# LongRangePlan

UNIVERSITY OF MAINE/UNIVERSITY OF NEW HAMPSHIRE
SEA GRANT COLLEGE PROGRAM /JANUARY 1990

University of Maine
University of New Hampshire
Sea Grant College Program

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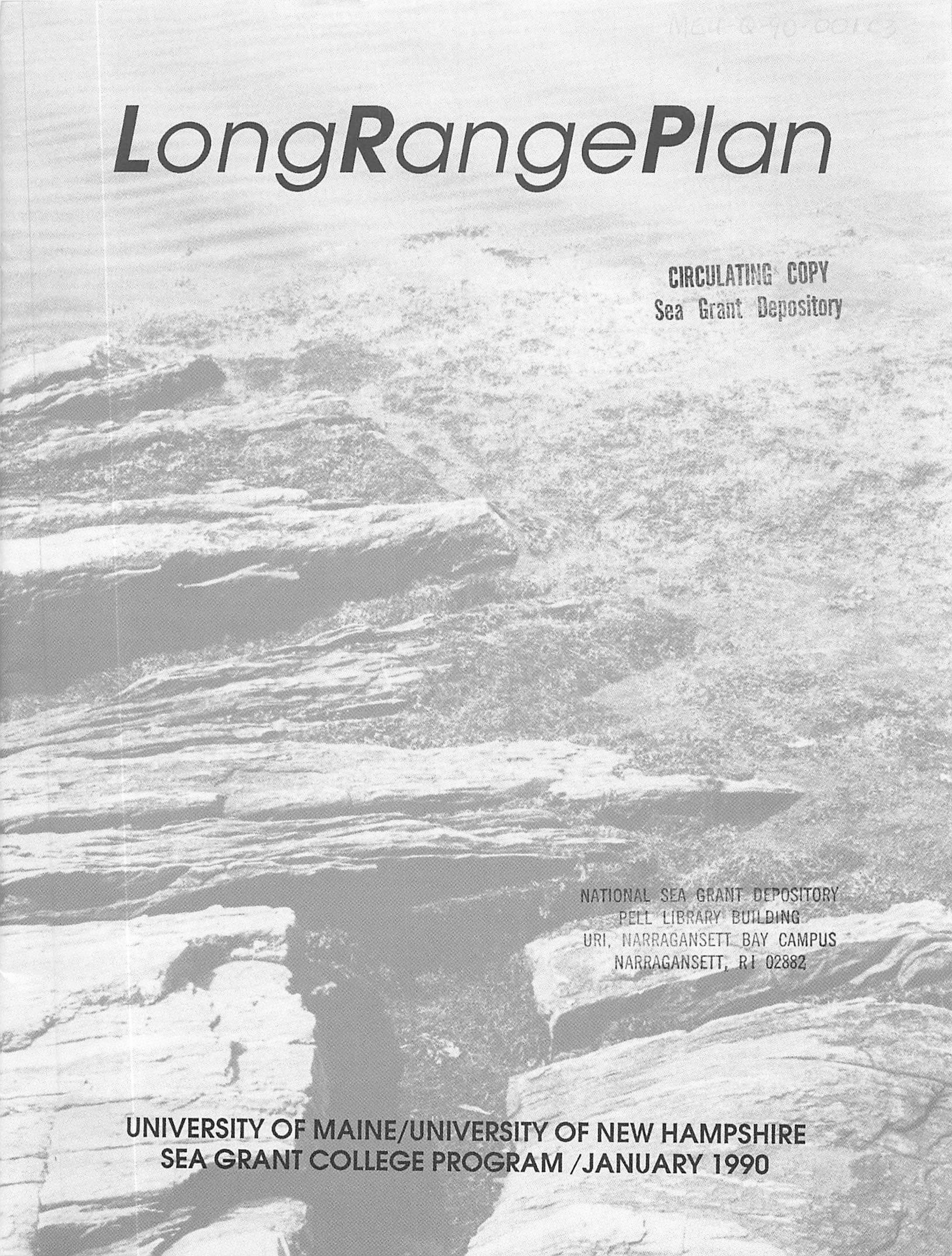





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# Introduction

## Overview of the Sea Grant College Program

The joint University of Maine/University of New Hampshire (UM/UNH) Sea Grant College Program is part of a national effort of research, education, and advisory (extension) services, whose primary goal is to promote the wise use, conservation, and development of our marine resources.

Conceived by Athelstan Spillhaus, science popularizer and academician, who felt the United States was devoting too much attention to the race for space and not enough to the exploration of the oceans, the National Sea Grant College Program was formally established by Congress in 1966. Twenty-three years later, a $39 million Sea Grant Program at 300 academic and non-profit institutions around the United States and Puerto Rico now returns an estimated $830 million annually in gross revenues and savings to marine industries.

Through the partnership of our two state universities, the federal government represented by the National Oceanic and Atmospheric Administration, the nation's earth systems agency, and our various marine clientele, the UM/UNH Sea Grant College Program has had a significant impact on marine resource use and development in northern New England.

In 1976 Maine and New Hampshire merged their separate programs to form a single, stronger, more balanced Sea Grant Program. Our undertakings in marine research, education, and advisory services have produced many far-reaching results. Much of that success can be attributed to our constant emphasis on taking a proactive, versus a reactive, role towards the wise use and development of our marine resources. Effective planning has evolved as the cornerstone upon which the Program is built.

## Purpose

The purpose of this document, the *UM/UNH Sea Grant Long Range Plan,* is to articulate key marine/coastal issues where the academic talents and resources of any institutions of higher learning in Maine and New Hampshire may be focused through the Sea Grant College Program. The plan sets a context for our involvement in these areas, helps guide academic interests and resource allocation, and, retroactively, provides a means for determining the extent of Sea Grant's contribution towards solving important marine problems facing the region and the nation.

Development of the plan was predicated on certain key assumptions about the process:

• **Issues-orientation.** It is generally felt that real world/marine coastal problems can be more accurately described in terms of issues than scientific disciplines. An issues-orientation offers the opportunity to highlight the need for interdisciplinary efforts to solve today's difficult marine resource problems. It also more clearly explains the approach used by the UM/UNH Sea Grant College Program to identify and solve these problems. Thus, a conscious effort has been made in the plan to identify key marine/coastal issues of importance to northern New England. In most instances, a number of scientific disciplines will need to be employed to address these issues.

• **Involvement of forward-looking thinkers.** In addition to our 22-member Policy Advisory Committee (PAC), input and ideas were sought from dozens of individuals recognized throughout the region for their special knowledge of marine/coastal issues. The planning process involved in-depth interviews, small group meetings, and solicited written input. Additionally, topical reports and documents which addressed various aspects of marine/coastal issues were reviewed.

• **Five-year time line.** Based on past experience, planning takes about five years, in most cases, to produce something of significance. However, anything much longer becomes guesswork.

• **Non-biased planning process.** During the planning process we attempted to have people tell us what the important issues were, *not* what they thought we should be doing. Closely related to this is the fact that the planning process purposely ignores existing program strengths. Issues are identified in the plan regardless of whether the Program has a history of involvement in that area or whether the academic talent currently exists within our university structure.

• **Major time commitment.** Development of a comprehensive, meaningful plan requires a great deal of time and effort on the part of the PAC and staff alike. Interviews, meetings, synthesizing of data, and rewriting drafts has taken nearly a year. However, because of the magnitude of the process, the final plan fairly represents the collective wisdom of a broad cross-section of our constituents.

While no one can accurately predict the future, we feel this plan provides a legitimate framework within which our Sea Grant College Program can operate in the next five years. By presenting a definitive statement about our Program's priorities, it is not meant to imply that these priorities are unyielding. Issues often change rapidly and new needs or opportunities often arise unexpectedly. However, since needs will always outweigh resources, this plan provides a rational basis upon which to build coherently focused efforts which integrate our research, extension, and education components.

## Coordination and Cooperation with Other Marine Entities

Throughout the 1970's and into the mid-1980's, the UM/UNH Sea Grant College Program was the principle source of support for marine research and extension in the region. Indeed, one could argue that it was almost the only "act in town." Over the past several years, however, there has been a remarkable expansion of new initiatives, activities, and organizations with interests in marine-related research and extension. At the University and state/regional level these include:

• **The Lobster Institute,** a joint academic/industry-supported venture to foster lobster research and education, is administered through the University of Maine's Center for Marine Studies.

• The growth and development of the **Institute for the Study of Earth, Oceans, and Space (EOS)** at the University of New Hampshire. Marine scientists connected with EOS examine oceanographic processes in a more global, interdisciplinary context than do traditional marine scientists.

• **The Maine Aquaculture Innovation Center,** designed to foster and support the development of aquaculture in Maine through the support of research and extension projects. It is a cooperative venture between the Maine Aquaculture Association and the UM Fisheries and Aquaculture Research Group of the Maine Agricultural Experiment Station. It is administered through the Maine Science and Technology Commission, a component of State government.

• The pending establishment of **academic programs in aquaculture** (B.S.) and **marine bioresources** ( M.S., and Ph.D.) at the University of Maine and the **formation of a new Department of Oceanography.**

• The designation of UM as one of a three-institution, NSF-supported **National Center for Geographic Information and Analysis** with significant potential and interests in marine data systems and remote sensing.

• The development of the UNH **Coastal Marine Laboratory** in New Castle, NH, which, with its new flowing sea water system, now provides a significant resource for UNH researchers studying living marine organisms.

At the state/regional and federal level these include:

• The three-state (ME, NH, MA) and two-province (NS, NB) **Gulf of Maine Initiative**, which is intended to design, develop and implement a long-term, regionally-planned marine environmental monitoring program for the Gulf of Maine.

• The formation and development of the **Association for Research on the Gulf of Maine (ARGO-MAINE)** to foster cooperative and coordinated research on this important marine ecosystem.

• **The Northeast Regional Aquaculture Center** which was established to support regionally important and well-coordinated research and extension in areas important to aquaculture. It is administered through Southeastern Massachusetts University and funded by the Department of Agriculture.

• The recent expansion of the **Saltonstall-Kennedy Program** to include, as a priority area, research in aquaculture.

• The pending $1.2 million expansion of the **marine science education center at Odiorne Point State Park** in Rye, NH through a combination of state, private, and corporate support.

• The recent designation of **National Estuarine Research Reserves** in Wells, Maine and Great Bay, NH which will provide additional opportunities for research and outreach education.

• Perhaps most significant of all are the collective initiatives of the Federal research funding agencies in the area of **global environmental change**. The oceans are, of course, one of the most important parts of this changing system, and the impacts of global changes are likely to be felt most strongly in our coastal regions.

Finally, it's worth noting that if pending legislative initiatives, both at the state and federal levels, are passed and funded, they will have great significance to future coastal marine research.

All these initiatives, activities, and organizations have developed out of perceived needs and opportunities. All of them have substantive contributions to make to the marine research and extension enterprise. While each of them has only been in existence for a relatively short period (less than five years), none of them has a mission as broadly defined as Sea Grant's. And all of them will benefit from coordination and cooperation with established Sea Grant programs.

In some ways, our long range plan provides a framework for these initiatives and organizations as well as for Sea Grant. This rapidly developing multi-faceted regime in coastal marine research and extension will provide new challenges and opportunities in defining primary, secondary, and shared responsibilities; matching private, state, and federal resources; and developing joint research and extension programs.

# *A Systems Approach*

To fully understand the complex processes occurring in the marine environment in general, and in the Gulf of Maine in particular, future scientific endeavors need to be approached from a systems level. Specifically, our program encourages investigation of the offshore, nearshore, and estuarine systems. Since they are very much interrelated, the health and vitality of one is heavily dependent upon the others.

The rich fishery of the Gulf of Maine will comprise a major focus of such programs. For example, we have recently initiated support for a group of scientists (spearheaded by physical oceanographers and geochemists) to investigate the water circulation and chemical fluxes in the offshore areas. Such oceanographic investigations provide an essential basis for understanding the Gulf of Maine's ecosystem, its high biological productivity, and the potential impacts on it of pollution, coastal development, and global and environmental change.

On the broader scale, the Gulf of Maine appears to be well-suited to serve as a microcosm for many of the global issues challenging scientists and society today. Apparently not nearly as spoiled as other semi-enclosed bodies of water around the world, the Gulf of Maine holds promise to serve as a living laboratory for studies related to sea level rise, marine pollution, and global warming.

In the nearshore area, we anticipate a majority of our investigations will continue to concentrate on coastal processes and the rich living resources of this habitat, including lobsters, clams, oysters, mussels, and seaweeds.

A relatively new initiative in estuaries rounds out our composite study of the Gulf of Maine. The number of estuaries along our northern New England coast and the important environmental processes occurring within them is simply too large to fund extensive and comprehensive studies in all of these systems. Consequently, investigators are encouraged to focus on representative systems in multi-faceted, coordinated programs that will multiply the benefits of any one study. With that in mind, we supported the recent designation of Great Bay as a NOAA National Estuarine Research Reserve. For over ten years, we have also supported UNH researchers in building up a data base on nutrient and hydrographic variations in this system. Within this estuary, unique in some features yet having the commonality of all estuaries, we will continue to encourage individual projects as well as multidisciplinary Sea Grant research.

The decision-making process for regulators, policy makers, and researchers requires a solid information base. The establishment of a unified information base would be an integral part of obtaining a true "systems approach" to marine research in the Gulf of Maine. As our research becomes more sophisticated and as we become more aware of the interconnectedness of the environment, our tools must become more sophisticated as well.

In the area of land use, for example, the concept of a **Geographic Information Systems (GIS)** has grown from an idea to an everyday working tool for a variety of applications, from researchers to town offices. In essence, the GIS allows a digital map with a variety of overlays, each containing a variety of spatial information. The spatial information could be: remote sensing information, zoning, utilities, roads, vegetation types, etc. We think that the development of an analogous system for the Gulf of Maine would benefit virtually everyone working in the marine environment, regardless of one's function.

In the marine area we see people using isolated data bases, remote sensing, and numerical simulations. The development of a system which integrated these three activities would greatly enhance the productivity of those involved. The Maine Department of Marine Resources and the Maine Geological Survey have, for example, both expressed the need for such a system. The Maine Geological Survey, in cooperation with the National Center for Geographic Information and Analysis (NCGIA), has already begun to investigate the possibility of using existing GIS technology for the management of their marine data.

We believe that the combination of marine data bases, numerical modeling, remote sensing, and GIS technology is a way to provide this "solid information base" to planners, policy makers, and researchers. This **Marine Geographic Information System (MGIS)** could have a major impact on the way people approach issues affecting our marine environment. On land, we are used to dealing with accurate maps and our ability to retrieve precisely measured information. However, both the perception and the reality of the marine environment are different. Therefore, the goal of a MGIS is to make information available to the user in a useful and common format.

Like Maine, New Hampshire has been developing a geographic information system, **GRANIT (Geographically Referenced Analysis Information Transfer)**. GRANIT is based on the widely used ARC/INFO system and is being promoted by NH Office of State Planning in coordination with other state agencies, federal agencies, and regional planning commissions. Recent developments include major contractual services with the University of New Hampshire's Complex Systems Research Center for digitizing data layers for detailed aquifer maps for the Nashua region, SCS soil maps for Strafford and Rockingham Counties, and coastal wetlands mapping. Currently, GRANIT is being used to digitize bathymetric maps of Great Bay and Little Bay, as well as maps for the New Hampshire Coastal Zone Program.

Given the reality of present and anticipated funding levels for the National Sea Grant College Program, it is clear that investigating the complex scientific questions associated with our offshore, nearshore, and estuarine systems will require extensive cooperation among our academic institutions, state agencies, and private research laboratories. We would like Sea Grant to play a central role in stimulating and fostering this kind of cooperation.

# National and Regional Implications

Due to geographical accessibility, our program has focused much of its attention on the Gulf of Maine. However, regional and national projects in identified strategic research initiatives will gain greater importance for the Maine/New Hampshire Sea Grant Program over the next five to ten years. With some experience already in these multi-state, multi-investigator projects, we anticipate assuming a major role in a number of such national initiatives, particularly those which relate to fisheries oceanography, estuarine systems, and, perhaps, marine biotechnology and sea level rise.

Fostering and furthering the Sea Grant concept among our academic institutions, Congress, and state legislatures will also be a key ingredient to our future success. Some of our efforts, such as those in marine education, lobster research/extension, and, most recently, an initiative to better coordinate federal, state, and private sector marine efforts, have generated significant new support from industry, NOAA, and state government, leading to further participation in NOAA's Coastal Ocean Initiative.

# Plan Format

The plan contains two major, interrelated areas. Each of these areas consists of a number of issues which are vitally important to the future use and development of marine resources in northern New England. Not surprisingly, the issues identified as important to this region are also important to much of the nation as well. The two major areas which the reader will find to be highly interrelated are:

- **Management and Development of Living Marine Resources**
- **Coastal Development**

Each major area contains subsections with a "Background" statement, as well as statements on "Research Opportunities" and "Extension/Education Opportunities." The "Background" statement briefly outlines the importance of the issue and provides some basis for Sea Grant involvement. Similar to previous plans, the "Research Opportunities" statement lists a series of examples of the types of research efforts which could make a contribution to the resolution of a specific aspect of the problem.

In a slight departure from our previous plans, we have added an "Extension/Education Opportunities" statement. This more extensively describes representative extension and education projects which could likely have an impact on the particular issue.

It should be noted that it is not the purpose of either of the "Opportunities" statements to limit creativity or attempt to structure specific proposals. On the contrary, these examples are meant to communicate the type of response appropriate for Sea Grant and to stimulate involvement of interested faculty and staff.

During the course of our planning process a number of issues were considered, which either had been major issues in our previous plans or generated strong support for separate sections in this version. Two such topics, **recreational use of coastal resources** and **marine biotechnology**, deserve further discussion. There is little doubt that both these topics could easily fit our rather broad definition of a marine issue. And there is plenty of opportunity within the framework of marine/coastal needs in northern New England to develop meaningful research and extension projects in these areas. However, marine biotechnology is not a discipline unto itself, but rather an important approach to, or refinement of, traditional areas. Therefore, rather than elevate marine biotechnology to the level of a major issue, it was felt that it should be carefully and visibly woven into the fabric of the two major areas: Management and Development of Living Marine Resources and Coastal Development.

During the course of our planning process, four promising areas of application for marine biotechnology were identified. *First,* new chemical compounds, ranging from pharmaceuticals to food additives, have already been isolated from marine organisms and are being utilized. This search for natural marine products will continue, as will the search for ways in which to more efficiently produce these products through genetic engineering.

*Second,* environmental pollution continues to be of great national concern, and ways in which to mitigate pollution will therefore remain a priority. Since many pollutants are entering estuaries and coastal ocean areas, on-site remediation will require an understanding of marine ecological processes and their modification through biotechnology.

*Third,* aquaculture is continuing to expand throughout the world, both in terms of species involved and total production; while traditional aquaculture continues to be important, applications of marine biotechnology are hastening the expansion.

*Fourth*, marine biotechnology is beginning to provide methods for controlling attachment of marine invertebrates, both desirable attachment (e.g., oyster spat settlement) and undesirable attachment (e.g., biofouling). Each of these four areas (**marine products, pollution remediation, aquaculture**, and **attachment**) is being looked at by UM/UNH Sea Grant investigators, and each will be addressed in the appropriate major area and subsection of this long range plan.

Similarly, in an attempt to streamline the long range plan, it was decided to blend discussions of recreational use of coastal resources into broader marine/coastal issues. Thus, the reader will find a discussion of recreational use of coastal resources in sections dealing with fisheries (where both sport and commercial are discussed), pollution, and alternative uses.

Finally, in developing this plan, the importance of modeling activities of all kinds (socioeconomic, ecosystem, conceptual, diagnostic, predictive, etc.) was recognized. However, as with biotechnology, we consider modeling to be a tool which is broadly useful, having numerous applications throughout the issue areas outlined in this plan.

Incorporating these and other topics or tools in this way is not intended to minimize their importance. On the contrary, the complexity of marine issues demands the integrated application of diverse tools and the involvement of nearly all scientific disciplines to develop effective solutions. It is the intent of this plan to foster and encourage such multi-disciplinary approaches.

Readers of previous Sea Grant long range plans will note some overlap in both the "Background" and "Research Opportunities" sections of this latest plan. We believe this overlap is indicative of several things:

1. that previous plans represent a thorough analysis of the issues and problems;

2. that the contexts for the issues and the issues themselves are of fundamental and long term significance;

3. that the resolution of these issues is also a long-term, evolutionary process involving a broad range and mix of cultural and socioeconomic as well as scientific research and extension components; and

4. that the human and fiscal resources available continue to be much too limited to adequately address most of the identified research and extension needs/opportunities.

# Special Note: Enhancing Science Education

The issue of enhancing science education in our elementary and secondary school systems, as well as at the undergraduate and graduate levels, is indirectly touched upon throughout this document. However, no marine science plan at this time in our history would be complete without a special focus on this topic.

Numerous studies over the past five years have exposed the fact that American students are woefully undereducated in the sciences. At a recent conference of the National Science Teachers Association, the incoming president cited figures showing only 7% of American high school graduates have enough science to continue in college-level science programs. In contrast, 85% of Soviet Union graduates are qualified for higher education science courses. In addition, one-third of science teachers are teaching classes in a discipline for which they weren't trained. Furthermore, it is anticipated that by the year 2000, 45,000 jobs in science and engineering will go unfilled because of a lack of trained graduates. All fields of science within oceanography and the marine sciences are also noticeably void of women and minority groups.

Such concerns have awakened a revival of interest in science and engineering education. Many of the nation's leaders and educators view a basic understanding of scientific and technological principles as necessary knowledge for our citizenry in an increasingly technological and scientific world. Several years ago in a report titled "Educating Americans for the 21st Century," the National Science Board Commission stated:

"students... should be able to use both the knowledge and the products of science, mathematics, and technology in their thinking, their lives and their work. They should be able to make informed choices regarding their own health and life styles..."

This goal cannot be approached without well-trained and enthusiastic educators at all levels of the educational system, who have the proper resources to interest, motivate, and teach their students effectively. The elementary school (K-8) teachers are of particular importance in this process. As a group they have tremendous influence on their students' view of science. If students leave the eighth grade without a successful science experience, they are unlikely to exceed the, often minimal, basic science requirements of high school, and they are even less likely to consider science as a reasonable career option.

However, few elementary school teachers are well-trained in science. Most have specialized in other areas and are unsure and uncomfortable teaching many areas of the science curriculum. In particular, few have any experience in marine science and find it difficult to profit from their students' natural interest in the ocean and its beaches. This is unfortunate because marine science, with its natural biological, chemical, geological, and physical science components provides a realistic, practical, and integrated core for an entire science program at the elementary school level. In addition, many of the science teaching methods and curricula at both the elementary and secondary levels are outdated and unimaginative. Equipment and resources for teachers are also frequently lacking.

Sea Grant, through its research, education, and extension components, can play a special role in enhancing science education throughout northern New England. Marine science concepts are built around basic sciences, and opportunities for creative teaching methods through discovery and real world problem-solving are readily provided. Since marine science is exciting to both teachers and students, it is a good way to draw in teachers who might be otherwise uncomfortable teaching science.

The UM/UNH Sea Grant College Program encourages the continuation of exemplary marine advisory program teacher training and curriculum development projects in the marine sciences. Fostering a sense of stewardship for our marine/coastal resources through science will not only enhance science education in our school systems but it will also protect the quality of life associated with the northern New England coast.

For the past eight years, curriculum development proposals outside of our core marine advisory program have been of low priority due to funding constraints. We anticipate that this will likely continue to be a Program policy in the foreseeable future. However, in the event of increased funding or a cooperative effort with another funding source, the following marine science education opportunities are seen as important to our Program:

- **Curriculum development on global issues** with regional applications, i.e., global warming trend, sea level rise, decline in biodiversity, deforestation of watersheds, and the use of chlorofluorocarbons (CFCs).
- **Slide files on marine topics** such as tidepools, estuaries, and Gulf of Maine fishes with explanatory materials.
- **Internships for educators** and student teachers within any number of marine science facilities or laboratories around the Gulf of Maine.
- Supporting material and **regional networking** among marine educators. What is being used in another part of the country can be adopted for this area.
- **Training teachers in problem-solving and critical training skills**, traditionally "science-oriented" skills.
- **Educational research on society's perception of estuaries**, their values and uses, especially targeting pollution, conservation, and preservation issues.
- **Developing curriculum** that draws connections between rivers, estuaries, and the **coast as an integrated system**. Curriculum development which emphasizes the Gulf of Maine's food production system is also encouraged.
- **Curriculum and workshops on estuarine systems** in NH and Maine which enable teachers and students to view them in an interdisciplinary way (i.e. science, social studies, history).
- **Cooperative opportunities with Medusa and GOMMEA** organizations of educators for kindergarten to college levels.

# Management and Development of Living Marine Resources

Maine, New Hampshire, Massachusetts, and the Maritime Provinces of New Brunswick and Nova Scotia, share in one of the world's most productive cold-water marine environments, the Gulf of Maine. A major and growing portion of our region's economy, culture, and heritage are vested in the living resources that are harvested from the wild or being grown in our Gulf of Maine waters. According to the National Fisheries Institute, 260,000 metric tons of fisheries products worth nearly $500 million were landed in New England in 1988. Maine and New Hampshire's contribution was 27% of this value. The total economic impact of the New England fishery, including harvesting, export, processing, distribution, food service, and retail activities has been estimated at $2 billion annually.

But a series of developments over the last ten years has significantly depleted many groundfish stocks and seriously threatens the continued viability of this rich resource. The passage of the **Magnuson Fisheries Management and Conservation Act** in 1976 stimulated a virtually unprecedented growth in the New England fishery. In the five-year period from 1978 to 1983 the number of vessels nearly doubled from 907 to 1,620, while commercial landings rose from 279,000 metric tons to 380,000 metric tons in that same time span.

Since 1983, however, nearly 400 boats have dropped out of the fishery and landings are down to around 260,000 metric tons. Popular species, such as cod, haddock, yellowtail and winter flounder, have been suffering particularly serious stock declines. Interestingly, lobster landings have been relatively stable for the decade, despite a tremendous growth in the number of lobster traps.

While the Gulf of Maine fishery has traditionally been cyclical in nature, industry members and fisheries managers alike agree that a quick turnaround under the current circumstances is unlikely. Improved fishing technologies, newer and more boats, over-fishing, difficulties with enforcing conservation/management regulations, and the loss to Canada in 1984 of a portion of the rich George's Bank fishing grounds have all contributed in some way to this decline .

Meanwhile, aquaculture development has experienced significant growth in Maine and the Maritime provinces. Of particular note is the explosive investment and increased numbers of finfish farmers raising salmon and trout (over 2,000,000 smolts introduced to coastal net pens in the spring of 1989), and the infrastructure that is evolving to support the enterprise (private hatcheries, marketing consortia, etc.). If successful, the value of these ventures alone could surpass that of our wild harvest ($110,000,000 in 1988) in the near future, and they are fully expected to do so in New Brunswick by 1990.

Equally exciting on the aquaculture front are the mounting efforts on the part of our traditional fisheries (lobster and clams) in public enhancement and ocean ranching efforts. No less than 10 towns are involved in clamflat reseeding efforts in eastern Maine, and lobster hatch/ release and habitat enhancement projects abound in communities and high school classrooms throughout Maine and New Hampshire. There is little doubt that these significant developments will create socioeconomic benefit of a substantial and far-reaching nature, in our northern New England region.

Sportfishing also has a major impact on Gulf of Maine fish stocks and the region's economy. According to the Sport Fishing Institute, national retail sales affiliated with saltwater fishing in 1985 amounted to nearly $5 billion. Best estimates indicate that Maine and New Hampshire accounted for about $50 million of that total. Residents of Maine and New Hampshire spent more than 1 million days fishing in coastal waters in 1985. This figure is expected to rise to 1.3 million by the year 2000. The northern New England charter and party boat industry is also sizable. About 300 boats produced revenues in excess of $6 million in 1985.

Although the problems associated with the Gulf of Maine fisheries are obvious, solutions are not so clear. International agreements, New England traditions, socioeconomic implications, enforceable management policies, and biological limitations must all be factored into acceptable solutions. Finding ways to ensure the successful conservation and allocation of these valuable fishing resources has always been a priority in our region. However, even more creative approaches and genuine commitments are needed at this critical time.

As indicated in the Introduction section, marine biotechnology has not been highlighted as a separate issue in this version of the plan. But it is a promising scientific tool which could have major impact on the management and development of fisheries stocks within the Gulf of Maine.

**Marine biotechnology** simply involves manipulation of organisms which are derived from the sea, and therefore it describes both traditional and emerging areas of marine science, including many areas of interest to Sea Grant. In its *Annual Program Guidance*, the National Sea Grant College Program (NSGCP) has listed marine biotechnology as a major programmatic theme for the past six years. In that document, NSGCP pointed out:

> "Basic studies on which to base production of goods and services through mediation of marine species have been neglected in the U.S. The advent of powerful new methods in DNA technology, including cloning of cell lines, and recent progress in research, as in chemistry and pharmacology of marine natural products, show the need to focus greater attention on developing marine resources through biotechnology. The results of this research will aid in realizing the potential of the marine world for greater contribution to economic and human well-being through new products, such as chemicals and food, and service, such as waste treatment with saline organisms."

Other federal agencies are also aware of the potential benefits offered by basic and applied research and development in marine biotechnology. For example, the Office of Naval Research requested that the National Research Council (NRC) investigate applications of biotechnology to naval needs. As a result, a 60-page document was published by the National Academy Press in 1985. In summary, the NRC Committee pointed out that development of marine biotechnology is dependent on advances in basic research, and that two broad areas need to be elucidated: **biomaterials** and **biosensors**.

Marine biotechnology, new techniques in culturing or enhancing populations through husbandry, and improved management practices offer promise to the potential for sustaining or increasing future yields from the Gulf of Maine. In order for our region to address the current issues and challenges in conserving and enhancing our marine resources, there is little doubt that our ability to adequately do either will rely on our ability to cooperatively and effectively manage the resources in the Gulf of Maine.

Future management will require a greater understanding of fundamental oceanographic processes; the evolution towards enlightened legal, socioeconomic management mechanisms; and the development of new technologies to enhance production capabilities through aquaculture. Therefore, the three major issues areas that the Maine/New Hampshire Sea Grant Program should focus its efforts on for the next five years include:

**1) a stronger scientific basis for management;**
**2) enlightened social context for management; and**
**3) new production technologies for fisheries enhancement and aquaculture.**

Sea Grant's role in fisheries development recognizes the importance of both the commercial and sport industries to local and regional economics. Research and extension projects which facilitate development, resolve conflict, identify new techniques/technologies for improved stocking or catching methods, or improve management practices are considered high priority.

# *Improving the Scientific Basis for Mangement*

***Background***

The **Technical Management Group** (TMG) of the **New England Fisheries Management Council** recently concluded that the *Multispecies Management Plan* implemented in 1987 to rescue depleted New England groundfish stocks has made little progress in doing so. The TMG offered a number of recommendations to improve the plan, which include bolstering enforcement techniques and enhancing our scientific basis for management. A particularly chilling excerpt from the report states:

"...This need is especially important because most of the fish stocks managed under the plan are at historic low levels of abundance, fishing effort is at historic high levels, catch per unit of fishing effort is at historic low levels, and prices are at historic high levels. These extreme conditions are not conducive to recovery of fish stocks because there is high economic incentive for harvesting any increases in stocks at a young age and hence small size, thus working against spawning stock increases."

The sportfishing industry represents a sizeable portion of the region's harvesting activity. Although not as well organized as New England commercial fishermen or sport anglers in other parts of the country, participants are keenly aware of problems currently facing the industry. These problems are very similar to those in the commercial arena, and they include commercial fishing conflicts, allocation of dwindling fish stocks, marine pollution, inadequate shoreline access, lack of conservation ethic among many anglers, and an ever-increasing number of individuals participating in marine recreational fishing.

Included within northern New England's sportfishing industry are two major sectors: **marine** and **anadromous**. The former is composed primarily of saltwater anglers and an extensive fleet of charter/head boat operators fishing for traditional marine species such as bluefish, mackerel, tuna, flounder, cod, and haddock.

Anadromous fisheries include brook, rainbow, and brown trout, and smelts. The region is aggressively stocking Atlantic and chinook salmon and American shad but returns to date (with the exception of shad) have not been as high as anticipated. New Hampshire's twenty-year experiment with stocking coho salmon was recently terminated due to poor returns. It has been replaced with a chinook stocking program.

Activity associated with marine recreational fishing can have major impacts on coastal economies, social patterns, and fish stocks. Even with increased Wallop-Breaux expenditures, funding for sportfishing-related activities is insufficient. Thus, licensing of marine recreational anglers is becoming a much-discussed alternative to gain additional resources for providing increased recreational fishing opportunities.

A thorough understanding of production processes and mechanisms constraining production are central to informed management. The UM/UNH Sea Grant College Program has made considerable progress in characterizing physical, chemical, and biological aspects of a number of elements within the Gulf of Maine. These fundamental efforts, along with understanding what elements are essential in driving the oceanographic processes, should be continued, especially for our commercially and recreationally-important species such as lobsters, shellfish, groundfish, and herring. Research on recruitment, predation, and other forms of mortality could also improve our understanding of fluctuations in the biomass of our overall fisheries.

The major issues related to recruitment are particularly important to our Program, since NOAA has recently released its *Recruitment Fisheries*

*Oceanography Program Development Plan* calling for increased coordinated efforts in this area. Fish and shellfish recruitment questions highlighted in the Plan address the effects of changes in abiotic or biotic factors on variations in spawning activity, on egg quantity and quality, and on the survival of eggs, larvae, and juveniles. Investigations of spatial and temporal scales related to recruitment mechanisms are also highlighted. These are appropriate Sea Grant areas; however, funding levels and the Program's mission dictate that long-term studies (i.e. > 3-4 years) would be difficult to maintain and, if supported, must be carefully selected.

Marine biotechnology also holds great promise for application in fisheries research. Phenomena such as declining fisheries, disease, and recruitment lend themselves to biotechnology, including improved methods of management.

Newer advances in oceanography via space technology are imminent and submersible vehicles, both manned and unmanned, are providing us the opportunity to look well beneath the ocean's surface. These vehicles, coupled with sophisticated new navigational techniques, are providing an opportunity to study patterns of plant and animal communities on the ocean bottom as never before. Because of previous investments in many fields of science and technology, especially those intended for terrestrial and outer-space use, we are now beginning to use new tools to understand the processes of biological productivity in the marine environment. It is appropriate that we utilize these technologies, as well as others, to expand our perspectives by considering elements and processes in a more integrated manner. **The UM/UNH Sea Grant College Program continues to encourage multi-disciplinary studies that will increase our understanding of the multiple components of marine ecosystems.**

### *Research Opportunities*

- What processes/factors constrain recruitment in commercially or recreationally-important organisms (lobsters, shellfish, groundfish and pelagic species)? Can we quantify the timing and significance of abiotic and biotic **factors in determining recruitment?**
- To what extent do **physical mixing/ transport processes** and primary production control recruitment? Is the control tightly coupled, loosely coupled, or multi-coupled? Are timing and spatial variability important? If so, what controls them?
- What **physical** characteristics (currents, wind, upwellings, intrusions) have significant **impacts on production**?
- What degree of **random variation in the physical environment** is sufficient to limit predictability of biotic systems? What portion of the variability in the coupled system are unpredictable or behave in a chaotic manner?
- How does large and small scale variation in the environment constrain **larval/ juvenile survival**? Does the absolute abundance of particular habitats limit production at any life history stage?
- What direct and indirect impact do **transient oceanographic phenomena** (such as rings or intrusions) have on survival?
- Following **disturbance to the environment**, does the species composition change in a predictable way? Is recovery possible for areas which were previously productive?
- What are the **impacts of selective exploration** on other biotic components of the ecosystem?
- What is the **role of food availability** in controlling survival of larvae and juveniles? What is the role of invertebrate and vertebrate predation in controlling survival of eggs, larvae, and juveniles?
- Does the relative importance of various **survival mechanisms** change within or among years?
- What is the potential of **artificial reefs** to contribute significantly to marine fish production in coastal New England waters? Are artificial reefs a valid means to mitigate loss of habitat through coastal alteration projects?
- Do artificial reefs, which generally are intended to aggregate fish and make them more available to fisherman, have a potential of seriously increasing the **problem of overfishing** of heavily exploited fish stocks?
- What are the principle causes of the very **low return rates of Atlantic and Pacific salmon** stocked in northern New England rivers over the past few years? Are there other species which might be suitable candidates for state/federal anadromous fish stocking programs?
- What is the **hooking/release mortality** of recreationally caught fish? Development of new gear to reduce hooking mortality is especially encouraged.
- **Genetic tags** should be developed for tracking species introduced to natural marine and estuarine environments. Tags could include both

conserved sequences unique to the species and engineered sequences introduced as interons.

- **Disease-resistant animals** need to be developed for release and recruitment to adult stocks. It is clear that disease is responsible for the demise of many marine plants and animals, and a greater degree of resistance in hatchery stock is therefore desirable.
- Use of **monoclonal antibodies** for recruitment research needs to be investigated. For example, could monoclonals be used to isolate larvae from the water column? Could monoclonals be used to track movement of larvae?
- Stocks that mature more rapidly, with a greater amount of edible flesh, can be produced through **genetic engineering**. Progress along this line is being made with livestock, and some success has been achieved with marine species, e.g., triploid oysters and transgenic fish that contain the gene for an express human growth hormone. More research needs to be done in this area, including examination of undesirable side effects in transgenic strains.
- The sensitivity of fish to **anthropogenic stress**, especially toxic chemicals, must be more carefully examined. This includes sensitivity of certain unique properties such as the antifreeze proteins in winter flounder.
- **DNA libraries** of commercially important fish and shellfish should be prepared for future use and manipulation.

### *Extension/Education Opportunities*

- Innovative programs on **marine safety** topics for all fishermen, aquaculturists, and recreational boaters are encouraged.
- Identification, testing, and use of materials which could **replace plastics** in the fishing industry is appropriate.
- Assistance should be provided to communities, docking facilities, and fisheries cooperatives in dealing with the shore side requirements of **MARPOL.**
- What are the **impacts** of different types **of gear** on the environment? If there are negative impacts, how might they be reduced?
- The development and demonstration of **conservation gear** and by-catch reduction is particularly important. Changes in regulations concerning gear requirements and the basis for them should be quickly disseminated to the fishing community.
- In some instances, extension can play a role in helping researchers connect with the fishing community to collect scientific data. **Increased interaction between extension staff, the fishing industry, and the research community** is strongly encouraged.
- What is really important to the public with respect to **fish contamination**? How can this information be transmitted? Currently, there is a great deal of confusion and possible misplaced concern among consumers on this subject.
- **Fisherman education programs** which focus not only on techniques, gear, and species, but also on ethics, conservation, pollution, and general fisheries issues, are considered important.
- The pending development of a **national seafood inspection program** could provide industry training opportunities for Sea Grant staff familiar with technology associated with the production of wholesome seafood products in northern New England.

## *The Social Context of Management*

### *Background*

The centerpiece of the nation's marine fisheries management program is the Magnuson Fishery Conservation and Management Act. Nearly all of the region's coastal fisheries, and the people who depend upon them, are in some way affected by the management strategies embodied in the *Fisheries Management Plans* (FMP's) created by the New England Fishery Management Council and adopted by the United States Department of Commerce.

In the New England region, fisheries have been managed through the use of varying allocation schemes since 1977. For example, regulations employing fishing quotas are no longer in use in the region's groundfish fishery (cod, haddock, flounder, etc.). This type of restriction was found to be difficult to enforce, and the resulting biological information, necessary to make wise conservation decisions, was not reliable. Current groundfish regulations utilize a combination of minimum fish sizes, gear size restrictions, and closed spawning areas to ensure that fish have the opportunity to reproduce before they are harvested.

For key fisheries in the region, interest in regulations to further limit fishing effort is being rekindled. Meanwhile, reductions in needed funds for the enforcement of fisheries management regulations have forced the agencies to consider implementation of some form of user fees to cover budgetary shortfalls. The development of effective, adequate harvesting regulations is an evolving process that will continue to build on the experiences of both regulatory agencies and industry over the past dozen years.

Each swing away from one fisheries management system towards another can have profound effects on the economic and social criteria which fisheries managers must sift through as their management decisions are reconsidered or reinforced. Fishery management decisions can affect the allocation of resources between sport and commercial fishermen, the economic health of a fishing port, the ability of a coastal community to realize tax revenues sufficient to pay for necessary services, one state or nation's legal relationship with a neighbor due to competing claims over a transboundary resource, the supply of fisheries by-products which may be needed to make modern waste-utilization methods feasible, or the opportunities for a fish processing company to expand its production to include modern, value-added food products.

In attempting to address these and similar socioeconomic issues, Sea Grant resources can be used to encourage research in such diverse fields as economics, sociology, political science, international law, soil science, or food engineering. Extension activities can then be utilized to bring research results to those in the community who have a stake in the success of the region's commercial and recreational fisheries.

The region's fishery management strategy will also continue to be affected by the Canadian Maritimes. Because of the growing importance of Canadian fisheries products in the domestic marketplace, enhanced by the recent approval of the **U.S./Canada Free Trade Area** agreement, and because the delimitation of the U.S./Canada maritime boundary leaves important transboundary fisheries stocks "managed" by different methods by each country, important discussions with Canada will continue over the next five years with respect to Gulf of Maine fisheries. These facts may provide reasons for the goals of fisheries management in the region to be re-examined.

The activities of the Sea Grant Program can play an important role in fostering mutual understanding, cooperation, and acceptable solutions. The challenge will be in focusing its energies on those issues and opportunities which will contribute to the long-term health of the region's fishing and aquaculture industries on both sides of the border.

***Research Opportunities***

- What is the **impact of various management structures** on the region's fisheries resources and their future value to the region's economy? Should it be the goal of our overall management strategy to ensure equal opportunities for recreational and commercial interests to compete or to ensure a profit for those fishing for a livelihood? What sort of basis could be used for selecting the most appropriate goal or structure?
- Is there an overall social or economic benefit to employing regulations that **limit entry** into a fishery or assign property rights which can be freely transferable? What are the major costs and benefits from alternative fisheries management strategies?
- What effects would **licensing** have on northern New England's sportfishing industry? Are marine recreational anglers adequately supporting the planning and management of fish stocks by federal/state agencies?
- The laws, regulations, and degree of **industry participation** through which the U.S. and Canada manage their fisheries resources are frequently different. What are the implications of these two different social systems to bilateral fisheries management? How might these differences be overcome to foster the development of common resource management goals and mechanisms?
- As development in the coastal zone continues, what responsibility, if any, does a community have in order to ensure that **waterfront-dependent businesses** have priority access to the source of their livelihood?
- Is there sufficient **public access** to facilitate the expected growth in marine recreational fishing over the next five years? Where should facilities expansion be targeted?
- **User conflicts** between traditional commercial fisheries employing different gear types, between commercial harvesters and aquaculture producers, and between recreational and commercial harvesters continue to flare up. What mechanisms can be employed to help those involved resolve their conflicts for their mutual benefit?

• How can public perceptions about **fish by-product disposal** options be changed to encourage better utilization of our marine resources? How might these possible options be pursued?

• Can appropriate incentives or techniques be devised which would increase consumer and industry demand for currently **less desirable species**?

• How can the **economic valuation of commercial and recreational fisheries** be standardized to provide a valid comparison of net economic benefits for use in allocation and fishery conflict resolution decisions?

• What is the linkage between fish stock characteristics and recreational fishery value? How do factors such as catch rate and size of fish, for example, effect the **economic value of recreational fisheries**?

• What are the key variables which describe regional participation, profitability, industry structure, and economic impacts in markets related to recreational fishing? An easily-updated model to predict **future sport angling participation** in northern New England would be helpful to fisheries managers, marine businesses, and other public officials.

### *Extension/Education Opportunities*

• If the fishing industry is going to make knowledgeable contributions to **fisheries management**, individual commercial fishermen and sport anglers alike will have to understand and participate in the processes. Sea Grant Extension can assist by fostering fishermen participation in the decision-making process.

• There are many licensing, limited entry, and limited effort schemes being suggested. Sea Grant Extension can help by keeping the industry informed of these schemes and their strengths and weaknesses. Extension can help the industry make informed choices by keeping them abreast of proposals and **pending legislation** in these areas.

• **User fees** are being discussed at the federal level. Sea Grant Extension can inform fishermen of what is being proposed and how they can be involved in the process.

• Most of the problems facing recreational fishermen and commercial fishermen are the same: **depleted stocks, pollution, an evolving management system**, and controversy over who is going to pay for fisheries management. Sea Grant Extension can be a liaison between the two groups and help them realize their common problems.

• Extension can help collect data for research pertaining to commercial and recreational use of common resources.

• There is need to coordinate efforts between certain segments of the sportfishing and tourism industries to develop **vacation packages promoting sportfishing** opportunities in northern New England.

• Extension efforts in **fisheries marketing** should include coordination with the recently established National Seafood and Marketing Council.

• **Shared resources** and boundaries with our Canadian counterparts, coupled with new and evolving trade policies will eventually require much greater bi-national interaction among resource managers, scientists, and industry. Extension programs could play a significant role in bringing parties who share common interests/issues together through forums, seminars, and workshops in open and objective settings.

## Production Technologies for Fisheries Enhancement and Aquaculture

### *Background*

Numerous estuaries, sheltered coves, and a large tidal flow of plankton-rich water make Maine and New Hampshire ideal places for aquaculture ventures. With Sea Grant's early efforts in northern New England focusing on cold water species, commercial aquaculture began in the early 1970's with a few small oyster, mussel, coho salmon, and rainbow trout operations. Maine's aquaculture lease statutes were passed in 1973, allowing for individuals and companies to have exclusive rights to their crops. Unfortunately, many of these pioneers were undercapitalized, could not obtain enough seed stock, selected poor sites, or their efforts proved to be too labor intensive. Consequently, during its first decade in Maine, the industry grew very slowly.

With the adoption of bottom culture techniques, mussel farming burgeoned from 1982 to 1986. Mussel farmers gather seed from crowded beds, and spread them out thinly on areas of the sea floor. Farm-raised mussels have a dockside value of approximately $2 million, but they account for only 15-20% of Maine's total mussel landings. However, due to the aggressive marketing efforts of several mussel farming companies, **mussels, a minor fisheries product 20 years ago, are now sixth in pounds landed each year.** Over 6.2 million pounds were harvested in 1988. According to the Maine Aquaculture Innovation Center, only a small percentage of the available good sites for mussel bottom culture are currently leased, such that future harvests could be valued at about $100 million per year.

This year's cultivated salmon harvest (including farm-raised rainbow trout called "salmon-trout") is expected to be over 1 million pounds, with a landed value between 4 and 5 million dollars. The **400 acres of salmon leases**, both granted and pending, could potentially yield an annual harvest with an estimated value of $180 million. While salmon grow-out sites have been limited by biological requirement and environmental factors, development of cold-resistant and faster-growing strains of fish seem to be the wave of the future.

Current statewide production of **cultivated oysters** numbers about 1 million count annually, while harvests from wild oysters from natural beds accounts for an additional 2 million oysters. With technological assistance, farm-raised production could easily exceed 10 million oysters annually within 5 years, with a dockside value of approximately $3 million. For every 1,000 acres planted, approximately $35 million of oysters could be harvested each year. Suitable conditions for growth of American oysters and quahogs occur in upper reaches of bays and estuaries in Maine, while the European oysters thrive in somewhat cooler oceanic sites.

Public aquaculture, or stock enhancement through aquaculture techniques, is becoming accepted in Maine and New Hampshire as a necessary and appropriate function. There are today two such enterprises in Maine focusing on enhancement of two traditional fisheries, lobsters and clams. A lobster hatchery was established in Cutler in 1986. In 1987, a clam hatchery was established on Beals Island and in the first year approximately 9 million clams (1/8"-1/2" long) were raised and transplanted to flats. In New Hampshire, Sea Grant and Cooperative Extension have recently established a shellfish aquaculture lab which has the potential of raising 1 to 2 million soft-shelled clams annually for stock enhancement. While research into the efficacy of these **aquaculture enhancement projects** is still necessary, early results appear promising and may provide major transformation in the philosophy of management for these species in the future.

Aquaculture of several other marine species, e.g. scallops, halibut, and certain "gourmet" seaweeds, has been proposed, but little or no R&D has been conducted. Culture of baitfish is a well-established industry in both states, with an annual market value of over $7 million.

Social resistance to aquaculture continues to hinder the development and expansion of the industry. Although both real and perceived user conflicts exist, the situation is complicated by inaccurate and insufficient information available to the public, not to mention to community leaders and legislators. At the same time, aquaculturists often ignore social, political, biological, and economic factors that have no immediate bearing on their operations. There is a need for improved public-private communications, as well as a broad-based understanding of aquaculture definitions and policies.

A coordinated effort in the **health management of fish and shellfish aquaculture** would greatly benefit the development of commercial culture of aquatic animals in the northeastern United States. Presently a number of government agencies and other groups have developed various regulations or guidelines regarding fish health and the transport of live fish across certain boundaries. The ideal would be to have one coordinated effort that would provide assurance to all interested parties that their concerns for limiting the spread of aquatic animal diseases would be met. This may take extensive negotiation to reach. An initial step would be to inform interested parties of what regulations and guidelines currently exist.

The next step in this coordinated effort would be to contribute an environment that facilitates meeting the regulations or guidelines. Aquaculturists face a serious problem in meeting the health inspection requirements prior to transport of live aquatic animals across state boundaries. The cost of inspection is extremely high and the producer must provide a number of fish (usually 60 fish per lot) that will be sacrificed during the inspection process. Research is needed to develop testing techniques that are sensitive, rapid, and economical to perform. Sampling techniques that are non-destructive of the animal would also be highly desirable, especially when dealing with a limited number of broodstock.

There is considerable economic risk and

uncertainty associated with aquaculture ventures. This risk and uncertainty is the result of technological uncertainties, market uncertainties, input supply uncertainties, regulatory uncertainties, capital constraints, and management skill levels. There has been little work done to evaluate the profitability and economic risks associated with northern New England aquaculture ventures. This lack of specific baseline information makes it difficult for the emerging aquaculture industry to obtain capital resources and insurance. In addition to the lack of regional financial and economic information, many aquaculturists are unfamiliar with the sources of capital and marketing options available. Aquaculturists also often do not have the background to develop effective business and marketing plans necessary to attract investors and other sources of support.

***Research Opportunities***

- **Fish and shellfish** disease diagnosis, treatment, and prevention are some of the most significant "financial variables" in the industry. Whether salmon in a hatchery or in pens, clams in a hatchery, etc., a disease outbreak can spell financial disaster. Research leading to improved diagnostic services, methods, treatments, and preventive measures is required.
- **Genetic variation/improvement** of finfish and shellfish through selective breeding and other techniques such as polyploidy are of significant interest to our industry. Selection for disease resistance, faster growth, and hardiness would improve the productivity of the industry. Development of new culture candidate species (halibut, sea scallops, etc.) is also a priority.
- Assessing the efficacy of **hatch-and-release enhancement efforts** is the top priority for community clam and lobster hatchery programs.
- **Shellfish waste**—develop economical alternatives to using landfills for this waste-composting by-product development.
- Development of systems or programs which can assist in mitigating the adverse effects of inferior **water quality** on fish and shellfish harvesting and marketing (e.g. depuration, relay, microbial, disinfection).
- Assessment of **aquaculture potential** for various species along the Maine/NH coast in terms of important environmental variables, such as natural productivity, habitat availability, flushing rates, carrying capacity, and water quality.
- Techniques for **genetic manipulation** of marine species, including archaeobacteria, bacteria, eucaryotic microorganisms, marine plants, marine invertebrates, and marine fishes, need to be thoroughly studied and refined. Once the genetic manipulations are in place, genetic engineering can be more successfully applied to marine aquacultured species.
- **Immune mechanisms** of marine invertebrates and vertebrates need to be elucidated, so that disease prevention among aquacultured species can become more effective.
- **Gene probes** need to be developed for improved detection of disease agents in aquacultured species. This includes both agents causing disease in the cultured species and agents causing human disease and capable of concentration in, and transmittance by, cultured species.
- **Reproductive cycles** of commercially-important marine species need to be elucidated, so that species propagation and growth can be increased in culture. This includes production of transgenic species, optimization of gamete production, and enhancement of metamorphosis.
- **Symbiotic relationships** between bacteria and commercially-important species may contribute to many critical facets in the development of the commercial species, e.g. chemical stimulation of metamorphosis. In some cases, these biochemical relationships are already being exploited as a means of enhancing aquaculture productivity. This type of applied research should be encouraged.
- **Aquaculture activities** may present a source of pollution, including sources of both human and marine animal pathogens. Risk assessment and risk management must be addressed.
- Scientifically and socially-acceptable **aquaculture industry siting criteria** are needed to facilitate the permitting process.

***Extension/Education Opportunities***

- Local and regional **laws and regulations** that affect the aquaculture industry should be compiled, assessed, and documented.
- **Workshops, site visits, and seminars** can be held to inform and assist regulators, public officials, and/or the interested public.
- **Production technology transfer** (west to east coast, Norway or the Netherlands to the US) is costly, time consuming, and ever-evolving. Extension efforts could assist in creating the infrastructure for rapid improvement in this area.

• **Educational and outreach programs** could provide the information, data, and awareness necessary for dispelling perceived conflicts which are invalid, determining those which are valid, and identifying common interests in order to foster acceptable and rational developments in aquaculture.

• A well-defined and **comprehensive database** should be developed on the existing water quality, fish and shellfish resources, land use/land cover and pollution sources (point and non-point) and their magnitude in the watershed. A strong database should be the foundation for problem assessment, watershed management plan development, political and legislative support, and future funding requests.

• **Ecological risk assessment** and communication program focusing on pollutant effects on fish and shellfish populations should be pursued.

# Coastal Development

Toxic algae blooms, global warming and sea level rise, oil spills, sludge and toxic waste dumping... such ocean-related threats to man's health and safety are frequent headline topics. Currently, the oceans contain vast potential to promote mankind's welfare, including mineral and fuel reserves, new medicines, recreation, and transportation, among others. These are non-living resources and constitute the complement to the preceding section dealing with living marine resources.

We have chosen to title this section "Coastal Development," because most of the issues in Maine and New Hampshire arise from the crush of growing population. In Maine, for example, the population of the coastal counties is expected to increase by 6.2% by 1995 (Maine State Department of Human Resources), while the inland counties are expected to grow less than 1%. In contrast, New Hampshire's two coastal counties are projected to grow by about 16%, while the remaining counties are projected to increase at a rate of about 12% between 1990 and 1995. Effects of this growth are manifested in changes in the distinct character of many small coastal towns, impacts on groundwater, destruction of wildlife habitat and important farmlands, and a strain on local capital facilities such as sewers and solid waste disposal sites. Rising sea level stands out as the single natural process that will profoundly affect all coastal development for the foreseeable future.

Within the context of Coastal Development three major issues have been identified which will be important over the next five years and where researchers, educators, and extension staff in our two states can make a contribution:

1) **Coastal Engineering**
   - Coastal Processes
   - Energy
   - Dredging
2) **Marine Pollution**
3) **Alternative Uses of Coastal Resources**
   - Access
   - Conflict Resolution

Our previous long range plan, *Looking Ahead*, categorized similar material into five categories. The current structure has been adapted to reflect recent concerns about burgeoning coastal development, pollution, and changing demography. While there are many major issues arising from increasing coastal development, this plan selects those deemed most pressing and thus likely candidates for our scarce resources.

# Coastal Engineering

This section treats issues related to construction, changes in the coastal zone, coastal processes, energy, and dredging. These issues are ordered into three sections: **Coastal Processes**, **Energy**, and **Dredging**. Clearly, there is overlap in the governing physical processes among these three, particularly sediment transport. A quantitative understanding of sediment transport pathways would greatly help in our understanding of beach dynamics as well as give us better clues for undertaking and regulating dredging in inlets and harbors.

In the National Sea Grant College Program's annual guidance document, "Coastal and Ocean Processes" is clearly indicated as a priority area. Indeed, this is a priority area for the Maine-New Hampshire region as well.

"COASTAL AND OCEAN PROCESSES. Research should focus on defining and quantifying the fundamental hydrodynamic and sedimentary processes that influence the quantity and quality of living and non-living coastal resources. The ultimate goal is to predict physical changes to nearshore environments based on time-dependent dynamical models. Research should be pursued through comprehensive process-oriented experiments to investigate and model forcing/response mechanism over a wide range of time and space scales. ..."

*Sea Grant Annual Program Guideline* (1989)

In considering the issues selected for the Maine/New Hampshire program, we encourage a new research direction in considering the role of wave dynamics in nearshore coastal processes.

The energy section has been continued from the previous plan, but as a lower priority. This section deals with the consequences of oil transport, possible offshore production in the Gulf of Maine, and the proposed power plant in the Bay of Fundy. While these topics are not currently in the public spotlight, it is obvious that these issues are here to stay. For example, a recent compilation by the New England Division of the U.S. Army Corps of Engineers indicated that nearly 40% of the significant oil spills from Long Island, New York to the Canadian border have occurred along the Maine/New Hampshire coast. The *Exxon Valdez* oil spill has heightened public awareness of the need for both research and planning.

Dredging continues to be a contentious issue in the region, which derives directly from the lack of a comprehensive dredging policy for coastal Maine and New Hampshire. Research on the processes and consequences related to dredging is needed to allow federal and state regulatory bodies, as well as local interests, to make informed decisions in this difficult area.

## Coastal Processes

### *Background*

Present demographic trends will certainly lead to increased pressure to develop the coastline, which consists primarily of rocky shores, harbors/tidal inlets, sandy beaches, and erodible bluffs. Development will include construction of new homes and businesses, remodeling and repair of existing facilities, and building of coastal structures. A 200-year historical trend indicates that man will continue to modify the coastline. However, development of the shoreline will become increasingly difficult due to both socioeconomic and environmental factors, such as rising sea level and increasing size and density of coastal structures.

Sea level is expected to rise substantially throughout the coming decades as a result of global warming. Consequences of the anticipated rise in sea level and coastal subsidence along the region's 3500-mile coastline need to be examined. Several issues related to this phenomenon include shoreline retreat; coastal erosion and flooding; health and safety; salt water intrusion in coastal aquifers, rivers, and bays; effects on structures (e.g., bridges, roads, houses, etc.), and the impact on recreation and other resources.

A recent publication by the National Academy of Sciences, *Responding to Changes in Sea Level*, illustrates some of our problems:

1. Sandy beaches exposed to ocean waves where natural processes may cause beaches to erode 1m or more for a 1-cm rise in sea level.
2. The wedge of saline water through estuaries and tidal rivers may advance as much as 1km for a 10-cm rise in mean sea level. This will be of special concern for drinking water supplies and coastal ecosystems.
3. Salinity intrusion in coastal aquifers where the landward displacement of the salt and freshwater interface is a large multiplier of the sea level rise. Current problems of salinity intrusion into groundwater supplies will be increased with

only relatively small rises in sea level.

A best estimate of the rate of sea level rise for Maine/NH, based on current observations (not predictions based on global warming), varies from 2.3 mm/year at Portland, Maine to 3.2 mm/year for Eastport, Maine. Predictions based on global warming would add considerably to this estimate. Of three scenarios for the magnitude of the sea level rise over the next 100 years, the most widely accepted predicts a rise of one meter! (Titus and Barth, 1987). Global warming will increase the volume of water in the oceans by raising ocean temperatures (thermal expansion), by melting the ice sheets (add more water), and thereby raising sea level.

A significant increase in sea level could cause widespread shoreline erosion and inundation. The two general response options available are to:

1. Stabilize the shoreline, either through beach nourishment or by new or augmented coastal armoring; or
2. Retreat from the shoreline, maintaining a more-or-less equal elevation above local sea level.

Whether to defend or to retreat depends on several factors, including the future sea level rise rate and the relative costs of retreat or stabilization. The former is poorly known, while the latter will vary from place to place.

Because of the impending pressure on the coastline, our ability to evaluate and estimate shoreline response to a rising sea level will become an increasingly important tool for planners and regulators in the future. This response was a key issue in the Maine Department of Environmental Protection's decision not to allow the construction of a condominium at a site near Old Orchard Beach. In what appears to be the first case of its kind in Maine, retreat was chosen as the response of choice.

***Research Opportunities***

- What are the volumes, sources, and directions of sediment movement along the coasts of Maine and New Hampshire?
- What conditions are most responsible for longshore transport: northeast storms, prevailing southerly waves, or others?
- What types of verifiable wave models can be developed to obtain a better understanding of nearshore processes?
- How do coastal engineering structures affect the natural cycles associated with annual/long-term beach expansion and retreat? Are there new forms of engineered structures which might have less negative impacts on these natural cycles?
- Can new technologies be used and/or developed to ease the detrimental impacts of development in marsh and coastal areas?
- What specific impacts will the anticipated sea level rise have on existing and future development along the northern New England coast? For example, what will be the effect on coastal aquifers?
- What will be the response of the coastal zone to rising sea level, e.g., where will the beach be in 50 or 100 years?
- Whether sea level rises or not, we need to understand not only the effects of manmade structures but also how to better design and build these structures. We need to better understand the environmental forces to enable effective design. In addition, we need to take advantage of new materials, better design, and more effective construction methods to afford the needed effort in many coastal areas.
- Can we use circulation models or new observational technologies to better understand and quantify the changing salinity in estuaries due to rising sea level?
- Can groundwater models be used to better understand and quantify the potential for saltwater intrusions in the groundwater?

***Extension/Education Opportunities***

- Produce informative videotape and companion publication for schools and television, presenting coastal processes in general and those aspects unique to Maine/New Hampshire.
- Train extension agents in aspects of coastal processes to better enable information transfer and provide liaison between coastal communities and Sea Grant and other researchers.
- Establish a training program for state agencies, regulatory boards, industry, and other users with direct responsibility for regions affected by these coastal processes.

## Energy

### *Background*

The prospect of large energy-facility construction has been a major issue facing both the Maine and New Hampshire coasts for more than a decade. These prospects have been somewhat diminished, as ideas which once seemed imminent are moved to the "back burner." But this change should be seen as an interlude in the issue of energy development and the potential conflicts arising with regard to coastal and marine interests. Issues that are likely to continue to be of interest over the next five years are: outer continental shelf (OCS) oil and gas exploration and development, the Bay of Fundy Tidal Power Project, and construction of new large scale power plants, possibly fueled by coal.

Specifically, it is highly probable that there will be renewed interest in oil field exploration and development on Georges Bank, an area subjected to violent storms and infrequent, but significant, earthquakes. The emplacement of oil production structures in this hostile environment would require careful regulation, based on the evaluation of subbottom characteristics. It has often been the case, however, that regulating agencies have had to rely on the regulated industry for information about ocean and subbottom conditions, since the oil industry has developed the more sophisticated, but proprietary, techniques for subbottom characterization.

However, even the most sophisticated techniques used in current practice are relatively crude. A 1987 workshop on the future of the Exclusive Economic Zone (EEZ), sponsored by the National Science Foundation, emphasized that in order to properly supervise seabottom/ subbottom exploration activities and evaluate their impact on the coastal ocean, appropriate bottom characterization systems must be developed "and made available in the public domain."

Furthermore, the *FY 89 Annual Program Guidance Statement* of the National Sea Grant College Program points out that "the design, construction and maintenance of ocean structures is hampered by poor knowledge of the fundamental engineering properties of marine soils..." Thus, it is important to develop new techniques for measuring the in-place properties of seabed soils, in order to reduce the risk of foundation failure of offshore structures under extreme loading conditions.

The Bay of Fundy Tidal Power Project has been an issue for some time. Model results by both the U.S. and Canadian researchers indicate that the proposed tidal power plant can have significant effect on the tides around the Gulf of Maine. For example, one proposed scenario would increase the tidal range in Boston by about one foot. Concern about the impacts on the coastal environments of Maine and New Hampshire, due to the altered current and tide regime, has been expressed by a number of scientists and by state governments. A single turbine, prototype unit is now in use at Annapolis Royal, Nova Scotia.

### *Research Opportunities*

- What management agreements might be instituted with Canada to ensure protection of northern New England coastal areas should drilling commence on the Canadian waters of the recently-settled boundary dispute?
- Projects which investigate or explore discrete components of the impacts of the Bay of Fundy Tidal Power Project on the New England coastline are considered important.
- New techniques for determining the geotechnical properties of offshore sediments is a key issue in the development of offshore structures of all types. Of particular interest is the development of techniques for the *in situ* determination of the sediment properties.
- Activities should be coordinated with the newly-developed industry response centers.
- Development of credible physical transport/dispersal predictive models for the Gulf of Maine and nearshore areas, for use as a basis for oil spill contingency planning.
- Develop, in consort with the National Sea Grant Network, answers to environmental questions related to oil spills. Generally stated, these questions boil down to: What is the history of impact/recvovery for various components of the biota? How do these interact or integrate with one another, and what are their short-term and cumulative long-term effects?

### *Extension/Education Opportunities*

- Contributing technical expertise toward the development of an oil spill contingency plan for the Gulf of Maine.
- Improving public understanding of the environmental costs of energy use and development, and of the short and long-term trade-offs

between different energy sources.

### Dredging

#### *Background*

Dredging includes maintenance of inlets and channels for passage of deep draft vessels, maintenance of minimum depth in harbors and anchorages, and for the creation of new harbors, inlets, and waterways. Sediment types vary widely from mud, silt, and clay in low current areas to sand and gravel in high energy areas. Because of this diversity of sediment type as well as environments, research regarding dredging will require a wide range of research areas to carry out the needed assessment.

As recreational boating and commercial fishing demands increase and existing and proposed cargo ports attempt to attract new business, the need for dredging to maintain or improve navigability becomes more pressing. In many harbors, the lack of dredging is clearly the limiting factor on expansion and economic development. Yet financial considerations, as well as environmental impacts, are not easily-resolvable problems. Contaminated spoils, such as those found in Portland and Portsmouth Harbors, have slowed the dredging permit and planning processes and made identification of acceptable disposal sites very difficult.

In analyzing dredging, we must look at the physical and environmental aspects. The physical aspects relate to changes in wave climate and resulting changes in the sediment transport patterns. The latter lead in many cases to the need for continuing maintenance dredging. The environmental aspects are related to topics covered in the Pollution section, which indicates the need for coordination between pollution and dredging research.

It is obvious, however, that there is increasing public concern about the long-term fate of dredge spoils which contains hazardous materials. It is not at all clear that such spoils will stay where they have been dumped; a highly significant but unknown migration of these spoils may take place during the dumping operation and even after the dump has been capped. Existing techniques for long-term monitoring of such dumps are extremely crude and must be developed further.

#### *Research Opportunities*

- Where, when, and how might dredge spoils best be dumped to minimize both environmental impact and cost?
- In what ways and to what extent do spoil nature, currents, wave effects, and erosion determine the distribution of spoil materials within the water column?
- Can clean, sandy dredge spoils be used for beach nourishment? Is there such a thing as clean sandy dredge spoils?
- What can be done to trace dredge spoils to quantify sediment transport rates and processing? Is it possible to create a "secure" dredge spoil?
- Can models be implemented and verified which predict sediment transport? Such models of "bedload transport" would be of use for harbors, navigation channels, bays, and inlets. Of related interest is the prediction of transport of suspended matter.
- How can the impacts of harbor/channel dredging be minimized to accommodate both environmental and industrial (i.e., boating, fishing, shipping) concerns?

#### *Extension/Education Opportunities*

- Developing informational material which summarizes our current understanding of dredging operations and technology and the associated environmental risks.
- Provide technical assistance in the design and implementation of monitoring projects to assess the short and long-term status of both dredge sites and dredged spoils.
- Develop mechanisms to foster effective communication and resolve conflicts between the interest groups impacted by dredging and spoil dumping.

## Marine Pollution

#### *Background*

If one steps back and looks at marine pollution in all of its aspects, the breadth and significance of the issues involved are great indeed. Nearly all of us are polluters. Furthermore, the impacts of pollution will touch nearly every aspect of the marine enterprise—from capture and cultured fisheries, through coastal planning and development, to recreation and tourism. The sources of marine pollution are multiple and diverse, and their delivery routes to the marine environment are many. The mechanisms by which pollutants are distributed and altered within the marine environment are also diverse and complex, as are the effects they have on that environment. The appreciation and understanding of their complexity by public and private concerns alike is growing rapidly.

Electronic and print media carried seemingly endless reports of wastes washing up on the Atlantic seaboard during the summers of 1987 and 1988. Recent catastrophic oil spills (e.g., 10 million gallons from the *Exxon Valdez* in March, 1989), the increasing burden of persistent marine debris, and mysterious deaths among marine mammals (e.g., mass mortalities among bottlenose dolphins inhabiting the southern and middle Atlantic coast of the United States and seals living in the North and Baltic Seas) have further captured public attention.

In addition, part of the 1988 presidential campaign focused on marine pollution issues. Several pollution-related bills were considered by the 100th Congress, and the 101st Congress promises to consider and pass even more. Clearly, widespread public awareness and political action are coming to bear on marine pollution. Solutions to this critical issue will require the Sea Grant approach: emphasis on marine research, advisory services, and education.

**Point source pollution.** It is convenient, for many reasons, to divide sources of pollution entering a body of water into *point* and *nonpoint* sources. Point sources occur at discrete points along shorelines, usually through pipeline discharges and direct dumping. Pipeline discharges to estuaries and coastal waters in the United States were recently estimated by the Office of Technology Assessment (OTA, 1987) to number almost 2,000, with most (96%) being located in estuaries. OTA further identified most dischargers as major industries (>66%), and the total volume discharged was conservatively estimated at 6.44 trillion gallons per year. Of direct interest to New England was the observation by OTA that 43% of the discharges were concentrated in the northern Atlantic region of the United States (OTA, 1987).

There are approximately 15,500 publicly owned treatment works (POTWs) in the United States, and according to OTA (1987) only 578 of them discharge directly into estuaries and coastal waters. However, these 578 POTWs account for one-fourth of the nation's wastewater, and 509 of them discharge into estuaries. Stated another way, of the 2.3 trillion gallons of municipal wastewater released to marine waters each year in the Untied States, 2 trillion gallons go into estuaries and 0.3 trillion into coastal waters.

At the local level, both Maine and New Hampshire have their own point source problems, most notably, the Great Bay Estuary and Casco Bay. In both systems, as well as in other areas of our northern New England coastline, there are many reports of toxic metals in sediments, shoreline hazardous waste sites, closed shellfish beds, diseased fish and shellfish, and coliform counts that preclude contact recreation.

**Nonpoint source pollution.** Nonpoint sources are diffuse, often ill-defined, if not unknown, inputs to estuaries, rivers, and coastal waters. Pollution sources categorized as nonpoint include surface runoff, rainfall or rainout, atmospheric fallout or deposition, underground transport, and leaching of materials to the water body. There are no good estimates of the contributions made by nonpoint sources to coastal areas, especially quantitative estimates. However, available data do permit some generalizations regarding nonpoint pollution.

*Surface runoff* contributes materials that are deposited on surfaces associated with cities, suburban areas, farmland, forests, wetlands, and industry; materials are subsequently removed from those surfaces by rainfall. Included are contributions from both generalized runoff and two specific point sources: streams and CSOs. Streams receive generalized runoff from upland areas and convey materials to estuaries and the coastal oceans. CSOs are those sewer interceptors that receive both wastewater and storm water and, because of inadequate capacity of the POTW to handle the increased volume due to storm water, divert the wastewater-storm water mixture directly to a receiving body of water without treatment. In general, surface runoff was implicated by OTA (1987) as a major source of fecal coliforms, suspended solids, and nutrients to coastal waters, including estuaries.

*Underground transport* includes both aquifers and septic systems that have contact with the upper water table that, in turn, connects with the coastal ocean. In some cases, the ground becomes so saturated with water that septic systems fail, wastewater breaks to the surface, and the surfaced material enters as surface runoff. Such overt failures play only a minor role in marine pollution and are repaired quickly, since they are often offensive to the property owner and adjacent residents. Of greater concern is the existence of "overflow" pipes connected to the leaching component of septic systems so as to prevent failure and subsequent surface break out. Overflow pipes were often designed to empty directly into a major body of water or, in some cases, a connecting ditch or stream. In the past, overflow pipes were quite common, and no doubt many exist in northern New England.

In a recent report, the U.S. Environmental Protection Agency (EPA) singled out nonpoint sources as the most important contributor of damaging pollutants in 48% of the cases where estuaries failed to support the key uses of fishing, swimming, and propagation of marine life (EPA,1984). The EPA (1984) further estimated that in all regions except the Northeast, nonpoint sources were more important than point sources.

**Sources and fate of pathogens.** Pathogenic microorganisms are associated with many waste materials, including domestic wastewater, industrial and hospital wastewater, wastes associated with wildlife, and wastes associated with boats and ships. Many of these pathogens are capable of survival and growth in aquatic habitats, including estuaries and the coastal ocean. Clearly, survival does occur for much longer periods of time than previously thought, and this extended survival has significant implications for marine pollution.

In addition to survival, fate also deals with habitat partitioning. Pathogens may reside in the water column, at air-water and solid-water interfaces, in estuarine and marine animals (e.g., oysters), and in the sediment. In general, the greatest concentrations of pathogenic microorganisms exist in animals, at interfaces, and in sediment. It will be necessary to develop more rapid and direct methods of pathogen detection and to improve methods of sewage treatment and disinfection.

**Toxic blooms.** Toxic blooms are also becoming more and more problematic for New England. Pollution seems to be related to the increasing frequency of blooms, and this has caused further burden on the fishing industry. It will be necessary to elucidate the ecology of toxin-forming microorganisms, develop more rapid and sensitive means of detection, and examine means for toxin removal and/or neutralization in fish and shellfish.

**Persistent marine debris.** Marine debris, primarily plastics, derive from both land-based and ocean sources. Land-based materials include styrofoam cups, trash bags, six-pack yokes, tampon applicators, milk jugs, balloons, strapping, suntan bottles, and similar items. Ocean sources of debris include fish nets (gill and trawl), line, floats, garbage bags, plastic traps, and other items used by fishermen, recreational boaters, merchant vessels, military and research vessels, and offshore structures (e.g., oil platforms).

The single most important thing that can be done to remedy this international crisis is to educate users of potential items of debris. Solid waste needs to be properly disposed of, newpackaging needs to be developed, clean-up monitoring needs to be encouraged and facilitated, and laws related to marine debris need to be vigorously implemented and enforced. Of great help will be the Marine Plastic Pollution Research and Control Act requiring that public vessels stop ocean disposal of plastics by 1993. The U.S. Navy alone dumps an estimated four tons of plastics into the oceans each day. Again, the Sea Grant approach can make a difference in this aspect of marine pollution.

**Discharges from marine craft.** There are tens of thousands of slips and moorings in northern New England, concomitantly providing contributions to the economy and marine pollution. There is considerable potential for contamination of estuaries and the coastal ocean with marine sanitary wastes. However, because of the intermittent and often covert nature of this type of disposal, the overall impact is difficult to assess. Clearly, research, education, and advisory activity is needed to fully understand and eliminate discharges from marine craft.

**Prevention of biofouling.** Organotin and copper-based protective coatings have come under close scrutiny in recent years. Tributyltin has been banned from use in small craft in Europe and the U.S. EPA has limited the release rate of tributyltin to 4 micrograms per square centimeter per day. Better solutions to biofouling prevention are clearly required, and this type of research should be greatly encouraged.

**Ocean disposal of wastes.** The oceans of the world have long provided a convenient medium of disposal for many types of wastes. While this has alleviated the burden of disposal on land, it has created problems in the ocean. Consequently, many types of wastes are now banned from ocean disposal (or soon will be banned), including plastics, toxic chemicals, sewage sludge, and radionuclides. Dredge spoil is still disposed of in the coastal ocean, although it too has come under closer scrutiny. Because wastes will continue to increase, both in terms of complexity and volume, the oceans should be examined as an alternate medium for disposal. Both risk assessment and risk management must be addressed, keeping in mind that we must eventually accept the concept of acceptable risk.

**Biotechnology.** Biotechnology has application to marine pollution problems in at least two different ways. *First*, more sophisticated means of pollution detection are possible with biotechnology, e.g., gene probe detection of human pathogens in recreational water. *Second*, pollution abatement may be possible by means of biotechnology, e.g., enhancement of xenobiotic biodegradation by releasing genetically engineered microorganisms (GEMs) at polluted sites.

This aspect of biotechnology has met with varying degrees of success, ranging from some extremely promising and marketable gene probes for pathogen detection to repeated failures of GEMs to rapidly and completely decompose xenobiotics in the laboratory. It is clear that more research and development must be applied to this application of marine biotechnology, and several possibilities exist for Sea Grant support.

***Research Opportunities***

- Better methods for detecting paralytic shellfish toxin (PST) and other marine toxins associated with toxic blooms are needed. There are several promising avenues for research, including antibody-based methodologies.
- Improved knowledge of the ecology of toxic organisms and understanding the causes of toxic blooms with the ultimate goal of minimizing their impact.
- Safe, effective methods for eliminating toxins from fish and shellfish without destroying the product are needed. Enzymatic remediation should be investigated.
- Better methods of monitoring recreational waters, shellfish, and shellfish harvest areas for human pathogens are needed. Further reliance on and development of indicator species are specifically discouraged; instead, potential investigators are encouraged to develop accurate and rapid methods for direct detection of pathogens, especially methods that can be automated.
- Immobilized enzyme systems capable of hydrolyzing or otherwise neutralizing xenobiotics of specific concern to northern New England are needed.
- The use of unmanned submersible vehicles to survey sites would be helpful. Collection systems for sampling water containing toxic chemicals and/or pathogenic microorganisms could be devised, including systems that would employ marine biotechnology.
- Further studies on the development and release of genetically-engineered microorganisms specifically adapted to estuarine and marine habitats are needed. However, these kinds of studies can be very cost-intensive, and therefore potential investigators are encouraged to submit proposals that will develop ideas and methods for further support by other funding agencies.
- Alternative wastewater treatment technology for island dwellings is needed. Consideration should be given to freshwater scarcity, possible lack of soil suitable for percolation of septage, adjacent shellfish beds, and system efficacy.
- On-vessel wastewater treatment systems and/or improved holding tanks are needed. Also needed is improved collection of marine vessel wastes and monitoring of illegal overboard discharge of wastes.
- Can guidelines be established to determine whether new marina complexes should be concentrated or spread out to minimize impact in the coastal environment? Do contaminants associated with boating activity (i.e., waste oil, bottom paints) represent significant threats to the marine environment?
- Methods for comparing risks associated with waste disposal in different media (i.e., air, water, land) must be improved. All aspects of ocean-based and land-based disposal options must be examined.
- Can wastes, including hazardous wastes, be treated or otherwise stabilized to make them safe for ocean disposal? Can methods of ocean disposal of wastes be improved? For example, are long ocean outfalls really better? Can better barges be built, barges that will more effectively dilute and disperse wastes? Can useful scientific and economic guidelines for the selection of waste disposal sites and for alternatives be developed?
- What is the fate of human pathogens, especially viruses and bacteria, in the ocean? How does the dormancy phenomenon affect survival and detection of pathogens? Are pathogens building up in marine sediments? What is the most efficacious means of wastewater disinfection? Do pathogens settle, meander with rings and gyres, aerosolize, or partition onto floatables and other

types of marine debris? Can decay rates be applied to living organisms capable of entering a state of dormancy?

• Are the present assumptions used in existing models for impact assessment of waste disposal on the marine environment valid?

• Because of advancing computer technology, can coastal hydrodynamic and contaminant transport models be made more effective? Can we coordinate model use and development with data archiving?

• What are better ways to dispose dredged materials at sea? Do dredged materials present risks? Should dredged materials be "capped" so as to prevent long-term movement? What is the most effective way of monitoring dredging operations and spoil movement?

• Can environmentally acceptable inhibitors be developed for use as antifouling agents? Can such materials be incorporated into marine paints in such a way as to deliver a sustained release of inhibitor over long periods of time? Can a single marine paint be developed to inhibit a wide variety of micro- and macrofouling marine organisms?

• Bioassay methods, ranging from determination of acute toxicity to evaluation of long-term or chronic toxicity, need to be refined. Particular attention should be given to development of site-specific assays.

• Synergistic pollution should be investigated. For example, does a sub-lethal burden of toxic chemical (e.g., PCB, chromium, mercury) or toxin (e.g., brevitoxin) make marine animals more susceptible to disease? Are immune systems impaired or inactivated by toxics? Can toxic chemicals stimulate growth of pathogens and simultaneously compromise a host for that pathogen?

• What are the primary sources and delivery mechanisms of the major pollutants to the Gulf of Maine system? How does this loading vary geographically and over time?

• How and to what extent do physical mixing and transport processes control the distribution and fluxes of pollutants to and within the marine environment?

• How, with what time constraints, and to what extent do marine chemical processes modify the character of pollutants and affect their impact, residence time, and distribution?

• Quantitatively, how do biological and ecological processes affect the sequestration and flow of pollutants through the marine food web; and, conversely, what are the effects of these pollutants at the organismal, community, and system levels?

***Extension/Education Opportunities***

• Educating the public about the impact of personal and community behavior on the water quality of their region (groundwater, surface waters, and coastal waterways) is a high priority.

• Programs need to focus the attention of the marine community and the general public on issues and potential solutions related to marine debris and plastics pollution.

• The public needs to be made aware of the reasons for closure of area shellfish beds to commercial/recreational harvesting. Similarly, information on water quality in swimming areas should be made available.

• Involving citizens and school groups in coastal water quality monitoring projects is encouraged to increase awareness of problems and build a credible data base.

• Programs focusing on the ability of the states and communities to respond to emergency pollution events, such as oil spills, hazardous waste dumping, and medical debris, are considered high priority.

• Special attention should be given to rapid development of extension materials which summarize results of important pollution-related research as soon as they become available.

• Levels and types of pollutants found in swimming areas, shellfish beds, and fish caught for personal consumption are major concerns to the public. Programs dealing with the sources, levels, potential impacts, and health risks of these pollutants are encouraged, and identification of the process used to test for pollution levels is also important.

# Alternative Uses of Coastal Resources

The coastal environment of Maine and New Hampshire faces unprecedented demands for a wide variety of uses. Some of these alternative uses are consistent with one another; while many others are not. Although most of the shoreline is in private hands, the public sector continues to have a major influence on which uses will be permitted. The public sector has this influence because of its sovereignty over submerged lands and its obligations for land use planning and environmental protection.

At least six primary and relatively distinct uses of the coastal resources can be readily identified in northern New England:

1. transient tourist activities, including sight-seeing, hotel, restaurant, and retail trade;
2. recreation, including boating, sailing, sportfishing, and swimming;
3. primary residential and vacation homes;
4. traditional marine industries and related activities, including harvesting and aquaculture, fish processing, shipping, and shipbuilding;
5. industrial uses, including manufacturing facilities, energy production, extractive activities; and
6. areas targeted for environmental protection, whether through preserves or restricted uses.

For some of these uses, the environmental and socioeconomic impacts related to development are obvious. But for others, the impacts, especially the cumulative impacts, are more difficult to gauge. The extent to which alternative uses are compatible or incompatible is often not understood.

Both Maine and New Hampshire have state coastal programs that provide assistance to local communities in dealing with growth and conflict. While local New Hampshire coastal communities are not required by law to participate, Maine has established a timetable under which all towns must develop land use plans and enact implementing ordinances by 1993. This law has been a major impetus for interest in planning in Maine. However, there is a growing awareness that planning is not in itself a panacea. Rather, the quality of a plan is crucial.

The art of planning is not perfectly understood, and well-meaning plans may have unintended effects. For example, the use of minimum lot and minimum road frontages for residential development plans generally has the perverse effect of encouraging "strip development" that is generally unwanted. Alternative plans, which permit denser residential development but include permanent underdeveloped buffers, may be more effective in maintaining a rural ambiance and preventing environmental destruction.

When planning is concerned with marine resources, a neat line cannot be drawn one hundred feet, or a quarter of a mile, or ten miles back from the coast. Rather, land use decisions back from the immediate coast often impact directly or indirectly upon the coastal resources. Design of highways or other infrastructures are good examples. Research on planning itself is very important to the protection of coastal resources, because planning will be a major tool for such protection.

The environmental impact of coastal development is obviously a major issue and is generally addressed in the pollution section of this plan. However, cumulative impacts of growth, as well as aesthetic impacts, are of equal interest to coastal communities. The concept of cumulative impacts on coastal resources has only recently been raised, and it has not traditionally entered into the planning process, either at the state or local levels. But to help apply this concept, more scientific information on carrying capacities is needed.

Even with the best planning activities, however, the alternative pressures for use of coastal resources will inevitably create conflicts over resource use. These conflicts will be resolved in a variety of arenas, including the courts and quasi-judicial bodies, legislative bodies, and executive agencies at every level of government. We need to understand not only the conflicts that arise but also how to assign the responsibility for conflict resolution among the various institutions. These conflicts over marine resource use present an exceptionally broad range of research and educational issues. Although Sea Grant is interested in virtually the entire range of issues related to use conflicts, two have particular interest:

- **access**
- **conflict resolution**

### Access

#### *Background*

The traditional marine industries of Maine and New Hampshire, which include fishing and fish processing, shipping, boat-building and repair, marinas, and marine-related manufacturing, face increasing competition for waterfront space and access to marine resources. These industries have helped define the unique character of the coast of Maine and New Hampshire. If these industries are driven by economic forces from much of the coast, the change in the character of the coast will have far-reaching impacts. Legislative action on coastal planning makes it clear that the public wants to preserve these coastal activities.

The pressures that move traditional industries off the coast are obvious: land prices on the coast are being pushed up by demands from alternative users, primarily for residential and recreational uses. Recreational boaters compete for mooring space, especially in the summer. Access to clam flats is sometimes restricted by the sale of waterfront properties.

In other parts of the country, recreational fishing or laws designed to protect recreational species have restricted commercial fishermen. This is at least a minor issue for salmon in Maine at present. Fish processing activities are increasingly seen as undesirable neighbors by residential owners. For example, all fish reduction firms in Maine have been closed, due in part to concerns over odors. In addition, summer traffic often limits access to some docks and piers.

The ports and harbors of Maine and New Hampshire face particularly critical access issues. In the past decade boating traffic has doubled, boat mooring space has become scarce, and there has been a significant increase in onshore demands placed upon the scarce resources within these harbors. The choice is whether to plan for growth or to let external factors determine the direction and degree of growth. The very real possibility that burgeoning growth will change the character of the ports and harbors is a persuasive argument for local decision-makers to take a more pro-active route.

Aquaculture has also produced a variety of conflicts. Maine's aquaculture siting law does give clear precedence to existing fisheries. In addition to direct competition for habitat, aquaculturists also must deal with access issues related to navigation, opposition by riparian owners, and general concerns by fishermen that their activities will reduce commercial markets.

### *Research Opportunities*

- What are the present and future sources of competition for coastal access?
- Where are there synergistic opportunities for cooperation? For example, recreational boaters may help support boat service industries that are important to commercial fishermen.
- How do we document or quantify the intangible contributions of traditional industries?
- What kinds of planning and management activities are most effective in preserving access to traditional uses and creating opportunities for non-traditional uses?
- How can zoning, public ownership of docks and rights-of-way, development moratoria, subsidies or tax advantages, and restrictive covenants be used to balance the access needs of both traditional and non-traditional uses? Many different approaches have already been applied along the coast, so evaluative studies may be an effective approach.
- Can meaningful, scientifically-based siting guidelines be developed for northern New England's rapidly expanding salmon aquaculture industry?

### *Extension/Education Opportunities*

- Increased awareness should be provided on public policy issues affecting access such as incremental growth and development along the coast; legal issues relating to submerged lands; "upland" soil erosion impact on local harbors; and public rights to the shore.
- Educational programs which seek to engage groups requiring coastal access in productive dialogue are encouraged.

## Conflict Resolution

### *Background*

Growth along the northern New England coastal corridor has continued at a substantial rate over the past decade. Along with this growth has come major new development and an increased demand for space and services in our coastal zone. For example, nearly all marinas are at capacity, moorage space is virtually impossible to find in New Hampshire and the southern half of Maine, and harbors are overcrowded with a variety of users, including pleasure boaters, sightseeing boats, jet-skiers, wind-surfers, and a myriad of other commercial and industrial users.

Despite soaring property values and a slowdown in the region's economy, the steady influx of both new residents and tourists is expected to continue through the 1990's. Less desireable land in the populated coastal areas and pristine sites in sparsely populated downeast Maine are expected to receive the heaviest development pressures.

While many coastal communities have historically welcomed most forms of development, the pendulum has started to reverse. There are numerous examples of tourism and recreational facilities and commercial and residential development out-competing other legitimate and traditional New England coastal zone uses. Shellfish harvesting areas, beach access, and commercial fishing dockage have been particularly vulnerable. Communities have recognized that this type of waterfront evolution is not only potentially damaging to their marine resources but that the traditional character of their coastal towns is also being threatened. Thus, we can anticipate a continued and more vigorous opposition to coastal development if it appears to pose a threat to traditional users or sensitive coastal environments.

A primary problem facing port managers is determining the criteria they should use in deciding types of non-marine uses for port lands. A port's legislative mandate may specify uses or limit port activities. Where legislation is broad and allows choices among many uses, the port manager must consider the potential for revenue, the potential for jobs the use may create, how compatible the use may be with other uses, and whether the service is already being provided.

As competition for limited coastal resources intensifies, managers and decision-makers are increasingly seeking information which can be used to effectively predict the future impacts of specific types of development. They are concerned about such things as employment patterns, economic impacts, social trends, land values, taxes, and aesthetics, as well as environmental impacts.

The measurement of the economic and social benefits derived from alternative uses of coastal resources is deemed appropriate and useful. Development of conceptual models, empirical methods, or alternative valuation techniques continues to be a priority line of research. However, projects aimed solely at providing a descriptive picture, inventory, or baseline economic data are not encouraged.

Sea Grant's role here should be to more accurately determine potential impacts of coastal development and facilitate resolution of user conflicts where possible.

***Research Opportunities***

- Are acceptable and effective mitigation options available to coastal zone developers?
- Which areas of the coast, not presently being utilized, can we expect to be developed in the future? An examination of the process by which state and local officials develop policies and management guidelines, which influence the present and future distribution of new development projects, is another area for fruitful investigation.
- Can the impacts of past planning activities be assessed? What are the most appropriate planning techniques which states and communities could utilize to help insure orderly growth?
- Are there alternative techniques available to help resolve resource conflicts? How would they most effectively function?
- Is water surface zoning a viable option for resolving coastal zone user conflicts or ensuring safety for varied users?
- What sort of policies, user fee structure, or tax mechanism could be implemented to encourage marina and other water dependent users to remain on the waterfront?
- How will the demand for specific alternative uses grow in the future? How do these uses interact?
- What type of framework is required to accurately describe the types of impacts which various uses are having on coastal resources? Social, (e.g., amount of use, type of use, use conflicts) as well as environmental data, are needed for a variety of different user groups to provide descriptive baseline information.
- Can impacts be identified and evaluated using a systems approach?
- Are there technical, legal, or socioeconomic changes needed to control, broaden opportunities for, or remove barriers to future coastal development.

***Extension/Education Opportunities***

- As the topic of submerged lands lease fees becomes more discussed, local/state officials and users need to be informed of options, policies, model programs, and other data concerning this subject.
- To better identify and help resolve specific use conflict concerns related to coastal development, a regional forum or conference is suggested.
- Community and state officials require information on planning techniques for managing the multiple uses competing for limited shorefront space. Are water dependent use regulations being effectively utilized in other regions?
- What kinds of programs can be developed to increase citizen involvement in the community planning process?
- Exploration of expanded or new public/private initiatives focused on efforts to blend open space preservation with responsible and environmentally-sound development appears to be a fruitful area.

- Efforts are needed to help communities deal with the inconsistency of various coastal regulations derived from the lack of strong state involvement or control.
- Studies which examine the concept of marine resource carrying capacities (particularly as they relate to development potential) should be highlighted and made available to appropriate state/local officials.
- Infrastructure dealing with coastal development issues within both states is complex and often confusing. Programs which seek to facilitate the orderly flow of information and enhance effective decision-making through cooperation and coordination are encouraged.