UNIVERSITY OF Delaware Sea Grant College Program

Sea Grant

Strategic Plan 2000 – 2005

TABLE OF CONTENTS

UNIVERSITY OF DELAWARE

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INTRODUCTION

In 1966, the United States Congress created the National Sea Grant College Program to promote the wise use, conservation, and development of the nation's marine and Great Lake resources. Two years later, the University of Delaware received its first Sea Grant project award — for mariculture research — and soon began expanding into other areas of marine resource development, conservation, and education. In 1976, the National Sea Grant College Program designated the University of Delaware the nation's ninth Sea Grant College, acknowledging Delaware's excellence in a broad program of research, education, and outreach built upon a strong foundation of statewide support.

Today, the University of Delaware Sea Grant College Program continues to emphasize research aimed at developing new products from marine resources, research that will enhance and conserve our coastal environment and promote sustainability, and research that will help solve pressing problems facing our oceans and coasts. We continue to provide graduate students with multidisciplinary education and hands-on practical experience in the field and laboratory that will contribute to their success as skilled marine scientists and educators. Our outreach program continues to serve the citizens of Delaware, from business owners and resource managers to school teachers, through one-on-one consultation, demonstration projects, workshops, publications, and electronic media. Increasingly, our outreach program is crossing state boundaries to join with other Sea Grant programs to address regional and national concerns.

Vision 2000 – 2005

What course should the University of Delaware Sea Grant College Program be charting for the beginning of the new century? What does the future hold for our marine resources, and what role will we play in developing and conserving those resources for the benefit of the environment and humankind? This strategic plan highlights the marine issues we believe will be most critical to our state, region, and nation in the next five years.

In addition to seeking the wisdom and advice of our 39-member Sea Grant Advisory Council to develop this vision of the future, we have consulted with a host of representatives from academia, industry, and the general public. We have also factored in the guidance provided by the *National Sea Grant College Program Strategic Plan.* The input from all these sources has been invaluable in developing our long-range plan. We believe this document, the result of a coordinated planning process, provides a legitimate framework upon which our program can operate in the next five years. We realize, however, that this is a "living" document, and as such, will need constant revision as new events affecting our marine and coastal resources occur, as our knowledge of important issues changes, and as our program's ability to address marine users' needs continues to develop.

Our Mission: **To participate as a strong member of a national network of universities in the promotion, understanding, development, use, and conservation of marine and coastal resources.** Central to the accomplishment of this mission is the need to foster partnerships in which the academic, public, and private sectors pool their human and financial resources to address the National Sea Grant College Program's priority issues of economic leadership, coastal ecosystem health and public safety, and human resource development.

Our Vision: **To enhance the strength, sphere of influence, and effectiveness of UD Sea Grant through the building of *true working partnerships.*** These partnerships can take many forms, including regional collaborations with other Mid-Atlantic Sea Grant programs, joint research with industry, and co-sponsorship of research and outreach with other federal and state agencies. The marine and coastal challenges facing us are far too great

for any single entity to resolve. Sea Grant provides a constant foundation of support that can be leveraged by forming vested partnerships. The interaction among the members of the partnership enhances the knowledge and wisdom of each, while resulting in a better response to real marine and coastal problems and opportunities.

THE PLANNING ENVIRONMENT: DELAWARE, "THE DIAMOND STATE"

Delaware, located on the eastern seaboard of the United States, is bordered by the Atlantic Ocean and the Delaware Bay, as well as the states of New Jersey, Pennsylvania, and Maryland. At the heart of the Mid-Atlantic seaboard, Delaware is halfway between Washington, DC, and New York City. A circle of 200 miles' radius centered at Cape Henlopen, Delaware, encompasses approximately 45 million people, about 20% of the nation's population. This high population density often results in serious pressure on and competing demands for marine and coastal resources.

The Citizenry

Often referred to as the "Diamond State" due to its small size but wealth of resources, Delaware has a land area of 1,982 square miles and a population of approximately 731,200 people. Only 12.6% of the state's residents are age 65 or over, while 25% are younger than 18. While the state ranks forty-ninth among the 50 states in land area, only five states are more densely populated than Delaware. According to the *1998 Population Projection Series*, Delaware's population is expected to grow by almost 17% — to nearly 854,000 persons — between now and the year 2020. The projected growth for each of the state's three counties is found in Table 1.

The Delaware Population Consortium sees continued in-migration of working-age persons to Delaware due to the state's strong economy and employment growth. Of particular note is the projected growth in Sussex County, the state's southernmost county. The 34.9% projected population increase is due to growth in employment opportunities throughout the county and to the rise in the number of commuters living in Sussex County and working in the surrounding region. Sussex County is replete with waterfront properties and water-based recreation, making it an attractive place to live.

Delawareans are generally well-paid, with the average annual salary of $29,120 ranking as tenth highest in the nation. The state's median household income of almost $35,000 is just above the national average. One economic negative is the state income tax. Delawareans keep only 85% of their income after taxes, a percentage which is among the lowest in the country. The typical house is worth $100,100 in Delaware, the tenth highest in the country. Delaware ranks sixth in money spent per pupil in school and twelfth in average teacher salaries. However, students performed below the national average in fourth-grade reading and have a lower high-school graduation rate than the national average. Perhaps this situation explains why Delaware also has the highest percentage of elementary and secondary school students in the country in private schools.

Table 1. Projected Delaware Population Growth, 1997 – 2020

	1997	2020	% Change
State of Delaware	731,210	853,982	16.8
Kent County	122,673	143,777	17.2
New Castle County	474,250	529,008	11.5
Sussex County	134,287	181,197	34.9

Source: Delaware Population Consortium.

How is Delaware as a place to live? There are a few other statistics that point to some major challenges for its residents. For example, for recreation, residents have less than 1% of the state in a park system (ranking it twenty-eighth), while **more than 87% of waterways are polluted (ranking it fifth).**

The Economy

In December 1997, *Financial World* magazine ranked Delaware as the number-two state in the nation in which to locate a business. (Texas ranked number one in the survey.) Delaware outpaced neighboring states by leaps and bounds. The next-best state in the region — New Jersey — placed 35th, while Maryland ranked 36th, and Pennsylvania 48th. According to the article, "Despite being surrounded by states with enormous costs, Delaware has been able to keep down its own while its economy has grown 5% annually over the past five years. Its energy costs are 5% below the national average and way below the rates in the north."

Other economic statistics noted in the article include the following:

- Delaware's unemployment rate currently stands at 3.6%, far below the national average.
- A survey of top executives by *CFO* magazine revealed Delaware to be the top state in the nation in which to locate or expand based on tax policy.
- Delaware ranks fifth in the nation in new job creation, with more than 50,000 jobs created in the past five years.

- In the past year, Delaware's financial services industry has grown at a faster percentage than in any other state in America.
- In 1997, Delaware ranked third behind Florida and New York in the establishment of new business incorporations.

It is no surprise that in a business-friendly state, the costs of doing business are low. Delaware companies spent only an average of $1,822 in health care payments for employees and their families, more than $700 less than the national average. In addition, only 4.8% of a payroll was spent on workers compensation insurance, although the average benefits paid in Delaware were higher than the national average.

Dominated by the chemical and automotive industries, manufacturing is the largest source of state income and the third largest employer; closely following are services and trade. Financial services and tourism continue to be important factors in the state's economy. The state's major tourist attractions include unique historic sites and museums, ocean beaches, and bay shoreline.

Agriculture plays a vital part in the state economy, with poultry accounting for over two-thirds of agricultural receipts. In 1997, Delaware ranked eighth in the United States in the number of chickens raised: 263 million. Soybeans and dairy products are also primary farm products, and one-half of the state's land acreage is used for farming.

Since 1985, a total of 83,200 net new jobs have been created in the Delaware economy, a 28% increase. The state's labor force has kept pace with this growing job market by expanding faster than the national average over the same period. The state boasts not only labor quantity but quality, as evidenced by the latest survey by the National Science Foundation, which illustrates that Delaware has more scientists and engineers per capita than any other state in the nation.

The Coastal Zone

Delaware has a rich coastal environment, with more than 260 miles of saltwater shoreline, including 24 miles of ocean coastline, about 90,000 acres of tidal wetlands, two major estuaries that have been the focus of National Estuary Programs — the Delaware Estuary and the Inland Bays, the busiest canal in the United States — the Chesapeake and Delaware Canal, and nationally acclaimed beaches spanning the 24-mile Atlantic oceanfront from Lewes to Fenwick Island. A more detailed description of the two major estuarine systems follows.

The **Delaware Bay** drainage area includes areas in Pennsylvania, New York, New Jersey, and Delaware. The bay itself is the boundary between the shorelines of Delaware and New Jersey. This estuary is classified not only as a drowned river valley, but also as a partially mixed and moderately stratified estuary. The salinity of surface waters increases from zero at Chester, Pennsylvania, to about 30 parts per thousand at the mouth of the estuary. Normally, the estuary is well-mixed by strong tidal currents. Suspended sediments in the Delaware Estuary range in size from sand grains to clay particles to colloidal materials. They are predominantly derived from shore and land erosion, and are carried in to the estuary by rivers.

The Delaware Bay receives heavy inputs of nutrients primarily from urban and industrial sources. The waters flowing between Burlington, New Jersey, and Wilmington, Delaware, have the highest concentrations of nitrogen of any major estuary in the United States. Approximately 50% of the inorganic nitrogen that enters the Delaware Estuary comes from input, and it has been estimated that 80% of the phosphate entering the estuary results from human activity.

Additionally, more than 100 species of finfish have been identified in the Delaware Estuary, which also boasts the world's largest population of horseshoe crabs and is internationally recognized for its importance as a stopover for migrating shorebirds. The estuary is also a major transportation corridor and home to the second largest oil port in the United States.

Delaware's Inland Bays are an example of coastal embayments and include three interconnected water bodies: Indian River Bay, Rehoboth Bay, and Little Assawoman Bay. These bays are the crown jewels of a beach recreational industry valued in excess of $250 million dollars annually. The Inland Bays have a drainage area of about 300 square miles, a water surface area of 32 square miles, a marsh area of 9 square miles, a mean low-water volume of 4 billion cubic feet, and a freshwater discharge of 300 cubic feet per second. Almost 30 square miles of the Inland Bays are classified as shellfish waters; 19 square miles are presently approved for shellfishing. There are about 126 people per square mile in the Inland Bays watershed, and the land is about 10% urban, 44% forested, and 46% agriculture. The Inland Bays are tidally flushed, with flushing estimates typically converging on 90–100 days for Indian River Bay and 80 days for Rehoboth Bay. No flushing estimates are available for Little Assawoman Bay.

The Inland Bays are suffering from plant nutrient enrichment (eutrophication) that causes unwanted phytoplankton blooms with resulting decline in light penetration and oxygen levels. These changes in environmental quality have led to eradication of submerged aquatic vegetation (sea grasses) and to declines in desirable finfish and shellfish. Major sources of these nutrients are land runoff from intensive agribusiness operations, intrusion of nutrient-contaminated groundwater from agricultural and domestic sources, and sewage treatment plant effluents.

Delaware's rich marine environment has contributed to the development of numerous marine-related industries and

a growing coastal population. For example, the population of Sussex County, Delaware's southernmost county, grew 40% over the last 10 years, and visitor traffic to the county's popular beach resorts during the summer months continues to grow. This rapid expansion required coastal communities to provide drinking water, sewage treatment, and other services, yet this development is occurring in a county that also produces more chickens per capita than anywhere else in the nation. This intensive form of agriculture contributes to nitrogen and phosphorus contamination of freshwater aquifers and eutrophication of water bodies such as the Inland Bays.

Since 1971 when the Coastal Zone Act went into effect, there has been an attempt to control the growth and pollution in Delaware's Coastal Zone. This law, which banned new heavy industry along the state's coast, was hailed internationally as a landmark in preventing pollution of rivers, coastlines, and marshes. The protected zone takes in marsh, wetlands, and adjoining property stretching from the Delaware River north of Wilmington to the state's Atlantic shoreline. The 273,442-acre zone contains 80% of the state's tidal wetlands, all its beaches, and most fish and shellfish spawning and nursery areas.

From the time the Coastal Zone Act went into effect, there has been pressure for state officials to write specific regulations for the law, or if not translated into a set of regulations, then repeal it. While the law banned *new industry*, existing plants or activities were allowed to remain, with provision for "expansion of extension" occurring through the permitting process. After 27 years, regulations have yet to be enacted. Regulators consider changes in plant operations for those industries existing in the coastal zone on a case-by-case basis. This practice has resulted in regular tensions between the Department of Natural Resources and Environmental Control and coastal industries. A set of draft regulations is currently under review and debate; public hearings have yet to be held.

THE UNIVERSITY OF DELAWARE SEA GRANT COLLEGE PROGRAM

The University of Delaware

As one of the oldest institutions of higher education in the United States, the University of Delaware combines tradition and innovation, offering students a rich heritage along with the latest in instructional and research technology. The University traces its origin to a small school in New London, Pennsylvania, opened in 1743 by the distinguished Colonial scholar, the Rev. Dr. Francis Alison. By 1765, the school had moved to Newark, Delaware, where it received a charter as the Academy of Newark from Thomas and Richard Penn in 1769. The State of Delaware chartered the school in 1833, and the institution was named Delaware College in 1843. A Women's College was opened in 1914, and in 1921, the two coordinate colleges were officially named the University of Delaware.

A private university with public support, the University of Delaware is a Land-Grant, Sea-Grant, Space-Grant and Urban-Grant institution. It is the oldest university in the state, and the largest, with an annual enrollment of more than 14,500 undergraduates and nearly 3,000 graduate students. As a state-assisted, privately controlled institution, the University seeks to enroll students from diverse backgrounds and a wide variety of geographic regions. Currently, 60% of all undergraduates are non-residents who represent nearly every state and several foreign countries. The Class of 1995 included the University's 100,000th graduate. There are more than 96,000 living University of Delaware alumni who reside in every state in the United States and more than 75 foreign countries.

In Fiscal Year 97, the University's operating budget was $388.4 million, and the endowment was valued at $662.8 million. In addition to the main campus in Newark in the northern part of the state, the University of Delaware operates campuses in Lewes, Georgetown, Dover, and Wilmington. A total of 432 facilities and land holdings of more than 2,551 acres comprise the physical plant.

The University has seven colleges: Agriculture and Natural Resources; Arts and Science; Business and Economics; Engineering; Health and Nursing Science; Human Resources, Education, and Policy; and Marine Studies. One is exclusively a graduate college — Marine Studies. Students may pursue degree programs in 114 undergraduate majors, 72 master's areas, and 38 doctoral fields.

The educational, research, and public service endeavors of the University are supported by administrators, faculty, and staff numbering 3,624. Other important educational assets include the University Library, which contains 2.3 million scholarly volumes and 2.9 million microforms. Additionally, the University was honored recently as a national model for its exemplary campus-wide technology network planning, management, and accessibility, as well as for its effective use of the network to enhance teaching, learning, and research.

The 32-member University of Delaware Board of Trustees is responsible for the institution's management. The board has four ex-officio members: the governor, the University president, the master of the State Grange, and the president of the State Board of Education. The governor appoints eight members, and the board elects by majority vote the remaining 20 members, one of whom is a recent University graduate.

For the past seven years, Dr. David Roselle, President of the University of Delaware, has committed to four main goals for his administration: (1) a more student-centered institution; (2) competitive compensation for all employees; (3) increased support for student scholarships; and (4) improved facilities to support the best possible living and learning environment. At the Board of Trustees meet-

ing in December 1997, President Roselle added a fifth priority to his list of goals; that is, to provide opportunities and instruction for all University of Delaware students that will motivate them to be lifelong learners. Said another way, there is a commitment to expand the institutional focus on discovery-based learning.

The Graduate College of Marine Studies and Sea Grant College Program

The Graduate College of Marine Studies is the administrative home of the University of Delaware Sea Grant College Program. The College was founded in 1970. However, marine research and educational activities actually began at the University of Delaware more than 40 years ago. In 1950, a group of local fishermen approached the Delaware General Assembly for help in determining why fisheries were declining in Delaware Bay. The fishermen believed the University could come to their aid. The 116th session of the General Assembly responded by allocating $30,000 to set up a marine biology program in the University's Department of Biological Sciences.

Over the years, interest in marine science grew throughout the University, but no program existed to unite the various pockets of marine research. The University received its first Sea Grant award, for oyster research, in 1968 — the same year Dr. E. A. Trabant took office as University President. Shortly thereafter, he appointed a study group charged with identifying steps to strengthen the University's marine capability. The resulting recommendation was to establish a graduate college of marine studies. On June 6, 1970, the University of Delaware Board of Trustees officially created the College of Marine Studies (CMS). Since then, CMS has enjoyed unprecedented growth, spanning campuses in Newark, where Robinson Hall serves as the college's administrative base, and in Lewes, where the Marine Studies Complex on the Hugh R. Sharp Campus provides students with easy access to Nature's classroom.

When the Board of Trustees approved formation of the college 28 years ago, they not only created an academic home for marine-oriented faculty and students, but they also assigned management of the University's Sea Grant Program to the new college. The Sea Grant Program at the University of Delaware actually preceded the formation of the college by two years, as the first project grant was received in 1968. In a sense, CMS and Sea Grant evolved together, complementing and benefiting each other over the years. The University of Delaware was the first in the country to start with a single project award and progress through various stages of maturation, finally achieving Sea Grant College status in 1976. Along the way, a partnership among the University, government, and private sector has been forged.

During the 30-plus years of Sea Grant's existence at the University of Delaware, the program's coordinated research and outreach activities have attracted an investment of $53.5 million ($29.5 million federal; $24 million match). This consistent financial base, especially in the early years, allowed the University to expand its marine-oriented talent pool. Today, there are 86 faculty members and research scientists engaged in marine research and teaching at the University of Delaware. Of these, 32 are core faculty, 4 are research-ladder scientists, and 4 are emeritus faculty directly affiliated with CMS; the others hold joint appointments to the college from other University departments or are adjunct appointees. Since the University was designated a Sea Grant College more than two decades ago, more than 350 students have been trained as marine scientists and are now working in both private and public sectors.

The faculty's research interests cover a broad spectrum, from molecular biology to marine policy. Research activity is fully integrated with graduate education. Over its 28-year history, CMS has awarded a total of 472 degrees at the magisterial and doctoral levels. CMS offers interdisciplinary degree programs in applied ocean science, marine biology-biochemistry, marine policy, and oceanography. Each student specializes in one area but is expected to gain a general understanding of other areas through required courses. In addition to being active participants in original research projects, CMS graduate students also regularly compete with other students across the nation for the National Sea Grant College Program's Knauss Marine Policy Fellowships. In 1998, two University of Delaware students were selected to be Sea Grant Fellows: Milen Dyoulgerov and Maria Honeycutt. A native of Bulgaria and now a Ph.D. student in marine policy, Dyoulgerov's chief ambition is to foster international cooperation in managing ocean resources. As a Sea Grant Fellow in NOAA's Office of International Programs, he'll gain valuable knowledge and experience toward that goal. Honeycutt, who recently completed her master's degree in oceanography at CMS, will work in the Mitigation Directorate of the Federal Emergency Management Agency, where she will focus on hurricane damage prevention and other coastal hazards issues.

The resources available to CMS students include specialized marine research centers and laboratories, an award-winning computer network, and the University of Delaware Library. Also, in 1993, a two-way interactive television (ITV) system was installed to link the Newark and Lewes campuses, enabling CMS students, faculty, and staff to easily attend lectures and meetings on site, significantly reducing the need for the 180-mile round-trip commute between the two campuses. The ITV system was such a success that a second pair of classrooms, one in Newark and the other in Lewes, are being connected through ITV.

Robinson Hall, the CMS administrative base on the Newark main campus, houses 40% of the college's faculty and students along with two research centers. The Center for Remote Sensing gathers and analyzes satellite data to

yield valuable information about oceanic properties and coastal resources, ranging from dispersion of oil slicks to global change in plant production. The Center for the Study of Marine Policy, the first of its kind to be established at an American university, conducts interdisciplinary policy research under grants, contracts, and gifts from public and private resources.

In 1993, CMS facilities in Newark were expanded significantly with completion of the Lammot du Pont Chemistry and Marine Studies Laboratory, which provides state-of-the-art, contamination-free, "clean-lab" facilities for marine biogeochemistry initiatives. Additional CMS marine biochemistry research is conducted in adjacent Brown Lab.

The 387-acre Hugh R. Sharp Campus in Lewes, 90 miles south of Newark on the shores of Delaware Bay, is home to four marine science laboratory buildings, the college's harbor, and research vessels. Cannon Laboratory, the largest of our facilities in southern Delaware, houses offices, classrooms, research and teaching labs, computer facilities, the Delaware Aquaculture Resource Center, and the CMS library. The building is equipped with a 40,000-liter recirculating seawater system and controlled-environment rooms used to hold organisms in individual aquaria.

Cannon Lab also includes the Joint Center for Research in the Management of Oceanic Data, whose scientists work closely with the National Ocean Data Center in Washington, DC, to archive the nation's oceans data; and the Marine Plant Biochemistry/Biophysics Research Laboratory, with four, walk-in, temperature- and humidity-controlled chambers for the study of the photosynthesis, growth, and metabolism of marine and terrestrial plants to improve plant survival and growth in drought conditions.

Thanks to private donations, a marine geochemistry laboratory was added to Cannon Lab during the summer of 1994, and two 20-foot, state-of-the-art laboratory vans were constructed. These portable vans may be attached to Lammot du Pont in Newark or Cannon Lab in Lewes, as well as to our research vessel *Cape Henlopen*, providing a unique advantage for CMS faculty and students conducting research at sea.

Otis H. Smith Laboratory is equipped with a recirculating seawater system and includes 10,000 square feet of greenhouse space for halophyte (salt-tolerant plant) research and a 14-foot-high water tunnel for the study of benthic creatures under realistic ocean wave and bottom conditions. Smith Lab also houses a shellfish hatchery, algal culture facilities, and various tanks for fisheries research.

Two smaller laboratories in Lewes contain specialized research facilities. Henlopen Lab, adjacent to Cape Henlo-pen State Park, holds the Air-Sea Interaction Laboratory, including the 42-meter, tilting Wind-Wave-Current Research Facility — one of the largest wave tanks in the world — and additional equipment for the study of physical phenomena at the air-sea interface. The Pollution Ecology Laboratory serves as supplemental space for biochemical research.

The college also operates the 120-foot *Cape Henlopen*, a general purpose, coastal research vessel that can accommodate 12 scientists on cruises lasting up to 10 days. It is a member of the University-National Oceanographic Laboratory System (UNOLS), a fleet of academic-owned research ships that receives approximately 70% of its funding from the National Science Foundation. The other vessel in the college fleet is the 26-foot, high-speed sampling boat *Captain Thomas White*, which is used for short trips into Delaware Bay and nearby coastal waters.

Another major coastal research facility at the University of Delaware is the Ocean Engineering Lab in the Center for Applied Coastal Research, College of Engineering. This impressive laboratory contains such novel devices as the directional wave basin, a 66-foot-long, 66-foot-wide, 3.3-foot-deep apparatus equipped with 34 wave-generating paddles that can create realistic sea conditions for faculty and students studying the physics of waves and the effectiveness of certain coastal protection measures.

Management of the University of Delaware Sea Grant College Program

The administrative headquarters of the University of Delaware Sea Grant College Program are in the Graduate College of Marine Studies (CMS), Robinson Hall, on the Newark campus. Locating the Sea Grant College Program in CMS maximizes the opportunity for interprogram coordination that otherwise might be difficult to attain.

Long-range planning and integration of Sea Grant into the University's broader marine program are the responsibilities of the program's director, Dr. Carolyn Thoroughgood, who is also dean of the Graduate College of Marine Studies. Dr. Thoroughgood has a long relationship with Sea Grant. She was director of the Marine Advisory Service from 1974 to 1980; associate Sea Grant director for program planning and operations from 1976 to 1978; and executive director from 1984 to 1985 before assuming the dual roles of CMS dean and Sea Grant director.

Mr. Richard Tarpley is both executive director of the Sea Grant Program and executive officer of the college. He served as executive director of the college from 1988 to the present, and assumed responsibility for the day-to-day operation of the Sea Grant College Program beginning in 1989.

Dr. Kent S. Price is director of the Sea Grant Marine Advisory Service, and Tracey Bryant is the program's communicator. She is also marine outreach coordinator of the Marine Communications Office, which provides communications expertise and support to both CMS and Sea Grant.

These four individuals — the Sea Grant director, executive director, MAS director, and communicator — comprise the UD Sea Grant Management Team.

Assisting in the coordination of Sea Grant research are Research Team Leaders in each of the major areas in which our program has shown historical strength. These individuals help with quality control in project selection as well as with project integration for development of cohesive programming. The Research Team Leaders and the UD Sea Grant Management Team comprise the UD Sea Grant Executive Committee.

Program Planning and Integration

Strategic planning involving constituencies both external and internal to the University of Delaware has been a long-standing and integral component to the development of the UD Sea Grant College Program. The first level of external guidance for strategic planning comes from the National Sea Grant Office. With national priorities in hand, the UD Sea Grant Management Team then turns to a group of state representatives — the Sea Grant Advisory Council (SGAC).

The SGAC, the statewide external advisory body to the UD Sea Grant College Program, was first created in 1974. Its members come from marine-oriented business and industry, resource management and engineering firms, state government, public interest groups, the pre-college educational sector, and the media. The SGAC, working within the national priorities provided by the National Sea Grant Office, further refines and defines the priority issues relevant to Delaware.

The SGAC has also been instrumental in obtaining additional matching dollars for the UD Sea Grant College Program. Early in our history, the SGAC spearheaded the request to the Delaware General Assembly for a line in the state budget earmarked for the Sea Grant College Program. In 1975, a line item of $250,000 was secured. Since then, the SGAC has assisted us in maintaining and increasing our state appropriation, as well as assisted us in acquiring matching funds from the private sector for specific research initiatives. The council also helps us identify potential partners for accomplishing specific research and outreach objectives. The Marine Advisory Service makes extensive use of the SGAC in formulating its program of work. Each of our agent/specialists has a sub-committee of SGAC members with whom he or she works.

For internal input, the UD Sea Grant Management Team holds strategic planning sessions involving faculty from all colleges at the University of Delaware. Representatives from Delaware State University are also invited. During the past 30 years, these Sea Grant planning meetings have taken many forms, but the ultimate objective has always been to access the talent base resident in higher education in Delaware. We want to take advantage of their interest, expertise, and experience in further refining the priorities identified by the SGAC. Assisting in the coordination of Sea Grant research planning are Research Team Leaders for each of the major research priority areas identified by the SGAC. These individuals are selected because of their leadership positions within their respective fields. They typically are senior professors who have extensive records of research accomplishment and scholarship. In addition, they serve on many environmental advisory committees external to the University and participate in local, regional, and national exchanges devoted to marine research.

The guidance from all these sources is then synthesized to create the UD Sea Grant College Program five-year plan, which is then distributed throughout the state and the Mid-Atlantic region. The existing Sea Grant projects stem from guidance found in *University of Delaware Sea Grant College Program Future Perspectives 1994 – 1999.*

Preparation of the Program Plan 2000 – 2005

Soliciting input from the broad marine community of organizations and individuals in the Delaware region for the purpose of establishing priorities for UD Sea Grant has become a matter of course over the 30-year tenure of the program. In anticipation of the need to develop a new five-year plan, UD Sea Grant management decided to build upon the strategic planning under way in the Graduate College of Marine Studies. In September 1997, a day-long UD Sea Grant strategic planning meeting was scheduled back-to-back with day-long college strategic planning. It seemed reasonable to think that some of the new hires being planned for in the college's strategic plan would have the potential to contribute to UD Sea Grant. A diverse group of faculty with marine interests was invited to the two days of strategic planning. The Sea Grant strategic planning invitees were provided with the National Sea Grant guidance document. They were also advised of the change in program oversight by the National Sea Grant Office, where accomplishment, as compared to the proposal of a scope of work, will be emphasized in program evaluation. Provocateurs presented each element of the National Sea Grant Strategic Plan, and significant discussion followed. Each of the presenters then prepared a consensus description of the various potential UD Sea Grant priority issues for review and refinement by the attendees. The final draft was distributed to the UD Sea Grant Advisory Council.

At a meeting of the UD Sea Grant Advisory Council in December 1997, the draft of priorities created by the academic community was reviewed and discussed. Each council member was asked to provide written responses to the draft; they were also encouraged to make suggestions for additions/deletions. A separate solicitation for input also was made to the relevant section heads of the Delaware Department of Natural Resources and Environmental Control (DNREC). (Even though DNREC has formal representation on the SGAC, it is also solicited separately for its list of priority issues.) In all cases, consideration was given to significance and relevance

of the science, the amount of resident expertise available to address a particular issue, the degree of community concern, the opportunity for interagency collaboration, and degree of public benefit. Of course, the *National Sea Grant Strategic Plan* set the overall boundary conditions.

Because of Delaware's small physical size, it is possible within these two forums to involve the majority of those organizations and individuals with the greatest interest in and responsibility for state and regional marine and coastal resources. The strategic plan that follows represents the collective concerns of Delaware's marine community from all levels. It highlights important marine and coastal issues and research needs. It also commits to the expansion of partnerships, especially industry partnerships, with the creation of the **UD Sea Grant Research Partnership Fund.** This fund is supported by $100,000 that can only be accessed if the principal investigator has an industry partner willing to match Sea Grant funds dollar for dollar.

The planning process also yielded significant input to the Marine Advisory Service. Repeatedly, the need for expanded outreach, communication, and education was voiced. These needs could consume the entire UD Sea Grant budget and reaffirm the importance of partnering at every opportunity. The task ahead is far more than that which can be funded by UD Sea Grant. Fortunately, our Marine Advisory Service has had a long history in leveraging the SG investment.

PRIORITY MARINE RESEARCH ISSUES IN DELAWARE

Marine-related challenges and opportunities are numerous and diverse in Delaware, but their scope is not limited to the region, and their solutions have national application. Many of the most pressing state environmental issues, including degradation of nearshore coastal waters, aquatic habitats, and drinking-water supplies, stem from intensified use conflicts for marine and coastal resources. The coastline pressures are exacerbated by the natural hazards of storms and short- and long-term coastal erosion, as well as those created by improper coastal engineering and development. The expectations for Delaware Sea Grant's assistance on issues related to coastal erosion are best exemplified in testimony given by Congressman Michael N. Castle (R-Del.) in support of authorization legislation for the National Sea Grant College Program. He said the Sea Grant money could help the Delaware beaches in their battle against erosion and storm damage. "One of the most important services the National Sea Grant College Program provides is assistance in protecting beaches, roads, buildings, and wildlife along our fragile coastlines," he said on the House floor.

Economic development is also a high priority in the state of Delaware. To that end, there is great interest in revitalizing Delaware's commercial fisheries, enhancing Delaware's recreational fisheries, and increasing revenue from recreation and tourism within the state. In addition, because of the major presence of the chemical and pharmaceutical industries in Delaware and the region, there is a strong interest in marine natural products research for potential human use.

With a historically strong commitment to excellence in multidisciplinary marine program development and partnership building, the University of Delaware is well-poised to continue its contributions to these significant problems and opportunities though integrated research, education, and public service efforts. The complexity of the high-priority marine research issues identified through our planning process calls for an integrated approach in advancing our understanding of the issues and in developing solutions. **To that end, the marine policy projects will be embedded throughout the identified priorities rather than be a "stand alone" priority as in past Delaware Sea Grant submissions.** The transfer and application of results will be assured again by integrating Marine Advisory Service activities into the stated priorities. In all programmatic elements, active partnerships with appropriate governmental agencies and/or business and industry will be expected. To foster increased industrial collaborations, Delaware Sea Grant management has set aside a portion of its funds that are only accessible to principal investigators who have industry partners.

The following section highlights the University of Delaware Sea Grant College Program's highest marine research priorities, which with their companion marine policy and outreach components, will guide the program over the next two proposal cycles. The comprehensive list of priorities includes the following:

University of Delaware Sea Grant Research Priorities

1. *Improvement of the scientific basis for assessing and managing the response of estuaries, coastal waters, and watersheds to human impact.*
2. *Development of environmental technologies for cost-effective marine ecosystems assessment and monitoring.*
3. *Development of predictive models of shoreline change and assessment/improvement of coastal erosion mitigation strategies.*
4. *Exploration, development, and use of the adaptational prowess of marine organisms.*
5. *Achievement of sustainable fisheries and aquaculture.*
6. *Education of future environmental professionals/ leaders and enhancement of marine literacy among Delaware citizens.*

University of Delaware Sea Grant Research Priority

1. Improvement of the Scientific Basis for Assessing and Managing the Response of Estuaries, Coastal Waters, and Watersheds to Human Impact.

Background

Estuaries, the coastal ocean, and watersheds around the world appear under siege, as evidenced by continuing reports of fish kills, hypoxia, and toxic algal blooms such as *Pfiesteria*. Environmentalists think it's obvious that human society somehow is to blame. Certainly, few if any estuaries are left untouched by human impacts since about 50% of the world's population lives within 100 km of a coast. Vitousek et al. (1997) recently claimed that the long-term declines in coastal fisheries can be attributed partially to eutrophication of estuaries and coastal waters due to human activity. Given the problems we already have, what will happen to our estuaries and coastal waters as urban development continues, agriculture intensifies, and industrial output increases— when the world's coastal population reaches perhaps 4 billion in 2020?

There are many reasons, besides ethical and aesthetic ones, why we should protect our estuaries, coastal waters, and watersheds. These systems contribute about half of all marine biological production, and they are important components of global carbon budgets. They provide habitats and nurseries for most of the world's commercial and recreational fisheries. Much of this country's commerce is affected by ships passing through our estuaries and coastal waters, to and from ports like Philadelphia and San Francisco. Costanza et al. (1997) estimated the economic value of estuaries and coastal regions to be $12.6 trillion per year, greatest of all ecosystems.

Are we really to blame for all estuarine ills? Is runoff from farms, for example, really more complicated than suggested by newspaper headlines, as illustrated by comparing several estuaries in the Mid-Atlantic region? The Delaware Estuary receives more nutrients per volume than any other estuary in the United States, but it does not have the eutrophication problems of the nearby Chesapeake Bay (Sharp 1988) and Delaware's Inland Bays (Price 1997). Although nutrient concentrations are as high in the Delaware Estuary as in neighboring waters plagued with hypoxia and *Pfiesteria* (Burkholder and Glasgow 1997), this estuary does not suffer from these problems. We know much about why the Delaware Estuary does not have hypoxia problems, but we do not know why harmful algal blooms have failed to appear. Our inability to explain completely why these two adjacent estuaries differ reveals how little we know about many basic process occurring in marine ecosystems.

This research priority attends to the need to understand the problems facing the coastal zone today and into the future. It is tomorrow's assaults by human activities that both concern us and justify our efforts to understand the basic biogeochemistry and ecology of marine waters. We use the term "biogeochemistry" to describe the complex, interrelated suite of chemical reactions usually mediated by microbes. We need to understand biogeochemcial processes and the ecology of several marine organisms if we are to address this priority fully.

Goals and Objectives

Our primary goal is to assess and predict how estuaries, coastal waters, and watersheds will respond to external inputs that will change during the next decade and beyond. Embodied in this goal is the need to establish linkages between land-use practices, impact of shipping activity, ecosystem production, water quality, and the health of coastal habitats. Specific objectives include the following:

- Understanding the contribution of various external sources (groundwater, runoff, atmospheric deposition, dredge spoil, point sources) of materials introduced into estuaries.
- Determining what nutrients are being "stored" in the watershed and in sediments.
- Determining the role of the benthos in primary productivity, nutrient regeneration, and nutrient sequestration.
- Understanding the relationship between external nutrient supply and algal blooms.
- Determining what controls oxygen concentrations in estuaries.
- Understanding how the microbial community structure changes with nutrient supply and ratios.
- Understanding the linkage between lower and higher trophic levels.
- Determining relationships between nutrient overenrichment and habitat loss.

- Developing biological/ecological indicators of water quality and habitat health that will document change and/or progress toward ecosystems health.
- Determining the impact (both biological and physical) of dredging and channel deepening on estuarine ecosystems.

Related marine policy and outreach objectives include the following:

- Assessing economic feasibility and impact of various restoration, rehabilitation, and management strategies for coastal ecosystem health.
- Exploring public trust issues associated with coastal watershed management.
- Developing risk assessment models to predict cumulative effects of watershed alterations.
- Developing and implementing nutrient overenrichment and toxics remediation strategies.
- Developing continual monitoring systems to determine sources and amounts of nutrients entering estuarine ecosystems.

Resources

A comprehensive research program addressing the needs of Delaware and the nation requires multiple partners and sponsors. The University of Delaware Sea Grant College Program continues to seek funding for environmental research in cooperation with other state (Department of Natural Resources and Environmental Control and Department of Transportation), private (agribusiness, power, chemical and oil companies, marine transporters, etc.), and federal (Environmental Protection Agency, National Science Foundation, other NOAA components) agencies. Sea Grant-funded studies in Delaware Bay and the Delaware coastal region have benefited from NSF-funded ship time on UNOLS vessels.

Research into the status and trends of water quality in Delaware's Inland Bays has been supported by the Environmental Protection Agency, providing background for proposals to conduct process-oriented research. One of the largest estuarine-watershed coordinated monitoring efforts is currently under way on the Delaware Estuary — including a large U.S. Geological Survey National Water Quality Assessment (NAWQA) study of the Delaware drainage basin, a U.S. Geological Survey-led Committee on Environment and Natural Resources (CENR) study, and the EPA-led Mid-Atlantic Integrated Assessment (MAIA) program with principal sampling on the Delaware Estuary.

Advances in remote sensing technology, data reduction (including Geographical Information Systems, or GIS), and ocean instrumentation (including untended instrumental moorings) are likely to play a greater role in future studies of ecosystem structure and function, geochemical cycling, and pollutant transport. Advances in marine molecular biology make it now possible to think about the use of molecular probes in establishing the health of an estuarine system. All these capabilities reside at the University of Delaware.

Relevance to Existing Research Goals

The University of Delaware has had a long, fruitful history in the area of environmental studies. Early work in the 1970s and 1980s centered almost exclusively on the Delaware Bay estuary and its wetlands. This research provided much of the background for the management plan developed by the Delaware Estuary Program (EPA funded and involving the states of Delaware, New Jersey, and Pennsylvania). This research also has had a clear impact beyond the local arena as evidenced by a number of internationally recognized peer-reviewed publications.

The subject matter of ecosystem studies has evolved as our understanding of complex systems has increased and human uses and abuses of the environment have changed. A growing consensus among the federal agencies charged with predicting and mitigating the undesirable effects of human activities in the coastal zone compounded by actual incidences of harmful algal blooms in local estuarine systems has led UD Sea Grant to include this general topic of coastal ecosystem health among its highest research priorities.

University of Delaware Sea Grant Research Priority

2. *Development of Environmental Technologies for Cost-Effective Marine Ecosystems Assessment and Monitoring.*

Background

To protect coastal and estuarine waters from long-term and short-term environmental and ecological disasters and to track ecosystem health, there will need to be unattended, in-situ measurement platforms and remote-sensing observing systems. An up-to-date, comprehensive management system must be supported by long-term and real-time monitoring of the oceanographic and environmental parameters and must use a strong science base for assessing the response of estuaries and coastal waters to human impact.

Ocean scientists in the last several decades have relied on in-situ measurements to examine the physical processes in coastal waters. Physical processes in estuarine and coastal waters often carry significant spatial and temporal variability. This phenomenon can be due to the presence of complex bathymetry and geometry as well as short-period tidal and long-period motions induced by atmospheric and riverine forcing. To fully understand the transport processes and the associated distributions of properties such as water temperature and density through observational means, one has to sample the system with sufficient spatial and temporal resolutions to minimize the effect of aliasing. This condition presents a challenge for coastal oceanographers, as the traditional means of observation typically cover either fine spatial/temporal resolutions (such as intensive, but short-term, shipboard observations) or long-term observations with limited spatial resolution (such as moored current meters).

The development of remote sensing methods, which can be used to determine the temporal variations in the three-dimensional distributions of water properties, is a timely subject. Traditional remote sensing techniques, however, are limited to detecting features that appear on the surface. Physical properties within the water column are inferred from these boundary features rather than measured directly, thereby increasing the likelihood of error. Hence, there is a critical need for development of innovative technologies for use in complex coastal systems.

Goals and Objectives

The coastal environment is controlled by a complex interaction of physical, chemical, biological, and geological processes. In order to understand these coastal ecosystems, it is necessary to take novel approaches to monitor key parameters that are representative of the multivariate processes that control the coastal environment. Hence, the goal is to develop innovative technologies, combining satellite imagery with environmental technology that can carry out long-term, in-situ, multivariate measurements for cost-effective monitoring of coastal environments. Specific objectives include the following:

- Identifying both the scientific and management questions that need to be addressed for assessment of environmental conditions.
- Deploying existing and/or developing technologies that permit real-time data collection to be used for determining both short-term environmental events as well as long-term environmental trends. Specifications for these technologies include the following:
  - — programmable sensors for data collection at predetermined time intervals.
  - — sensors located in situ, in the water body.
  - — long-term capability, with low resolution so that effects of natural processes can be assessed.
  - — capability for multivariate measurements including current, temperature, salinity, turbidity, light attenuation, dissolved oxygen, and nutrient levels.
- Demonstrating the validity of the data collected by prototype environmental systems, comparing predictions with observations under a variety of conditions.
- Integrating information from different sensors to determine relative importance of different processes to predict future water quality.
- Developing pollution control technology (e.g. low-cost waste treatment, biofilters, etc.).
- Developing effective remediation technology for contaminated water bodies and sediments.

Related marine policy and outreach objectives include the following:

- Developing "adaptive" (those that evolve as new information and techniques are developed) environmental management strategies.

- Conducting a demonstration project collaboratively with management agencies to substantiate capabilities of a remote monitoring system.
- Linking process modeling with management strategies to promote informed decision-making.

Resources

To be able to achieve the proposed objectives, it is essential to demonstrate the feasibility of this novel approach in a major estuary. This prototype system would take advantage of the large number of lighthouses found in many major estuaries. Such a system of fixed platforms exists in the Delaware Bay. These existing platforms will allow field testing of a "new environmental technology system" at a fraction of the cost of establishing new facilities.

A wide variety of sensors for environmental measurements already exist. The challenge is to build upon and modify this existing technology and to link the various component parts to make a system for remote environmental monitoring and assessment.

Interest in civilian applications for some of the Navy's detection and surveillance equipment results in financial resources, largely through the Office of Naval Research (ONR), being available to complement Sea Grant support. Since Sea Grant has traditionally not funded ship time, ONR would be a likely source of funds to support the deployment of candidate sensors. The Coast Guard is also willing to assist with regular maintenance needs of deployed equipment as they see this project outcome useful to their mission.

Relevance to Existing Research Goals

The development of environmental technology addresses the desire to promote both economic growth and environmental quality. There is the potential to develop new environmental sensors and/or combine these new/modified sensors into an environmental monitoring system. Both new sensors and multivariate systems represent new marketable products. From the environmental quality perspective, this in-situ monitoring capability is essential to real-time observations and assessment of water quality. Remote-sensing observing systems will be the watch-guard for large, high-risk, marine ecosystems and sanctuaries.

UNIVERSITY OF DELAWARE SEA GRANT RESEARCH PRIORITY

3. *Development of Predictive Models of Shoreline Change and Assessment/Improvement of Coastal Erosion Mitigation Strategies*

Background

The coastline of the United States is a valuable natural resource that is threatened continually by natural hazards such as storms and short- and long-term coastal erosion, as well as from improper development that exacerbates these problems. As the population along the nation's coast continues to increase, so do the cost and complexity of dealing with multiple uses and coastal disasters. The coastline serves many purposes, from providing residential sites to an ever-increasing percentage of the U.S. population, to ports and harbors for trade and marine industries, to recreation and tourism. The beaches of the United States even serve as a major source of foreign trade, due to their attraction to international tourists. These foreign tourists more often go to beaches than to national parks (Houston 1997).

Delaware has 24 miles of Atlantic Ocean beaches, with well-developed infrastructure for tourism in the communities of Rehoboth Beach, Dewey Beach, Bethany Beach, and Fenwick Island. In 1990, it was estimated that almost $165 million dollars was spent by tourists at these beaches in a nine-month period (Davidson-Peterson Assoc., 1990).

The State of Delaware is very active in maintaining state-owned beaches (which constitute about two-thirds of the Delaware total). Beach nourishment, sand bypassing, and other techniques are used to keep the beaches attractive and inviting. Nevertheless, these beaches are slowly eroding, due to sea-level rise, and, in recent years, an increasing number of northeasters that have caused severe damage in the millions of dollars.

The purpose of this research priority is to develop means to predict the behavior of the shoreline in both the short-term (on the order of a storm duration) and the long-term (decades) and to assess the various technologies that are used to protect beaches, such as beach nourishment. These assessments would be comprised of both coastal engineering as well as economic/policy analyses. Finally, there is the need to identify new engineering and pubic policy approaches to result in integrated coastal management.

The whole problem of coastal modeling is an extremely difficult one as it involves a combination of hydrodynamics and sediment transport under very unsteady conditions. Over the past 20 years, important strides have been made in the numerical modeling of water waves from offshore to onshore, the development of models to predict the nearshore circulation system, and understanding the nature of swash on the beach face, where a considerable portion of the longshore transport exists. However, despite these advances, the critical coupling between the hydrodynamics and the sediment transport still awaits proper solution as much of the science still needs to be done. This complexity and difficulty are in part due to the unsteady turbulent nature of the flow and in part due to the many types of sediment transport that occur on beaches: swash transport, bedload and suspended transport in the surf zone, and the transport in the offshore zone.

The development of coastal prediction models will be a long-term process, involving all aspects of research: basic, field, lab, and numerical modeling. It will take considerable time and effort, but every year, our predictive abilities increase. Simple models exist now, but more sophistication is needed for use in coastal planning.

There is also a need to develop new mitigation strategies for coastline preservation. The majority of the hard structures for protecting beaches have been used by coastal engineers for over a hundred years. Innovative coastal erosion devices should be developed and tested. Examples of more modern approaches are beach fills; beach drains, which are wells that drain the water table in the beach with the intent of drawing sand to the beachthe construction. This measure has served well in the past, despite the lack of inclusion of recreational benefits into the calculation. With increased recreational use and pressure on shoreline areas, this current metric for benefit/cost analysis needs further amplification.

Goals and Objectives

The scope of this research is such that while it is relevant locally, the nature of the work is global. Models of waves and currents developed at the University are in use worldwide. The overarching goal is to develop the tools and the modeling techniques for coastal processes. These tools will allow the assessment of various erosion mitigation strategies and permit coastal

planning when coupled with economic and policy analyses. Specific objectives include the following:

- Understanding coastal processes to answer the following questions:
  - — How do the waves mobilize sediment?
  - — How can we quantify the sediment transport at the shoreline?
  - — How are the nearshore currents, which move the sand along the beach, created?
  - — What are the elements of the sand budget (generically and locally)?
  - — How can we predict both for the duration of a storm or in the longer term the behavior of a beach?
- Refining existing wave, tide, current, and sediment transport models for practical application.
- Developing shoreline erosion models that can be used for coastal development and management.
- Examining the efficacy of shore protection and the role that tidal inlets have in water quality, navigation, and as agents for erosion.
- Exploring cost-effective techniques for sedimentation control, navigation maintenance, and circulation enhancement for improved water quality.
- Assessing the relationship of shoreline changes/responses to new combinations of sea-level rise and physical changes.
- Designing and evaluating nonstructural engineering alternatives to the management of shoreline change.

Related marine policy and outreach activities are a high priority because of the changing population and environmental conditions along the coastline. Protecting life and property from the impacts of coastal hazards has become more difficult due to such trends as sea-level rise, higher coastal population density, and the inexperience of coastal populations to deal with coastal hazards. Hurricanes and northeasters play an important role on the east coast of the United States in the loss of life and property. They represent about 20% of all the Declarations of Disasters by Congress (Sylves). This analysis of risk is many fold. The challenge to protect life and property along the nation's coasts is further exacerbated by the additional multiple and conflicting uses placed on the coastal margins by society. Specific marine policy and outreach objectives include the following:

- Developing probabilistic design methods to interpret risk management options to coastal managers and residents.
- Enhancing existing benefit/cost models to factor in multiple-use benefits, particularly recreation.
- Developing new socio-economic evaluation tools to enable communities and developers to make informed choices regarding multiple uses.
- Expanding evaluation of mitigation techniques to ameliorate the impact of natural and man-made disasters on the coastal margin.
- Assessing economic impact and cost of recovery from storms, flooding, evacuation, and spills.
- Transferring information on the prediction, impacts, and recovery from storm surges.
- Assisting local governments and developers in incorporating water availability limitations, groundwater contamination, erosion rates and setbacks, and coastal building codes into development activities to increase return on investments.
- Providing training programs for local planners and engineers to implement adaptive integrated coastal management techniques.
- Expanding outreach efforts to include coastal hazard agent/specialist.
- Determining and communicating the risk associated with living at the coast.
  - — Characterize the climate, storms and waves, and the associated risk
  - — Translate this risk (including risk of construction) to the public.
  - — Replace use of deterministic design with probabilistic design methods and inform the public. [As an example, the success of a beach fill as a means to counter shoreline erosion will depend on the wave climate to which it is exposed after construction. Therefore, the client and the public need to understand that the lifetime of a beach fill necessarily can only be estimated based on the likelihood of the wave climate. Projecting lifetimes in terms of probabilities presents a more realistic assessment of the future.]

Resources

Sea Grant efforts in coastal engineering have been augmented by other funding agencies that have sponsored coastal engineering research including the Office of Naval Research, the Army Research Office, the National Science Foundation, and the University of Delaware. These agencies have funded equipment/computer purchases and research time that have hastened Sea Grant model development or provided equipment for Sea Grant use that would be unavailable otherwise.

At present, the Center for Applied Coastal Research, housed in the Ocean Engineering Laboratory, is one of the

best-equipped coastal engineering organizations in the United States. The Ocean Engineering Laboratory, a two-story building dedicated to physical and numerical modeling, contains five major facilities for physical and numerical modeling, including a directional wave basin and a recirculating flow wave tank. Another major center wave tank, the Sand Wave Tank, is located in a nearby building. Recently, the center installed a parallel computer to speed up numerical codes and to begin developing parallel computer codes used on major supercomputers. In addition, the Delaware Department of Natural Resources and Environmental Control, Beaches and Shores Branch, has been helpful in obtaining and maintaining beach profile data for Delaware beaches.

Relevance to Existing Research Goals

Present Sea Grant-funded research is directed at the topic of understanding coastal processes, with the long-term goal of developing a coastal erosion model. The program has a long history of research into the fundamental topics of nearshore circulation and wave modeling, which has resulted in successful nearshore circulation and wave models that have been released to the profession.

The University is home to one of the largest coastal engineering programs in the world and has provided a considerable amount of research/expertise to the field. A significant fraction of the country's coastal engineers are graduated from the University of Delaware.

University of Delaware Sea Grant Research Priority

4. Exploration, Development, and Use of the Adaptational Prowess of Marine Organisms

Background

Marine biotechnology has its roots in the resonance between the organism and the environment. From the organism's perspective, the resonance is usually referred to as adaptation. As more and more organisms are discovered in extreme habitats, i.e., extreme temperature, salinity, pollution, anoxia, PH, and other kinds of stress, an awareness of the value of knowledge about the molecular and physiological basis of adaptation has become acute. Genes, enzymes, and perhaps adaptational prowess can be cloned, transferred, modified, or modulated in unusual and profitable applications.

At least five initiatives in marine biotechnology have achieved world-wide recognition. These involve the antifreezes of cold-water fish, mineralized exoskeletons of various marine invertebrates, marine toxins, blood coagulogens of horseshoe crab species, and enzymes from especially heat-tolerant microbes. Each of these has developed from a solid scientific base beginning in the 1960s; each presently has one or more industrial/commercial partners, and, in the case of enzymes from hyperthermophiles and coagulogens, profitable products have resulted. Brief discussions of two of these success stories follow.

Marine Toxins. Baldomero Olivera of the California Institute of Technology and the University of Utah pursued a childhood interest of his: the poisonous darts of *Conus* snails. The sluggish hunters of the tropical intertidal zone paralyze their prey by injecting them with a tiny harpoon loaded with poison. The prey is then quietly ingested. Olivera has characterized many of the toxic peptides and found them to have a potent and specific effect on the neuromuscular junction of higher vertebrates. Many of the peptides have been synthesized and some are being developed for clinical use by Neurex Corporation of Palo Alto.

Blood Coagulogens. Horseshoe crab coagulogens form clots in response to femtogram amounts of endotoxin (pyrogen). This was first observed by Frederick Bang in 1960 and studied by many since then. The sensitivity of the reaction was recognized by some to offer a compelling alternative to the Haze test for pyrogens, and coagulogen kits became available in the 1980s. The Japanese, ever keen to streamline and improve, are developing a more reproducible version based on the first step of the coagulogen cascade: detection of endotoxin by factor C, and self-activation of protease activity. As they see it, the new diagnostic will consist of just factor C (probably a recombinant version) that is induced to form a chromophore upon binding endotoxin.

What these case histories have in common is . . .

- A continuous history of basic research extending back to the sixties.
- Federal funding.
- Intellectual property.
- "Key players" in academia with industrial liaisons.
- Well-focused goals as well as perceived commercial need.
- An element of risk.
- Luck.

Well-studied examples of marine adaptation well-suited to commercialization will soon be exhausted. What successful marine biotechnology needs is a balance of support for studies of the physiological and molecular bases for adaptation with the research demonstrating application and use.

Goals and Objectives

Given the great number of possible research directions in marine biotechnology, it is impossible to anticipate the most fruitful facets of marine biodiversity to pursue. The University of Delaware Sea Grant College Program has been involved in the study of marine natural products since the mid-1970s. Some of the early natural products research focused on chitin and its medical applications; more recently Delaware Sea Grant investigators have used marine biotechnology in the study of biofouling and biocorrosion, halophyte biology, disease resistance in shellfish, biomaterials from marine organisms living in extreme environments, and molecular detection of exotic species. Building on this track record, our future research objectives include the following:

- Developing non-toxic methods for control of biofouling and associated corrosion.
- Defining the chemical, physical, and biological properties of marine materials, particularly biopolymers, as a basis for industrial use.

- Isolating and identifying compounds that are biologically active and have commercial or medical potential.
- Isolating, identifying, and determining the function of enzymes controlling processes of potential economic or commercial benefit.
- Determining if the natural adhesives produced by organisms such as shellfish can be exploited for commercial use.
- Developing technology to use culture cells of macroalgae in bioreactors to produce useful biochemicals.
- Developing techniques for using halophytes in agriculture and in restoring coastal environments.
- Exploiting unique biological processes to develop new types of molecular biosensors including indicator systems for detecting low-level toxicity.
- Developing genetically engineered species with the potential for use in either producing chemical products or in industrial processing.

Related marine policy and outreach objectives include the following:

- Developing an understanding of the public policy concerns regarding the exploitation of marine biodiversity.
- Examining the legal frameworks for developing marine biotechnology and commercializing any products resulting from research in this general area.
- Developing pilot-scale demonstrations of applications for potential users.

Resources

Research in marine biotechnology has been under way at the University of Delaware for many years. Therefore, laboratory facilities are already in place. Faculty research has been funded by several other federal agencies, including the National Science Foundation, Office of Naval Research, National Institutes of Health, U.S. Department of Agriculture, and the Department of Energy. Previous Sea Grant-funded studies in the area of biotechnology have benefited from NSF-funded ship time on UNOLS vessels for collection of samples, and such collaborations are necessary for future research. In the study of salt-tolerant plants, there are collaborations with several international research organizations and the provision of test plots for demonstration projects. In considering the human dimensions of marine biotechnology, again the UD Sea Grant Program has drawn upon the faculty in the Center for the Study of Marine Policy to carry out initial studies on societal impacts and considerations of exploiting marine biodiversity for human benefit.

Relevance to Existing Research Goals

The UD Sea Grant Program currently has several ongoing projects in the "Marine Biotechnology Functional Group." The emphasis in the past has been primarily in exploiting marine natural products and/or traits such as salt-tolerance. However, as our understanding of the power of molecular tools has increased, it is now possible to use molecular biology techniques to assess environmental health — especially through the development of molecular probes. Molecular biology/biotechnology will be a powerful tool in "improving the scientific basis for assessing and managing the response of estuaries, coastal waters, and watersheds to human impact."

UNIVERSITY OF DELAWARE SEA GRANT RESEARCH PRIORITY

5. Achievement of Sustainable Fisheries and Aquaculture Production

Background

Many of our estuarine and coastal marine fishery stocks are known to have been in decline for many years (Houde and Rutherford 1993; Sissenwine and Rosenberg 1993). This situation continues, along the Mid-Atlantic coast and nationwide, with many species' population sizes well below levels which would maximize production (Atlantic States Marine Fisheries Commission 1997). To return stock levels to sustainable sizes we must understand how overfishing, decreased (or variable) recruitment, and habitat alterations affect healthy fish populations. These effects may act individually or synergistically, depending on the species and the fishery.

Clearly we need to do a better job of identifying the factors (natural and anthropogenic) affecting healthy fish stocks, and further, of affecting the necessary policy changes to see the trends reversed. Natural processes affecting successful early feeding, growth, transport, and thus survival is essential to strong annual recruitment of new young individuals into the population. In addition it is recognized that human activities can also contribute to fisheries declines (Vitousek et al. 1997). This is particularly important for estuarine and coastal fisheries, where human activities have more negatively impacted water quality and other aspects of overall habitat quality.

The issue of fish habitat is particularly timely since the reauthorization of the Magnuson Fishery Conservation and Management Act was made by Congress in 1996. This Act, known as the Sustainable Fisheries Act, requires identification and delineation of Essential Fish Habitat (EFH) and conservation and enhancement measures for EFH relevant to all species for which Federal Fishery Management Plans (FMPs) exist. In addition, the Atlantic States Marine Fisheries Commission's FMPs are also required to have sections describing EFH for each of the species under the states' management authority. Thus, research on environmental factors/habitats which promote fish reproduction, growth, and production is essential to meet management needs at both state and federal levels.

There are several species (fisheries) of importance for study in our region, many of which have already been the subject of studies at the University of Delaware, using Sea Grant and other funds. These include blue crab, weakfish, American oyster, summer flounder, striped bass, tautog, and bluefish. This list is intended to be a guide to species of regional importance, not an exclusive list of potential research species.

Aquaculture can help substitute for lost natural production, in terms of overall seafood production. It has been noted that as natural fisheries decline, aquaculture often increases production to help compensate (Smith 1986). Increasing aquaculture production in the Mid-Atlantic region requires studies on genetic stock improvement, nutrition, and disease control and water-quality management. Appropriate species for study include summer flounder, hybrid striped bass, black sea bass, tautog, American oyster, clams (hard and surf), and bay scallops.

Attention must be given to the health of our natural fisheries and to increased aquaculture production. This research priority addresses needs to help enhance and achieve sustainable natural fisheries as well as to enhance aquaculture production in the Mid-Atlantic region and throughout the species' ranges.

Goals and Objectives

Our goals and objectives for research on sustainable fisheries and aquaculture involve linkages between fisheries science, water quality, and the health of coastal habitats, and marine policy. Specific objectives include the following:

- Identifying critical processes controlling replenishment (recruitment) of fishery resources. (This will involve assessment of the roles of physical and biological processes, both natural and anthropogenic.)
- Defining essential fish habitat as it relates to habitat areas and parameters important to growth, reproduction, and production of fishery species. (This ties in with the broad issues of coastal ecosystem health and water quality.)
- Determining the potential of habitat enhancement to increase, or sustain, productivity.
- Using biotechnology and other approaches to improve the quality of seed stocks for stock enhancement through aquaculture. (Work is needed to enhance growth, improve disease resistance and treatment, control reproduction, develop techniques for identifying cultured stocks in the oceans, and to understand the genetic consequences of enhancement.)

- Evaluating survival of released cohorts and for certain stocks, providing the ecological evaluation necessary to maximize successful releases into the wild.
- Identify the environmental impacts of aquaculture operations; impacts which may range from positive to negative.
- Coordinate development of educational and demonstration programs necessary for effective technological transfer.

Resources

Research on fisheries and aquaculture at the University of Delaware has been supported from a number of sources in addition to Sea Grant. These sources of support include the Delaware Department of Natural Resources and Environmental Control, National Science Foundation, Environmental Protection Agency, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Northeastern Regional Aquaculture Center (USDA), and private power companies. We expect such sources to continue to augment our research program.

The University of Delaware's Graduate College of Marine Studies is uniquely qualified to undertake the multidisciplinary approach to the goals and objectives outlined above. We have maintained a faculty/staff with expertise ranging across the necessary research areas of fisheries ecology, oceanography, water quality and the health of coastal habitats, physiology, genetics and molecular biology, marine policy, and aquaculture.

Relevance to Existing Research Goals

Research on fisheries at the University of Delaware has focused on recruitment dynamics and the physical/biological factors underlying early feeding, growth, transport, and survival of fishes such as blue crab, weakfish, summer flounder, tautog, and bluefish. This research has also had relevance to the topic of environmental factors underlying essential fish habitat. Other research areas include the use of genetic techniques for analyzing the population structure of fishery species. Genetic markers may also be used to evaluate the success of stock enhancement programs for species such as the American oyster. Research on the reproductive physiology of fishes has included temperature/photoperiod manipulations of reproduction in captivity. These research efforts will continue, and we look forward to Sea Grant's contribution to the advancement of this research effort at the University of Delaware.

University of Delaware Sea Grant Research Priority

6. *Education of Future Environmental Professionals/Leaders and Enhancement of Marine Literacy Among Delaware Citizens*

Background

This human resources development program addresses NOAA's strategic plan that reinforces President Clinton's priority as outlined in *Putting People First* — "The only way Americans can compete and win in the twenty-first century is to have the best-educated, best-trained work force in the world, linked together by transportation and communication networks second to none" (Baker et al., 1993).

A steadfast goal of our program throughout its history has been to educate our nation's future marine scientists by giving selected graduate students the opportunity to develop their research an analytical skills by assisting scientists with Sea Grant projects. Since the University of Delaware was designated a Sea Grant College in 1976, we have trained over 190 students directly and contributed to the research efforts of more than 175 other students. Our students are an integral part of the program and a direct extension into other educational institutions, industry, and government.

Our graduate students have assumed prominent positions where they can impact directly on the continued wise use, sustainable development, and conservation of marine and coastal resources. For example, our former graduate students now have careers at the National Academy of Sciences, American Cyanamide Co., National Marine Fisheries Service, Delaware Department of Natural Resources and Environmental Control, Boston University of Medicine, W. L Gore Corporation, the South Carolina Sea Grant Consortium, and a host of other universities, companies, and government agencies in the United States and in several foreign countries. They carry with them the unique mission and vision of Sea Grant and are, in themselves, a vital link to keeping the UD Sea Grant Program dynamic and expanding.

The University of Delaware Sea Grant College Program also has an impressive record of accomplishment in educating students in grades kindergarten through 12, as well as successfully targeting educational projects at specific used groups and the public at large. Our interactions with the pre-college sector are largely the responsibility of the Marine Advisory Service, but Sea Grant researchers are active participants in workshops designed to "educate" the K-12 teachers who then involve their students. UD Sea Grant has hosted in-service training workshops for Delaware teachers for more than 25 years.

Inherent in this national priority to educate America's work force is the need to reflect the nation's racial, ethnic and gender diversity. In a number of states, more than half the population is non-white. By the middle of the next century, "minorities" will comprise more than 50% of the total U.S. population. By the end of this century, 15% of the new entrants to the labor force will be white males. Minorities represent a vast and largely untapped reservoir of talent (Williams 1990).

In the early 1970s, this nation began to see an increasing shortage of technically trained personnel; projections made at that time indicated that the need for technically trained workers would become critical by the turn of the 20th century. Simultaneously, the engineering profession became concerned about the chronically low participation of African Americans and Hispanics in engineering education and practice. Some 28 years later, we find ourselves facing the reality of earlier projections. In the United States, minorities continue to earn a small percentage of the science and engineering doctoral degrees; for example, in 1992, only 5.1% of the Ph.D.s in science and engineering were awarded to African-Americans (Culotta 1993).

In oceanography, the underrepresentation is even more extreme than in other scientific disciplines. In fact, the National Science Foundation characterized the situation regarding the number of black professionals as "too few cases to estimate," and the number of Hispanics accounted for only 2.3% of the oceanographers in the United States (*Changing America: The New Face of Science and Engineering* 1988). Between 1975 and 1988, only two African-Americans, two Native Americans, and 13 Hispanics received doctorates in marine-related degree programs (Luther 1990). Continuation of these current trends would mean the perpetuation of population groups ill-prepared to meet the needs of a technically competent work force and even more significantly to exercise their rights and responsibilities of citizenship in a modern democracy.

In addition to formal education, there is also a need to facilitate education of the general public, both in technology transfer and in enhancing marine literacy. This outreach mission is shared between our Marine Advisory Service (MAS) and Marine Communications. The staffs of these two groups work together and separately to transfer to the public a wide variety of information gained through Sea Grant research. They also embark on independent efforts in applied research and marine education to address user problems and needs, and to heighten public awareness and understanding of marine and coastal environments and issues.

The "information superhighway" is both a blessing and a curse. Information technology means that more people can indeed be reached; the challenge is staying current with the rapid production of knowledge and information. With information dissemination facilitated by technology, it should now be the focus of the outreach staffs to be the synthesizers, translators, and integrators of Sea Grant research. To insure that the outreach staffs do not fall prey to information overload, their integration into research priorities is being orchestrated much more carefully.

Goals and Objectives

Through partnerships with other universities, especially the Historically Black Colleges and Universities (HBCUs), government agencies, citizen groups, and business and industry, UD Sea Grant will pursue the following objectives:

- Continue undergraduate and graduate assistantships for the best students in marine studies.
- Assist in the education of future environmental professionals/leaders through post-secondary educational opportunities, with special emphasis on underrepresented populations.
- Improve formal pre-college education by infusing marine studies information into adopted curricula and by offering in-service teacher training on ways to maximize its use.
- Provide new knowledge to target audiences via electronic highways, remote sensing, and information retrieval in data management systems.
- Develop opportunities to train and retrain MAS agent/specialists, managers, planners, and policy makers to deal with problems/opportunities created by multiple and conflicting uses of coastal and marine resources.
- Increase public understanding of science and technology by using innovative media technologies to reach informal education audiences.
- Develop outreach programs targeted to various levels of decision-makers to address emerging coastal resource issues that require management and conservation policies.

Resources

The Graduate College of Marine Studies (CMS) serves as the focal point for formal marine education at the University of Delaware. A brief description of CMS was presented earlier in this document. Even though CMS is a graduate-only college, it does offer a series of undergraduate courses and has operated a Research Experience for Undergraduates, sponsored largely by the National Science Foundation, for 15 years. In-service teacher training for credit is also offered through CMS.

The Marine Advisory Service (MAS) and Marine Communications staffs are largely responsible for outreach, although they are regularly assisted by CMS faculty. Excluding administrative staff, the MAS is staffed by 5.5 FTE. The director, Kent Price, is also an associate professor in marine biology-biochemistry at CMS, and his time is split equally between CMS and Sea Grant. The remaining 5 FTE are agent/specialists.

At present, MAS outreach activities are targeted in the areas of coastal business and economic development, coastal resource management and conflict resolution, fisheries and marine safety, seafood technology, aquaculture, and marine education. To increase their sphere of activity, each MAS agent/specialist is expected to generate the equivalent of three salary months. The partnerships generated by actual investment from sources such as the National Science Foundation, Center for the Inland Bays, State of Delaware, and others, have contributed to the MAS's ability to reach a greater number of audiences than Sea Grant funding would permit. The MAS staff size has been constant for more than a decade. As pressures for assistance on coastal management issues continue to evolve, the composition of talents represented on the MAS staff and the number of staff will need to be revisited.

Marine Communications' goals are to educate the public about the marine environment and promote its wise use, conservation, and sustainable development through outreach products that are accurate, understandable, cost-effective, high in quality, and expeditiously distributed. Excluding administrative staff, Marine Communications is staffed by 2.0 FTE. Four staff members share their time equally with Sea Grant and CMS. Tracey Bryant coordinates Sea Grant communications efforts and serves as a writer and editor. Marine outreach specialist Claire McCabe is also a writer/editor. David Barczak is the art director, and Pamela Donnelly is production manager.

The Marine Communications staff not only supports Sea Grant management and MAS, but also assists faculty funded by Sea Grant with their publications/presentations. A newly added responsibility to Marine Communications is the design and updating of our World Wide Web site, as the information superhighway is changing dramatically the way we communicate with the public-at-large. This staff entered into desktop publishing several years ago. It is only through the use of sophisticated computer technology that the staff has been able to keep pace with the rapidly growing demands on its time. However, ever-increasing demands for Web-based information necessitates our review of staff size.

Relevance to Existing Research Goals.

Human resource development, education, and outreach activities are intertwined with research priorities. To reinforce this interactive, mutually supportive condition, outreach objectives are listed with each research priority. From the perspective of formal education, we are committed to discovery-oriented learning and therefore teach through the conduct of research.

UNIVERSITY OF DELAWARE SEA GRANT PROGRAM IMPLEMENTATION

Overview Statement

As with all long-range planning documents, the University of Delaware Sea Grant College Program plan is a dynamic instrument that will evolve as conditions, constraints, and opportunities become more clear over time. This plan provides direction and sets the stage for implementation, which will occur over the entire period. In accordance with the procedures set forth by the National Sea Grant College Program and with the concurrence of the Delaware Sea Grant Advisory Council, the primary elements of program implementation are as follows:

- Developing and distributing a Request for Proposals (RFP).
- Defining and completing a selection process to guide the award of research grants.
- Awarding and administering grants.
- Reviewing and evaluating the progress of the funded research.
- Documenting the impacts of research and outreach activities.
- Reviewing and revising the program plan.

Request for Proposals

A Request for Proposals (RFP) will be developed biannually by the UD Sea Grant Management Team. It will emphasize the priority research and outreach issues identified in this strategic plan and encourage collaboration among investigators within the state and the Mid-Atlantic region where appropriate. The RFP will be distributed widely among the marine community in the state. It will call for pre-proposals to be submitted for consideration prior to full proposals. The pre-proposals will be evaluated based on their compatibility with the priorities identified in the RFP and this plan. All responses and pre-proposal outcomes will be documented.

Proposal Evaluation and Selection

Proposals will be evaluated based on these criteria:

- Scientific merit and scientific feasibility based on external peer review.
- Relevance of the proposed effort to the priorities identified in this plan, or to other pressing issues in Delaware that may arise but are not included in the plan.
- Relationships with Delaware Sea Grant outreach components and users, including industry, decision-makers, researchers, and the public.
- The degree of, or potential for, interdisciplinary collaboration and cooperation among state and regional investigators.
- The potential for the successful completion of work within the stated time and budget.

Each proposal received will be evaluated by at least three external peer reviews. Additionally, a technical panel external to the Delaware Sea Grant College Program will evaluate proposals and peer reviews and recommend to the Sea Grant director those proposals deemed most worthy of consideration. The director will consider the panel's recommendations, consult with the management staff, and determine which proposals should be included in the core program. The director will notify the National Sea Grant Office of these decisions, will document the rationale for them, and will inform potential investigators of the decisions after final approval by the National Office.

Project Review Procedures

Evaluation of progress is continuous. Formal and informal reporting of results to program, state, and national decision-makers is key to the process. The Delaware Sea Grant College Program will continue its long-standing system of ongoing evaluation to monitor program progress. Each principal investigator will report on the status of project research on a regular basis by means of periodic discussions with the director, an annual written report, and a report to the Delaware Sea Grant Advisory Council at the end of the project funding cycle. The director will report accomplishments of each program element annually to the Governor and General Assembly as well as the National Sea Grant Office.

Implementation Schedule

The following general schedule delineates the steps required to implement the priorities stated in this program plan:

1998

January — Appoint Sea Grant Advisory Council.

March — Issue Delaware Sea Grant Program Plan. Issue Request for Proposals (1).

April — Evaluate pre-proposals; notify proposers.

June — Annual report due to the Governor and General Assembly. Full proposals due in Delaware Sea Grant Office.

July – August — Evaluate proposals (technical and programmatic review).

September — Proposals selected; notify proposers.

November — Biennial implementation plan and omnibus proposal (1) due in National Sea Grant Office.

1999

February — New funding cycle begins (1).

June — Annual Report due to the Governor and General Assembly.

Sept. – Dec. — Six-month evaluation of program progress; personal interviews with investigators.

2000

January — Twelve-month evaluation of program progress: written progress reports due in Delaware Sea Grant Office.

February — Revise Delaware Sea Grant strategic plan. Submit annual progress report to National Sea Grant Office.

March — Issue Request for Proposals (2).

April — Evaluate pre-proposals; notify proposers.

June — Annual report due to Governor and General Assembly. Full proposals due in Delaware Sea Grant Office.

July – August — Evaluate proposals (technical and programmatic review).

September — Proposals selected; notify proposers.

November — Biennial implementation plan and omnibus proposal (2) due in National Sea Grant Office.

2001

February — Funding cycle ends (1); new funding cycle begins (2).

March — Final research reports due in Delaware Sea Grant Office (1).

April — Investigators present completed research projects to Sea Grant Advisory Council.

May — Self-Evaluation of program reported to National Sea Grant Office.

June — Annual report due to Governor and General Assembly.

July — Program Assessment Team visit by National Sea Grant Office.

Sept. – Dec. — Six-month evaluation of program progress; personal interviews with investigators.

2002

January — Twelve-month evaluation of program progress; written progress reports due in Delaware Sea Grant Office.

February — Revise Delaware Sea Grant strategic plan. Submit annual progress report to National Sea Grant Office.

March — Issue Request for Proposals (3).

April — Evaluate pre-proposals; notify proposers.

June — Annual report due to Governor and General Assembly. Full proposals due in Delaware Sea Grant Office.

July – August — Evaluate proposals (peer and technical review).

September — Proposals selected; notify proposers.

November — Biannual implementation plan and omnibus proposal (3) due in National Sea Grant Office.

2003

February — Funding cycle ends (2); new funding cycle begins (3).

March — Final research reports due (2) in Delaware Sea Grant Office.

April — Investigators present completed research projects to Sea Grant Advisory Council.

June — Annual report due to Governor and General Assembly.

Sept. – Dec. — Six-month evaluation of program progress; personal interviews with investigators.

2004

January — Twelve-month evaluation of program progress: written progress reports due in Delaware Sea Grant Office.

February — Revise Delaware Sea Grant strategic plan. Submit annual progress report to National Sea Grant Office.

March — Issue Request for Proposals (4).

April — Evaluate pre-proposals; notify proposers.

June — Annual report due to Governor and General Assembly. Full proposals due in Delaware Sea Grant Office.

July – August — Evaluate proposals (technical and programmatic review).

September — Proposals selected; notify proposers.

November — Biannual implementation plan and omnibus proposal due in National Sea Grant Office.

2005

February — Funding cycle ends (3); new funding cycle begins (4).

March — Final research reports due (3) in Delaware Sea Grant Office.

April — Investigators present completed research projects to Sea Grant Advisory Council.

June — Annual report due to Governor and General Assembly.

Sept. – Dec. — Six-month evaluation of program progress; personal interviews with investigators.

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