote locations.
- Environmental impacts on divers; hazardous materials and pathogens, extreme temperatures, and psychological concerns.
- Equipment; protective or life support gear that enhances the diver's performance, and/or increases safety and well-being.
- Fundamental hyperbaric physiological research; all levels from cellular to systemic.

International Program

For a half-dozen years, up through the mid-1980s, Sea Grant received funding to strengthen the marine R&D capabilities of developing nations. Sea Grant proved to be a unique vehicle for this, successfully leaving behind in the developing world an enhanced marine research and development capability. Despite the success, budget pressures throughout the decade eventually brought to an end the International Program's appropriation.

Sea Grant's current authorizing legislation, however, still provides for the conduct of an International Program, although no funds are directly appropriated for this purpose. In fact, the legislation is considerably broader in scope than the original program whose domain was limited to providing technical assistance. The current legislation (Sec. 205a) authorizes a broad sweep of international activities which, in general, are aimed at mutual gains to cooperating nations:

- enhance cooperative international research and educational activities on ocean, coastal and Great Lakes resources;
- promote shared marine activities with universities in countries with which the United States has sustained mutual interest in ocean, coastal, and Great Lakes resources;
- encourage technology transfer that enhances wise use of ocean, coastal, and Great Lakes resources in other countries and in the United States;
- promote the exchange among the United States and foreign nations of information and data with respect to the assessment, development, utilization, and conservation of such resources;
- use the National Sea Grant College Program as a resource in other federal civilian agency international initiatives whose purposes are fundamentally related to research, education, technology transfer and public service programs concerning the understanding and wise use of ocean, coastal, and Great Lakes resources; and
- enhance regional collaboration between foreign nations and the United States with respect to marine scientific research, including activities which improve understanding of global oceanic and atmospheric processes, undersea minerals resources within the exclusive economic zone, and productivity and enhancement of living marine resources.

As with the 1991 Sea Grant Week meeting in Denver, the 1993 meeting in Honolulu demonstrated significant support within the Sea Grant network for greater involvement in international activities. Why?

- The Sea Grant Act authorizes an International Program more robust than our original program. We should capitalize on this.
- For its own vitality and health, Sea Grant must operate consistent with global realities—earth-scale environmental change, trans-national marine ecosystems, instantaneous communications, world markets, regional trading blocks, globalization of science, technology-driven multinational firms.
- While many Sea Grant principal investigators will do international work on their own, the likelihood of Sea Grant getting recognition, let alone funding, for its international activities is diminished without an organized initiative.

Goals

Some Sea Grant colleges continue to include projects with international components as part of their institutional programs, and we encourage this. In fact, the Denver meeting affirmed the need for Sea Grant to undertake several pilot projects which take advantage of Sea Grant's broader authority for conducting international programs and which might serve as the basis for developing a new international initiative within the National Sea Grant College Program. It's likely that most of this funding will have to come from other sources; however, the NSGO's tactical plan development approach might offer some limited opportunities for funding pilot projects.

The mission for a renewed International Program would be to provide the Sea Grant network with the opportunity to pursue Sea Grant's mandate in a manner which recognizes the global domain of the environment, science and technology, communications, and commerce. As such, projects under the Sea Grant International Program should encompass one or more of the following goals, listed without reference to order of priority:

- Promote international cooperative education related to the global environment and trans-national marine ecosystems.
- Foster international cooperation in the marine sciences.
- Gain the benefits of technology transfer across national boundaries through programs which capitalize on each country's strengths in marine technology development.
- Strengthen the competitive position of U.S. marine industries in world markets.
- Provide scholarship on significant geopolitical marine policy issues and on comparative institutional arrangements for marine resources management.
- Improve the capability of developing nations to become full partners in the world community's stewardship of the marine environment.
- Exploit global communications technology as a means to share marine scientific knowledge and enhance global environmental understanding among nations.