UNIVERSITY OF WISCONSIN

Great Lakes HORIZONS

THE LONG-RANGE PLAN

SEA GRANT INSTITUTE

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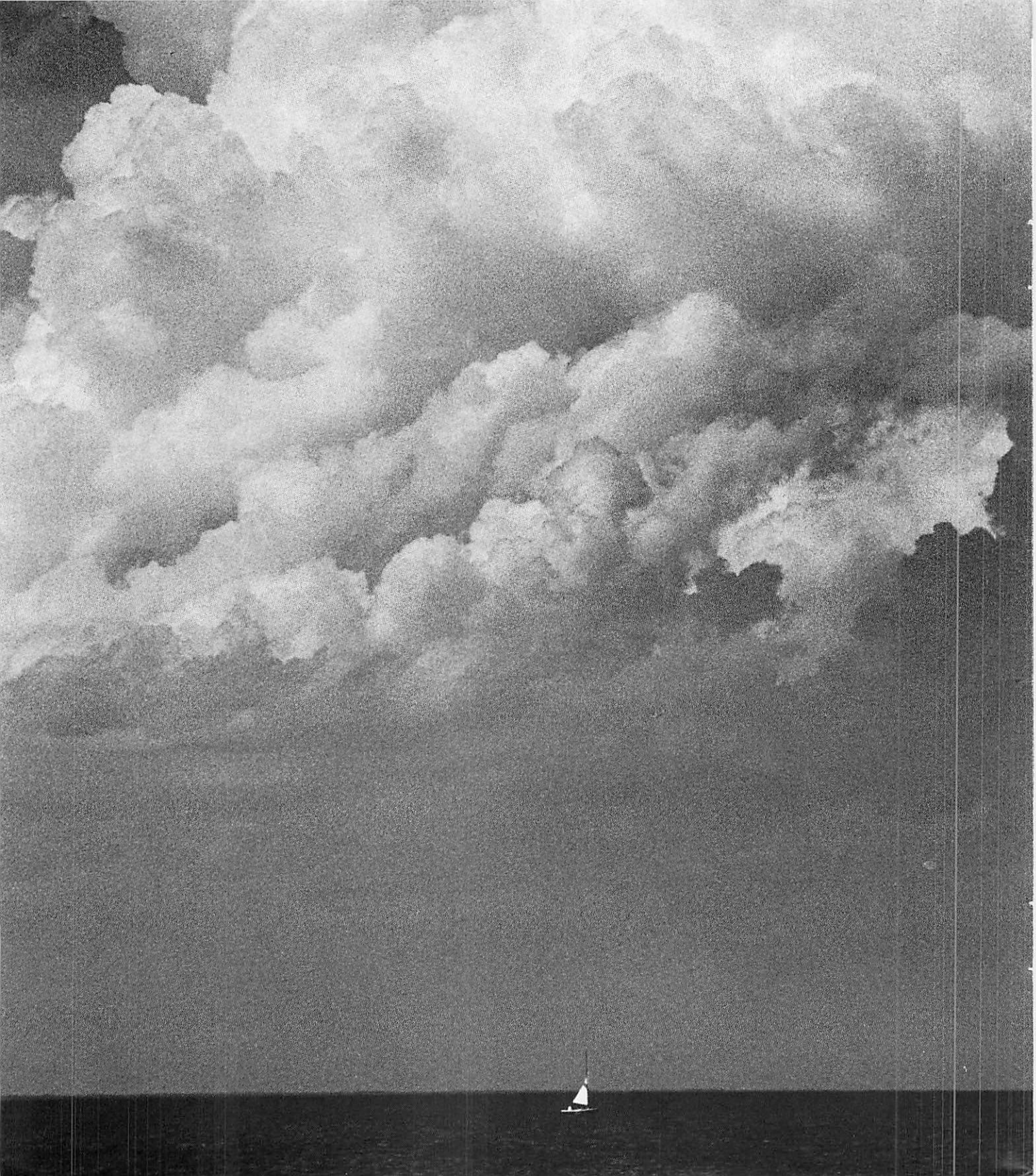


SEA GRANT AND THE GREAT LAKES

A Natural Resource

The five Great Lakes are among the world's greatest natural resources. Lakes Superior, Huron, Michigan, Erie and Ontario and their connecting rivers are the largest freshwater system on Earth, holding a fifth of all the surface freshwater on the planet. Four of the lakes are split by 1,200 miles of U.S.-Canadian border, though by treaty Canada also has a say in the use of the waters of the all-American Great Lake, Lake Michigan. Eight states (Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania and New York) and two Canadian provinces (Ontario and Quebec) share the lakes, their connecting waterways and the St. Lawrence River, through which the lakes empty into the Atlantic Ocean.

More than 40 million United States and Canadian citizens live in the Great Lakes Basin, and billions of gallons of Great Lakes water are used each day by the region's industries and municipalities. The Great Lakes-St. Lawrence Seaway system provides overseas shipping for midcontinent manufacturing and agricultural industries. The lakes also offer abundant recreational opportunities and provide employment for commercial and charter fishermen, shipbuilders, longshoremen, lock workers, sailors, and people in related businesses. The current economic benefit to the region of the sport and commercial fisheries alone is estimated to be nearly $2 billion a year.

A Scientific Resource

Apart from the intrinsic value of the Great Lakes, these inland seas also serve as a laboratory for improving and increasing scientific knowledge about vital aspects of the larger ocean environment. As a microcosm of the world ocean, the Great Lakes constitute a resource and management model from which much can be learned. This is especially true with regard to understanding the fates and effects of toxic chemicals in the aquatic environment and on human health; developing an ecosystem approach to fisheries management; rehabilitating estuarine environments, and exploring society's response to rising sea levels as a result of global warming.

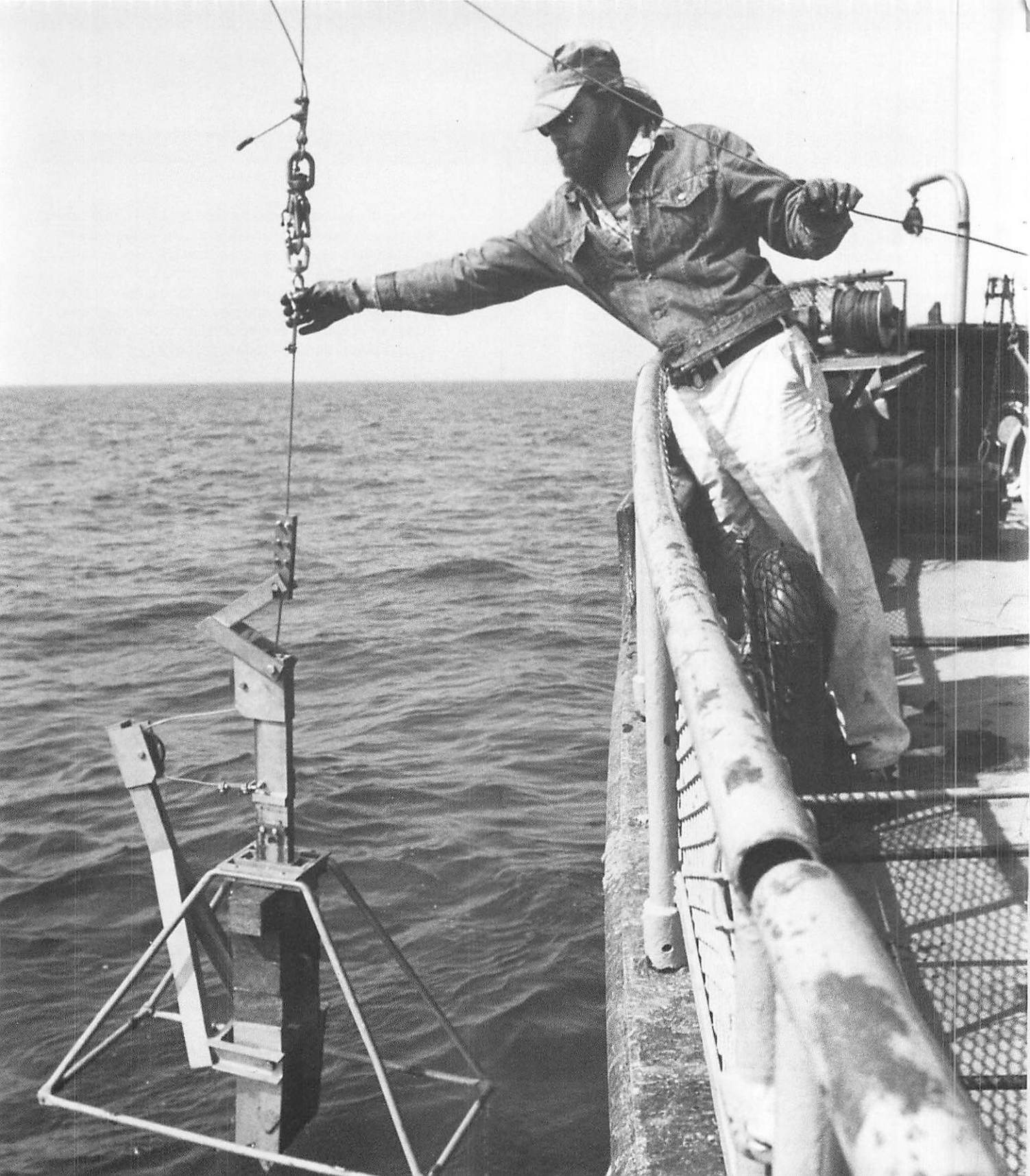
Today, it is generally recognized that the Great Lakes ecosystem must include people. The lakes are not isolated from people, nor can they be. Recognition of this fact has led to new approaches for dealing with the Great Lakes. Instead of focusing only on a particular chemical or species of fish, we must now consider how the entire ecosystem works and then try to prevent damage to any part of it.

A Management Resource

Clearly, Great Lakes and ocean resources must be managed in ways that will ensure their continued high quality and biological productivity. Their clean waters, diverse fisheries and varied recreational opportunities are bound to become more valuable in the future. Prudent stewardship of these renewable resources today will pay rich dividends in the years to come. This is what Sea Grant is all about—the protection and wise use of Great Lakes and ocean resources.

The Sea Grant experiment—the creation of a partnership of universities, federal and state governments and industries for developing interdisciplinary research and institutional structures that encourage creativity and effectiveness—has paid off handsomely. Sea Grant's focus on issues, rather than on single disciplines within the sciences, has kept universities responsive to the needs of the nation and enables creative individuals and groups of people to take advantage of new opportunities and to pursue new research initiatives. As a public university and the research arm of its state, the highly productive University of Wisconsin System has provided fertile ground for the Sea Grant model to flourish. As a founding Sea Grant institution, the University of Wisconsin has played a significant role in Sea Grant's national success—a success that is solidly based in the American public university's traditional tripartite structure of education, research and outreach.

Robert A. Ragotzkie, Director



THE UNIVERSITY OF WISCONSIN SEA GRANT COLLEGE PROGRAM

■ ***Overview***

The University of Wisconsin Sea Grant College Program is a unique working partnership of federal, state, university and private sectors. Established in 1968, the UW Sea Grant College Program embodies "The Wisconsin Idea" in action. The goal of the program is the preservation and wise use of the marine environment and its resources. In pursuit of this goal, the UW Sea Grant program conducts broad-based, comprehensive programs of research, education and outreach. Because of its Great Lakes location, the Wisconsin program maintains a major focus on these inland seas. However, most of the research program also has application to the saltwater oceans and estuaries. The educational program includes courses and degrees in both oceanography and limnology. The outreach program, though focused on Great Lakes issues and opportunities, also includes global ocean mineral resources.

In its entirety, the program strives to serve both the state of Wisconsin and the nation. As a nonadvocate, the UW Sea Grant program is ideally positioned to build bridges and foster partnerships among all the players in the marine environment—governments and resource management agencies, public users of these resources, and private industry. In addition, the program contributes to the education of future leaders in the field of marine environment and resources and to the creation and maintenance of an informed and educated public. It accomplishes these functions by providing accurate and credible information on the Great Lakes and ocean environment and related resources by conducting or supporting a wide variety of courses, conferences, workshops and traditional outreach activities. Through its research program and interactions with industries and state and federal management agencies, the University of Wisconsin Sea Grant College Program has made significant contributions to a better understanding and use of the Great Lakes. The Wisconsin Sea Grant College Program is recognized as a national leader in research on microcontaminants and water quality, fishery and ecosystem dynamics, estuarine systems and their management, and the medical and physiological aspects of scuba diving. Over the last 20 years, it has also provided a stream of well-trained and educated students, many of whom have gone on to leadership positions in the private and public sectors, where they continue to apply the results of Sea Grant research. The recognition of these contributions has earned the program continuous strong support from the Congress, the State of Wisconsin, the University of Wisconsin System and industry.

Since its inception, the UW Sea Grant program has held 12 major planning meetings focused on overall program management and direction as well as individual research subprogram goals and objectives. Participants included program staff, research subprogram coordinators, members of the UW Sea Grant Advisory Council, other university faculty and experts from industry, government, local communities and user groups. Regular meetings of the sub- program coordinators and project investigators and of program staff serve to flesh out and refine the detailed plans. Out of this broad and pluralistic process has come a general direction for the program and detailed plans for the subprogram components.
In creating and carrying out this plan, the UW Sea Grant program is guided by a set of policies—proven scientifically effective and highly productive in terms of long-term effect on the management of Great Lakes and ocean resources. Our policies are to:

- Encourge and support long-term research.
- Support graduate students in research projects.
- Maintain high research quality through rigorous peer review and project accountability.
- Emphasize interdisciplinary cooperation.
- Support high-risk, innovative research projects.
- Bring promising young investigators into the program.

The UW Sea Grant program is organized into eight research subprograms, plus the program-wide Advisory Services, Communications and Education activities. The goals and detailed plans for each of these units are presented in the following sections.

LIVING RESOURCES

Current Situation

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

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

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

Great Lakes ecosystems are undergoing rapid and continuous change due to management actions that reduce nutrient and contaminant loading and those that alter biological communities. In addition, the invasion and management of exotic species confound and compromise the long-term management goals of restoration and rehabilitation of native communities. Exotic species are an ecologically important reality for the foreseeable future and can be enhanced or diminished through appropriate actions. A functional view of species interactions within an ecosystem context is the first requisite of optimal development and use of Great Lakes resources. The Wisconsin Sea Grant College Program has been and will continue to be a leader in developing ecosystem perspectives for aquatic resource management.

Long-Term Goals and Priorities

Research projects in the University of Wisconsin Sea Grant Living Resources Subprogram focus on critical issues required for the understanding and effective management of Great Lakes resources. Living Resources research priorities are guided by and derived in part from the U.S.-Canadian International Joint Commission's ecosystem-level management objectives for water quality, fish community management goals coordinated through the Great Lakes Fishery Commission and the Strategic Fisheries Plan of the Wisconsin Department of Natural Resources (DNR).

The long-term goals of the Living Resources Subprogram revolve around three general themes:

- Understanding processes and mechanisms that structure biological communities and their ecosystem-level interactions.
- Causes of variability in populations and the management options that can respond to or alter that variability.
- Creative research applications that can enhance the development and use of living resources.

Short-Term Goals and Objectives

The Living Resources Subprogram has four major research goals for the next five years:

- Development of a size-based model of early life history dynamics and recruitment success for planktivorous fishes in Lake Michigan.
- Assessment of the role of yet another exotic species (Bythotrephes, a zooplankter) in Great Lakes food web interactions.
- Assessment of the value of paleolimnological evidence as a basis for conceptual and empirical analyses of Great Lakes food webs.
- Development and distribution of a library of bioenergetics models.

Specific research objectives for the 1988-90 biennium include:

- Development of a vital statistics fishery management model for the burbot populations of Green Bay, Lake Michigan.

- Synthesis and summary of the long-term projects on uses of artificial and natural chemical imprinting techniques as a basis for enhancement of spawning success of lake trout stocks in Lakes Michigan and Superior.

- Development of predator/prey–based energetics models specific to the various life histories represented by different strains of steelhead trout to be stocked by the Wisconsin DNR.

- Transfer of the energetics modeling technology, which was developed under Wisconsin Sea Grant support, to the professional fisheries community. This will be accomplished through a series of short courses and workshops geared towards federal, state, university and private industry workers involved in fisheries management, research and education.

■ *Opportunities*

In addition to the identified research goals and objectives, the Living Resources Subprogram will pursue development of multidisciplinary research initiatives with regard to important unresolved issues, such as developing techniques for the reestablishment and maintenance of native fish communities.

Subprogram scientists also plan to collaborate with investigators in the Microcontaminants and Water Quality Subprogram on the development of the experimental and modeling capability required to develop strategies for minimizing transfer of toxic contaminants through food webs.

Living Resources investigators will also respond to opportunities to collaborate and pursue new initiatives on issues raised in the Green Bay Estuary and Policy Studies subprograms.

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GREEN BAY ESTUARY

Current Situation

The University of Wisconsin Sea Grant Green Bay Estuary Subprogram was developed in recognition of the fact that Green Bay, besides being a microcosm of the Great Lakes, is fairly typical of industrialized and polluted estuaries everywhere. As such, it offers a model system for research on and management of not only the Great Lakes but estuaries in general.

The largest freshwater estuary in the world, Green Bay is highly productive and serves a variety of uses. It produces half the fish caught on Lake Michigan. It is a major waterfowl migration stop, and its coastal marshes provide critical fish spawning areas. Its 40,000-square-kilometer watershed is home to some 750,000 people. The bay also serves as a sink for waste discharges from five major municipal wastewater treatment facilities and 13 paper mills along the bay's major tributary, the heavily industrialized Lower Fox River, along with runoff from the basin's livestock and crop farms.

The concentrations of nutrients, toxics and biota in Green Bay are high, and so are the rates of physical, chemical and biological processes, gradients of which occur within distances of 30 to 40 miles. These factors facilitate the measurement and evaluation of ecological effects that may be due to changes in the management of the bay over the last 100 years.

In 1985, lower Green Bay was identified by the Water Quality Board of the International Joint Commission as one of 42 "areas of concern" in the Great Lakes requiring "Remedial Action Plans." Sea Grant's research and community presence served as a catalyst to precipitate this comprehensive rehabilitation program and contributed to Green Bay's selection as Wisconsin's first site for a Remedial Action Plan. The plan, which lays out key action items to restore the beneficial uses of the bay, was signed in February 1988—the first such plan completed in the region. It involved considerable effort by the Wisconsin Department of Natural Resources (DNR), local governments, faculty members associated with Sea Grant, industrialists and community citizens.

The Green Bay area has also been chosen as a focal point for a broad new interdisciplinary study by the U.S. Environmental Protection Agency (EPA) and the Wisconsin DNR called the "Green Bay PCB Mass Balance Study." U.S. EPA administrator Lee Thomas has called this project a "national showcase," and much of Wisconsin's Sea Grant research on contaminant transport and fate has been used to plan this important study. The Mass Balance Study is designed to answer such questions as: How much PCB enters Green Bay from the Fox River? For how long will this input remain? How polluted is Green Bay with respect to PCBs? How long will PCBs remain a problem in Green Bay? What is the rate of exchange of PCBs between the bay and the atmosphere? What quantity of the PCBs in Green Bay will enter Lake Michigan?

Sea Grant's involvement in these studies brings a needed research component on the processes governing the transport and fate of toxics in the environment. The development of mathematical models on toxics transport in multimedia environments could result in relatively rapid and inexpensive ways to complement field and laboratory measurements. Such models would also develop a global view for attacking water quality problems.

Subprogram research efforts are coordinated with those of management agencies, government laboratories and other universities. Subprogram investigators work directly with UW Sea Grant Advisory Services agents and specialists to deliver research information to resource management agencies and other user groups in the region and to provide feedback to Sea Grant's university scientists.

Long-Range Goals

The Green Bay Estuary Subprogram is a model for Great Lakes research. The U.S. EPA, Wisconsin DNR, U.S.-Canadian International Joint Commission and other agencies are closely following this research, the primary goal of which is to enable these and other management agencies to allocate limited resources to solve critical water quality problems.

The long-range goals of the Sea Grant Green Bay Estuary Subprogram encompass four major areas of research:

- Toxic Contaminants—Transport and fate processes, effects on flora and fauna, the dynamics of in-place pollutants, and the contaminants relationship between the bay and the rest of Lake Michigan.

- Nutrient/Trophic Interactions—Processes that influence the rates and movement of nutrient inputs to the bay as well as their ultimate effects on the quantity and quality of secondary production both in the bay and in Lake Michigan.

- Fisheries—Factors responsible for the emergence or decline of fish communities and the interaction between the fisheries of the bay and those of the rest of Lake Michigan.

- Socioeconomic Issues—Social and economic impact assessments of pollution abatement, risk assessment, fisheries management, and institutional analysis and identification of alternatives for the management of the Great Lakes ecosystem.

■ *Planned Research*

Toxic contaminants continue to plague the Green Bay system. Contaminants not only threaten the viability of aquatic species like fish and fish-eating birds, but also raise serious concern about the health effects on humans who ingest these contaminants by eating locally caught fish.

Studies planned for the next three to four years will combine previous research on biogeochemical cycling with the current effort of the U.S. EPA and Wisconsin DNR on contaminant mass balances to determine how quickly particles and the associated nutrients and contaminants move from source to sink, how many cycles particles make through the system before being permanently buried or lost from the bay, and how quickly the system will respond to changes in inputs of nutrients, particles and particle-associated contaminants.

Such research is crucial to understanding the transport and persistence of toxic organic compounds in Green Bay. It is clear that much of the organic contaminant loading of Green Bay is derived from the Fox River and lower bay sediments, and these studies will help determine if Green Bay is a sink for these contaminants or a source of contaminants to Lake Michigan and the other Great Lakes. The amount of individual PCB congeners, the rate of volatilization, degradation and permanent burial in this and similar coastal systems will also be quantified.

Over the next three to four years, the Green Bay Estuary Subprogram will also build on its previous research in the area of biological productivity to help state and federal management agencies make reasonable predictions of changes in phytoplankton productivity and in the herbivory effectiveness of zooplankton with regard to Remedial Action Plan recommendations on reducing phosphorus and suspended solids in lower Green Bay.

Planned research on the trophic size-class efficiency of fish production in the estuary will extend the conceptual framework of the trophic structure of the bay to include fish, which will help improve our understanding of the energy flow through the bay system, help resolve the question of "bottom-up" (nutrient) versus "top-down" (predator) control of the trophic status of the bay ecosystem and allow for more efficient harvest of its fish.

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MICROCONTAMINANTS & WATER QUALITY

Background

The University of Wisconsin Sea Grant Microcontaminants and Water Quality Subprogram was developed in response to problems related to chemical contaminants and eutrophication in the Great Lakes. While research on Lake Michigan is emphasized, subprogram project results are applicable to all the Great Lakes and much of the ocean environment.

Microcontaminants like PCBs accumulate in aquatic organisms and become concentrated as they move up the food chain. The contaminants pose a potential health threat to aquatic organisms, fish eating birds and mammals, and ultimately to people who eat the fish. Research in the Microcontaminants and Water Quality Subprogram is aimed at providing a sound basis for management of these microcontaminant problems.

Water quality is also affected by excessive algal growth. Algal populations are regulated not only by nutrient element loading and availability, but also by predation from organisms higher up the food chain. Management of water quality requires an understanding of the importance of both essential nutrients and trophic interactions in controlling algal populations.

Long-Range Goals

The goals of the Microcontaminants and Water Quality Subprogram are purposely broad to allow individual projects to focus on critical gaps in available information and to apply emerging technologies to microcontaminant and water quality problems.

The long-range goals of this subprogram are to:

- Identify microcontaminant and water quality problems, and their causes or sources.
- Determine the effects of these problems, particularly the effects of microcontaminants on aquatic organisms and associated food chains.
- Identify and evaluate the processes controlling the behavior, fate and effects of chemical contaminants.
- Develop and apply methods for predicting the response time of the system to changes in chemical loadings and to in-place contaminants.
- Seek improved strategies for contaminants and water quality surveillance and trend assessment.
- Develop methods and strategies for remedial action.
- Assess the risks associated with microcontaminant problems in ecosystems of the Great Lakes.

Short-Term Objectives

Research in this subprogram during the next five years will focus on the fate and effects of contaminants in the Great Lakes, nutrient element budgets and lake/groundwater interactions. Specific objectives and time frames are:

- To develop and improve procedures for assessing the fate of halogenated aromatic hydrocarbons in the Great Lakes and atmosphere. The effects of cosolvents, cosolutes, colloids and temperature on the aqueous solubility of chlorinated aromatic compounds will be investigated, and thermodynamic, semi-empirical and empirical predictive schemes will be developed. In addition, structure-activity relationships for predicting abiotic and biotic degradation will be evaluated. The results will be used to generate environmental behavior profiles for chlorinated aromatic hydrocarbons for comparison to *in situ* measurements. (Five years)
- To determine the rate and extent of contaminant uptake and release by natural particles in the lakes as a function of contaminant and particle properties and natural particle cycles. Major particle types and colloids will be obtained from Lake Michigan and speciated, and surface chemical, physical and hydrodynamic properties will be characterized. The kinetics of adsorption and desorption will be measured for selected inor-

ganic and organic contaminants. The results will be used to evaluate the role of specific particle groups in contaminant partitioning and the efficacy of using a contaminant distribution coefficient approach in modeling the cycling and residence times of contaminants in the lake systems. (Four years)

- To determine the sedimentary sink term for biogeochemical mass balances in Lake Michigan. The annual deposition rate of carbon, nitrogen, phosphorus and silica will be determined, and the fractions permanently buried and returned to the water column will be evaluated. These estimates will be used in developing mass balances and residence times in Lake Michigan, which are important to evaluating responses to nutrient loading and the transport of contaminants to sediments. (Three years)

- To evaluate lake/groundwater interactions along the Wisconsin shoreline of Lake Michigan. The hydrological properties of the Lake Michigan bed along the shoreline will be mapped using geophysical methods. The results will be used to determine the role of groundwater in the mass and chemical budgets of Lake Michigan and Green Bay. (Two years)

- To evaluate toxic halogenated aromatic hydrocarbons in lake trout gametes as a factor in fry survival. Specifically, to determine (1) whether exposure of fertilized eggs to tetrachlorodibenzo-*p*-dioxin (TCDD) causes egg, sac fry or fry mortality; (2) whether fry, exposed as eggs to TCDD, exhibit decreased growth from impaired absorption of yolk nutrients, hepatotoxicity or hypophagia; (3) mechanisms of TCDD embryo-larval toxicity, and (4) whether PCBs and TCDD interact to cause embryo-larval toxicity. The results will be used in evaluating the stocking of lake trout in Lake Michigan. (Four years)

- To assess, based on the relative quantities of PCB congeners in Sheboygan Harbor sediments, whether dechlorination processes are occurring and whether the sediment PCBs are less of a toxic hazard than originally thought. This Lake Michigan harbor is one of the major PCB contamination sites in the Great Lakes basin. Since Sheboygan Harbor sediments were contaminated with largely one type of Aroclor, a congener-specific assessment of the harbor sediments can determine if, and to what extent, dechlorination processes are occurring. If the PCB congeners found in the harbor sediments are found to be nontoxic, there would be substantial economic savings for the community and the public. (Three years)

■ *Anticipated Benefits*

The expected benefits of this research subprogram are far-reaching. Research on contaminant behavior and fate will lead to improved assessment of the relationships between the properties of contaminants, their distribution and persistence in the ecosystem, and the response time of the system to in-place contaminants. The investigations of toxicological responses to contaminants will advance our ability to detect and evaluate the effects of contaminants on fish and to determine the impact of contaminants on the lake trout stocking program in Lake Michigan.

These fundamental advances in understanding chemical and biological processes will be applicable to assessment of the fate of contaminants and the risk these pose to humans and to saltwater and other freshwater ecological systems as well as the Great Lakes. In the Great Lakes region, improved understanding of the fate and effects of contaminants will be of benefit to users concerned with exposure to toxic substances and to managers developing remedial programs for the resource and programs for protecting its users.

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AQUACULTURE

Current Situation

Aquaculture plays a key role in the management of fishery resources in the Great Lakes region and has significant potential as means of food production. Resource management agencies throughout the region depend on aquaculture to support Great Lakes recreational fisheries, which in 1985 had an estimated total value of $1.4 billion. The trout and salmon fisheries of Lake Michigan are maintained almost entirely by stocking, as are many inland fisheries. A large share of Wisconsin's fish propagation budget is spent on culturing coolwater species, especially walleye and muskellunge. In Wisconsin and many other parts of the nation, coolwater fish culture and management is one of the fastest-growing areas of freshwater fishery biology.

Wisconsin has a well-established aquaculture industry. According to the U.S. Department of Agriculture, Wisconsin is the nation's fourth largest producer of rainbow trout. The state has more than 50 licensed fish farmers, who raise a variety of panfish, bait, and cool- and warmwater game fish. The University of Wisconsin Sea Grant Aquaculture Subprogram has played a leading role in the development of aquaculture in the state, the region and the nation. Aquaculture Subprogram investigators were instrumental in the creation of the Wisconsin State Aquaculture Plan, an economic development report jointly prepared by the University of Wisconsin College of Agriculture & Life Sciences, the Wisconsin Trout Growers Association, the Wisconsin Department of Natural Resources (DNR) and the Wisconsin Department of Agriculture, Trade & Consumer Protection. The plan was presented to the governor and legislature in late 1988.

A strategic 20-year plan recently developed by the Wisconsin DNR should result in much greater private-sector involvement in the propagation of game and forage fish. Several of Wisconsin's large sport fishing clubs already operate fish hatching and rearing facilities, and more are being planned. Subprogram investigators were also active in the development of the National Sea Grant Aquaculture Plan and the U.S. Department of Agriculture's Regional Aquaculture Centers, including a center for the North Central Region.

Since its inception, the UW Sea Grant Aquaculture Subprogram has brought scientists together from diverse fields—animal science, food science, veterinary science, genetics, immunology, physiology, nutrition, aquatic biology and engineering. The subprogram routinely provides "on-site" consultation and a variety of other outreach services in conjunction with UW Sea Grant Advisory Services personnel, resulting in a close working relationship between subprogram researchers and Wisconsin's fish farmers, food industry and other private-sector investors.

UW Sea Grant aquaculture research and advisory activities are conducted in cooperation with the UW Great Lakes Research Facility; UW-Madison College of Agricultural & Life Sciences and College of Engineering; Wisconsin Department of Agriculture, Trade and Consumer Protection; Wisconsin Department of Natural Resources; U.S. Fish & Wildlife Service; Great Lakes Fishery Commission; Wisconsin Fisheries Council, and the Musky Clubs Alliance of Wisconsin. The subprogram also continues to receive support from private-sector investors and industry involved in aquaculture development.

Through a cooperative agreement with the Wisconsin DNR, the Lake Mills State Fish Hatchery serves as the primary site for UW Sea Grant aquaculture research. The Lake Mills hatchery has 24 ponds ranging in size from 0.3 to 3.8 acres, three outdoor raceways, a small shop and fish holding house, and an abundant supply of both lake and well water. A wide variety of cold-, cool- and warmwater fish species are currently raised there.

Long-Range Goals

Because of climate, aquaculture in the Great Lakes region will probably be restricted to coolwater species like perch, walleye and muskellunge, and coldwater species like trout, salmon and whitefish. The primary long-range goal of the Wisconsin Sea Grant Aquaculture Subprogram, therefore, is to develop and improve the scientific and technological database necessary for the propagation and culture of these fishes.

The main research goals of the UW Sea Grant Aquaculture Subprogram for the next five years are to:

- Identify, and if possible select, rainbow trout from hatchery and wild stocks that have enhanced disease resistance.

- Produce hybrid crosses and develop methods of inducing (chromosomal) triploidy and tetraploidy in coolwater fishes, and examine the potential of these genetic manipulations for enhancing growth and controlling reproduction.

- Evaluate the potential of various combinations of hybrid crosses, ploidy manipulations, and hormonal methods of manipulating sex and growth, to enhance the production efficiency of coolwater fish culture.

- Develop procedures for assessing the physiobiological responses of lake trout to environmental stressors, as compared to rainbow trout, and determine whether and the extent to which low-level gas supersaturation and/or oxygen supplementation elicit a general physiological stress response in these species.

Long-term plans for improving and expanding both the research and production facilities at Lake Mills are currently being formulated in concert with the Wisconsin DNR and the UW-Madison College of Agricultural and Life Sciences. This will dramatically increase the university's aquaculture research capabilities in the years ahead. The completion of the remodeling of the UW-Madison Water Science and Engineering Laboratory in 1989 will provide the UW Aquaculture Program with analytical and wet laboratories, shop space and offices on the UW-Madison campus, which will be particularly valuable for the training of graduate students.

■ *Current Activities*

Current Aquaculture Subprogram research is focused on genetics, control of sex and reproduction, stress physiology, disease resistance and other factors affecting fish health and growth. Subprogram investigators are examining various rainbow trout stocks for genetic traits that enhance disease resistance with the goal of improving fish survival and production efficiency. They are also hybridizing coolwater fishes and manipulating chromosome numbers (ploidy states) in an attempt to produce more productive strains.

Related efforts are aimed at improving techniques for genetically manipulating coolwater fishes and evaluating the effects of sex and reproductive state on growth enhancement of genetically altered coolwater fishes. Wisconsin Sea Grant Aquaculture researchers are also examining the stress responses of lake trout and rainbow trout to dissolved gas supersaturation and pure oxygen supplementation of fish rearing waters, which should help define the benefits, as well as the limits, of this new technology in improving production efficiency.

While many Aquaculture Subprogram research activities serve the goals of the State Aquaculture Plan, the knowledge gained and techniques developed as a result of these efforts will be applicable to fishery enhancement programs and to commercial aquaculture throughout the nation and world.

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SEAFOOD TECHNOLOGY

■ *Current Situation*

The U.S. seafood industry is currently experiencing a strong economy and anticipating an even stronger economic future as as result of increased consumer awareness of the health benefits of eating fish and seafood. To meet this increased demand, the industry needs to be kept abreast of new developments and technologies designed to improve seafood harvesting, handling and processing. This information need must be fulfilled if the U.S. seafood industry is to compete on the world market. For consumers, such improvements mean more stable and affordable prices for seafood items, and improved seafood quality and safety. Growing concern about seafood quality and safety has prompted consumer groups recently to call on Congress to establish mandatory national seafood inspection and bring more structure and uniformity to the seafood industry.

The seafood industry needs to improve its seafood processing methodology and to devise procedures for storing and maintaining the nutritional character and organoleptic quality of seafoods. The industry also must incorporate recently developed procedures for safely processing seafood and fishery products.

The University of Wisconsin Sea Grant Seafood Technology Subprogram was established to provide a vehicle for responding to the problems and concerns of the seafood industry. The focus of the Seafood Technology Subprogram has been on improving the quality of seafood products and promoting the development and wise use of the nation's aquatic food resources.

■ *Long-Range Goal*

Although fish production has improved in recent years with an increased harvest of some species, the Great Lakes fishery is still in a fragile state due to the limited number of fishable species, quotas and other restrictions. To improve their income, commercial fishermen and processors need to make more efficient use of the resources available to them. This will require creating new markets for underutilized fish stocks as well as making a more balanced use of existing stocks.

Burbot and suckers are two Great Lakes food fish netted regularly by commercial fishermen that are not being utilized because of their low value and marketability. Freshwater crayfish also has great potential as a commercial seafood product. Though also harvested for human consumption, Great Lakes smelt are marketed mostly for use in zoo animal feed and, like alewives, in pet foods. A more balanced use of these species would expand the market for smelt for human consumption and for alewives for livestock feeds.

No matter how the Great Lakes commercial fishery chooses to improve its competitive position, it will require the development and use of new and more sophisticated technology to harvest, process and market fishery products. Therefore, the overall long-range goal of the Seafood Technology Subprogram is to:

- Expand the information base on underutilized and traditional fish species and other seafood products to better determine the quality, shelf life, safety and marketability of existing and new seafood items.

■ *Short-Range Goal*

A major problem for the seafood industry at present is that the frozen muscle of members of the gadoid family (cod, pollock, hake, cusk and burbot) is extremely susceptible to textural deterioration during frozen storage due to the formation of formaldehyde in the muscle tissue. New technology is needed that can reduce or eliminate this problem, which would increase the use of underfished pollock and red hake stocks in the oceans and burbot stocks in the Great Lakes. Consequently, the major goal of this subprogram during the next few years is to:

- Expand the information base to better determine the quality, shelf life and marketability of gadoid fishes.

Available talent and funding will ultimately determine the scope of the research in this area.

■ *Present Status*

Despite its modest size, the Seafood Technology Subprogram's benefits to the seafood industry, other researchers and the general public to date have been substantial. Subprogram investigators have made significant advances in seafood flavor identification and stabilization, and in developing new packaging techniques for fresh and frozen seafood products.

They have also developed new and innovative analytical techniques for isolating chemical substances for gas-chromatographic analysis. Through published results and presentations at scientific meetings and other public forums, they have helped increase the public's awareness of the benefits of seafoods and how to properly handle, preserve and cook these foods.

The Seafood Technology Subprogram in the years ahead will continue to be closely tied to the Advisory Services and Communications subprograms to ensure that the latest seafood research findings are quickly and directly transferred to the private sector for development.

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POLICY STUDIES

Scope

The University of Wisconsin Sea Grant College Program's tradition of high-quality research includes a strong social sciences dimension—research that helps solve a broad range of current and potential public policy problems related to Great Lakes and ocean resources.

Projects in the UW Sea Grant Policy Studies Subprogram reflect the program's overall goals of identifying problem areas, exploring policy options and providing better information to resource managers, planners and the public. Highest priority is given to innovative projects that investigate both theoretical and methodological issues.

Long-Range Goals

The two long-range goals of the Policy Studies Subprogram are to:

- Update and assess Great Lakes policy issues related to risk assessment, fishery economics, institutional aspects of water quality and quantity, and the impact and importance of Great Lakes-based recreational developments and activities.

- Increase the scope and overall significance of Great Lakes policy studies within the UW Sea Grant College Program.

The objective of the latter subprogram goal is to expand the relative emphasis of policy studies in the UW Sea Grant College Program by attracting qualified investigators to take on high-priority policy-related issues. Specifically, the goal is to expand the Policy Studies Subprogram by adding at least one new investigator in each of the next biennial proposal cycles.

Current Activities

Currently, the Policy Studies Subprogram is focusing on three issues. The first is Great Lakes water policy. Abundant water is one of the region's most important economic assets and will play a major role in the economic evolution of the region in future years. However, the current consumptive use of Great Lakes water is not well documented, and future projections of water consumption are inadequate. Current research is aimed at greatly improving the estimates of current consumptive uses and investigating linkages with the regional economy as a basis for projections of future use. The investigators are also exploring the implications of consumptive uses on lake levels and water quality.

A second issue is the economic implications of alternative lake trout management strategies. Great Lakes fish management agencies have tried for nearly two decades to reestablish naturally reproducing stocks of lake trout wiped out by the invasion of parasitic sea lamprey in the 1940s and 1950s. Except for Lake Superior, these efforts have failed. The Great Lakes states and provinces and the federal governments of the United States and Canada are approaching a critical decision-point with regard to lake trout rehabilitation. Using Wisconsin waters of Lake Michigan as a case study, UW Sea Grant policy researchers are comparing the economics of continuing the present put-and-take sport fishery of hatchery-produced lake trout and other salmonids, versus the potential benefits and cost-savings of establishing naturally reproducing lake trout stocks.

The third area encompasses three objectives regarding the valuation of Great Lakes fisheries:

1) To develop an innovative research approach to determining the validity of new techniques for sport fishing valuation. (This will help policymakers more accurately value Great Lakes and ocean sport fishing opportunities. Available studies of the economic values generated by the Great Lakes commercial fisheries also need to be improved and updated).

2) To provide estimates of the benefits to consumers and other sectors of the economy from the major Great Lakes fisheries at both the state and national levels.

3) To estimate the existence values that accrue to the general population from rehabilitation of Great Lakes fisheries and ecosystems.

This information will help us more effectively address the economic merits of fishery rehabilitation policies, the potential ramifications of policies to deal with sport-commercial fishing conflicts, the potential impacts of risk management strategies to deal with environmental contaminants and other pressing policy issues.

■ *Opportunities for Future Research*

Policy studies must, to a large degree, be reactive, dealing with policy issues as they evolve. Based on its past successes, Wisconsin Sea Grant is in a unique position to periodically reassess, update and enlarge bodies of knowledge addressing policy problems in the areas of water pollution, commercial shipping, water consumption and lake levels management, fishery management and lake-related recreation.

Current issues needing more thorough research in the years ahead include the assessment, management and communication of the human health risks of toxic contaminants in fish; the institutional and economic aspects of water pollution control; processes for evaluating the effectiveness of Remedial Action Plans for degraded Great Lakes ecosystems; aquaculture development policy, and coastal land-use policies.

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DIVING PHYSIOLOGY

Background

The development of self-contained underwater breathing apparatus (SCUBA) in the early 1950s freed divers from airhoses and heavy gear. Since then, the numbers of commercial, scientific and recreational divers have increased dramatically. Today, more than three million Americans are trained scuba divers. Commercial diving is a vital activity, especially in the development of offshore energy resources. The needs of commercial divers have led to the development of new decompression procedures, and the principle of saturation diving has made extended activity practical at greater depths. Diving is also being used increasingly in undersea research, and scuba diving is one of the fastest growing sports in the country.

The field of hyperbaric medicine has advanced through the physiological knowledge gained through diving research and development. The physiological aspects of diving are still poorly understood, however, and the annual number of diver deaths and injuries remains unnecessarily high. Research on diving has been relatively slow. Before 1950, research in naval laboratories was almost the only source of progress. For a short time, the Office of Naval Research and the National Institutes of Health supported university-based diving research. That support has tapered off, and the United States is no longer a leader in diving technology.

Subprogram Development

The University of Wisconsin Sea Grant Diving Physiology Subprogram was established in 1978 to increase our knowledge of how the human body and mind respond to the stresses of immersion and high pressures of the underwater environment—knowledge that is vital for reducing the number of deaths and injuries both in sport and commercial diving ventures and in making the diving industry more cost-effective. This UW Sea Grant subprogram has assembled an interdisciplinary research team from a remarkable number and variety of fields and specialties, and in less than 10 years the University of Wisconsin has become recognized as a national leader in research on the medical, physiological and psychological aspects of diving.

Interest in the basic physiology of decompression led to a UW Sea Grant study of potential animal subjects for experiments too risky for human volunteers. This resulted in the discovery of sheep as the first practical animal model of aseptic bone necrosis, a potentially serious problem for people who make deep dives or work in compressed air environments. Bone necrosis can also develop in kidney transplant patients receiving steroid therapy to reduce rejection of the kidney. Further work with the "UW sheep model" promises important advances in understanding the mechanism, course and especially the early detection and effective treatment of bone necrosis.

Simulated dives expected to produce bone necrosis in sheep in turn led UW Sea Grant scientists to the first animal model of "the chokes," an uncommon but frequently fatal form of decompression sickness (DCS). A trial of short, relatively deep "bounce dives" with pygmy goats resulted in the discovery that this dive profile carries extraordinary risk of DCS injury to the spinal cord, including the likelihood of permanent paralysis. This form of DCS appears to be closely related to the currently high proportion of spinal cord injury among scuba divers. The likelihood that modified diving procedures may greatly reduce this risk adds an important direction to current UW Sea Grant studies.

Another Diving Physiology Subprogram project investigated the alarming published reports on the risks of diving during pregnancy. Using pregnant sheep in simulated dives, subprogram investigators found that instrumented fetal lambs invariably died of DCS, while control lambs showed no signs of DCS, thus indicating the reported special risks were an artifact of experimentation.

Another major contribution of this subprogram was an international symposium on loss of consciousness in diving held at UW-Madison in 1980 with support from the National Institutes of Health and the National Institute on Occupational Safety & Health. The symposium arose mainly from concern about respiratory effects of diving, especially from carbon dioxide retention from inadequate breathing during exertion.

That symposium also opened up an exciting new area of research when a UW-Madison investigator reported on his studies of panic behavior in firefighters using respiratory devices. Based on psychological tests, the investigator had successfully predicted which subjects would show inappropriate behavior in stressful situations. These studies conformed with the large proportion of fatal diving accidents that defy explanation, except for the probable role of psychological factors. These techniques are now being applied to users of underwater breathing apparatus to provide a practical means of identifying individuals likely to respond to stressful situations with panic or other life-threatening behavior. This research strongly indicates the practicability of identifying individuals who should either be trained to handle stress or perhaps discouraged from diving altogether.

■ *Long-Range Goal*

The overall goal of the UW Sea Grant Diving Physiology Subprogram for the next five to 10 years is to:

- Improve the safety and cost-effectiveness of diving through better understanding of physical and mental responses to the underwater environment.

Current objectives include better decompression procedures, earlier detection and treatment of such conditions as bone necrosis, and identification of panic-prone individuals. Opportunities to apply the findings beyond the field of diving, such as medical applications, will continue to be explored. A multidisciplinary research approach will continue to be emphasized.

■ *Current Objectives*

Specific objectives for the next five years include:

- A validated procedure for avoidance of spinal cord injury in short/deep scuba dives is the highest priority: Subprogram investigators aim to complete basic studies in sheep by the end of 1989. While the investigators will not develop testing procedures for humans, the information gained from the sheep model should greatly lessen the risks of such testing wherever it is done.
- Within a year, subprogram investigators expect to produce a definitive publication on the influence of different dive profiles on the prevalence of specific types of injury when DCS results.
- The goal of significant improvement in diver selection appears close at hand. Full validation and production of ultimate testing and interpretive materials is expected in the next two years. Firm procedures for improving of a diver's ability to cope with stress should be forthcoming within four years.
- Reaching a final end-point in studies of the mechanism, early detection and treatment of bone necrosis in the next three to four years is a relatively long-range goal. These studies will require the close cooperation of clinicians and the need for magnetic resonance imaging facilities.

■ *Anticipated Benefits*

Everyone involved in scientific, commercial or recreational diving—from individual divers and commercial diving contractors to governmental agencies like the National Oceanic & Atmospheric Administration and naval diving authorities—stand to benefit from this research. The large number of patients suffering from bone necrosis and related conditions may also benefit if medical spin-offs to this research are developed.

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NEW INITIATIVES

Scope

Investigations of the Great Lakes and ocean environment may be sweeping or sharply focused, aimed at specific locales or at vast regions. They may examine short or long periods of time; they may explore specific technologies as well as generic problems.

Given the breadth of research possibilities, Great Lakes and ocean investigations often reach beyond the predefined goals of any single UW Sea Grant subprogram and sometimes span two or more of the established subprograms.

The University of Wisconsin Sea Grant New Initiatives Subprogram provides a starting point for Great Lakes research projects that fall outside the confines of existing subprograms.

Long-Range Goal

The ongoing goal of the New Initiatives Subprogram is to:

- Provide an opportunity for university scientists and engineers to undertake original and innovative research on Great Lakes and ocean problems.

Opportunities for New Research

While virtually any Great Lakes or ocean environment and resources subject has potential as a Sea Grant project, the new Sea Grant Strategic Marine Research Program and the protocol added to the 1978 U.S.-Canadian Great Lakes Water Quality Agreement present a special opportunity for launching several new initiatives.

On the national level, appropriate areas of New Initiatives research include marine biotechnology and satellite remote sensing applications for the oceans and Great Lakes. The prospect of global warming and climate change investigations into the possible effects on the temperature, water levels and fisheries of the Great Lakes.

Another issue of growing interest and importance is the water budget of the Great Lakes and the diversion of water out of the basin. Other Great Lakes issues of current interest include dredging policy and shore erosion.

Current Activities

UW Sea Grant investigators are currently completing studies of the applications of three satellite systems for remotely sensing Great Lakes and coastal ocean water quality. These satellite systems can provide surface water temperature, chlorophyll-a and turbity measurements with a correlation coefficient greater than 0.90.

Such information could be useful for establishing an operational satellite-based water quality and temperature monitoring system for the Great Lakes and ocean waters.

UW Sea Grant scientists are correlating satellite data with fishery survey information as well as nutrient and plankton transects. This information and the methodology being developed will form the basis for a potential pilot project with the Wisconsin Department of Natural Resources that is aimed at satellite-based assessment of lake eutrophication.

Other UW Sea Grant investigators are studying the pullout resistance of harbor piles to ice forces. This project will provide information on improved design considerations for use by dock and harbor designers faced with piling "ice-jacking" problems characteristing of Great Lakes and arctic marine environments.

This information will help define improved design criteria for piles in these areas. The results of this research will also have broad applications for the oil and gas industry in offshore technology of anchor-piled floating platforms.

A third project is aimed at ascertaining how Great Lakes waves and storm surges are related and how this might affect coastal design. Specifically, the investigators will examine the combined effect of extreme strong waves and extreme storm surges along Lake Michigan. The investigators hope to develop accurate and realistic design tables for wave run-up

and produce public-domain personal computer software to enable a design engineer to use the results.

This information is presently unavailable and will be extremely useful for engineers designing shore protection for coastal property along Lake Michigan.

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ADVISORY SERVICES

Purpose

The University of Wisconsin Sea Grant Advisory Services Subprogram provides a link between the university and the users of Wisconsin's Great Lakes resources by conveying research findings and other information to the public, and by listening and responding to the information needs of client groups.

The Advisory Services Subprogram supports four field agents in five coastal Wisconsin communities—Superior/Ashland, Green Bay, Sister Bay and Milwaukee. Their clients include marine businesses, local governments, resource management agencies, shoreline residents and people involved in recreational pursuits. The agents provide information and assistance in solving marine-related problems to identified client groups through formal classes, informal workshops, short how-to publications, field demonstrations and individual assistance.

Four subject-area specialists complement the subprogram's field activities by providing in-depth knowledge of aquaculture, coastal engineering, fishery development and ice engineering. The specialists share their expertise by conducting statewide and national conferences, by providing technical assistance or demonstrations to individuals or groups of businesses, and by conducting field or laboratory research to assist in finding practical solutions to users' problems.

Support for issues of concern to the business community is provided by the UW-Extension Recreational Resources Center through workshops, consultation to field agents and businesses, surveys and the preparation of written business guidelines.

Long-Range Goal

The overall goal of UW Sea Grant Advisory Services is to:

- Apply university resources and all available information to solve marine-related problems and to provide new opportunities for users of Great Lakes and ocean resources.

To meet this goal, Advisory Services Subprogram personnel must:

- Be broadly based in knowledge of Great Lakes resources.
- Be skilled in a wide variety of techniques to deliver that knowledge to Great Lakes users.
- Be capable of quickly responding to user concerns and current Great Lakes issues.
- Be aware of changing trends in resource use and adjust efforts accordingly.

Current Issues and Opportunities

A current trend is the increasing use of Wisconsin's Great Lakes harbors for recreation. All of Wisconsin's 23 coastal communities have made or are in the process of making substantial public investments to capture tourist expenditures in water-based recreation. Marine recreation has become increasingly important to the economic stabilization and subsequent growth of these communities. Along with public investments have come private investments in marine recreation businesses. These developments provide the vacationer with increased opportunities for excursions, sailing, diving, windsurfing and other water-based experiences.

To assist in the development of Great Lakes-based recreation, UW Sea Grant Advisory Services plans to expand its activities in the years ahead to include:

- Water safety promotion and education.
- Assistance to emerging businesses in a variety of areas—from the design of coastal structures to prevent ice damage, to the marketing of Great Lakes recreational services.
- Educating the public about the social, economic and environmental impacts of marine recreation.

A second trend is the growing interest in aquaculture in the Great Lakes region for food production, sport fish stocking programs and for use in recreational fee-fishing ponds. Because of past aquaculture re-

search and outreach efforts, UW Sea Grant is viewed as the primary source of information and requests for information and attendance at aquaculture workshops have been growing. The Wisconsin State Aquaculture Plan, when fully implemented, is expected to further stimulate interest and encourage the creation of new aquaculture facilities.

To encourage private aquaculture enterprises in the state, UW Sea Grant Advisory Services will expand its services beyond providing general information to include specific hands-on training and one-to-one follow-up, with the objective of establishing successful operations for others to follow.

In an effort to maximize the use of existing commercial fish stocks, Advisory Services will continue to support the development and application of new techniques for processing, packaging and marketing fishery products, disposing of fishery wastes, and creating new products and markets for underutilized species, including burbot and freshwater crayfish.

To meet the need for an international forum on issues related to shallow- and deep-water mining of the ocean's floor, UW Sea Grant Advisory Services will continue to conduct the annual Underwater Mining Institute (UMI). The UMI provides a vehicle for interaction between the private sector, governmental agencies and universities on the extent and value of ocean minerals, and new technologies to profitably extract them. In cooperation with other Sea Grant programs, the UMI is held at an ocean coastal site (in 1988, Woods Hole Oceanographic Institution) to draw from current Sea Grant research and local practitioners.

■ *Future Opportunities*

To be able to meet the information needs of new users of the Great Lakes while continuing to meet the needs of traditional clients, it is necessary to explore new tools and approaches within the confines of existing staff and budgets. Recent advances in technology have provided the means for producing inexpensive educational videotapes for classroom and home use, business and engineering programs for microcomputers, telephone access to computerized databases and the use of satellite imagery.

To broaden its support to Great Lakes users, UW Sea Grant Advisory Services will increase its use of new electronic technology to bring innovative approaches to its field services. Current examples of this effort include the production of an instructional videotape on assessing the risks of flooding and erosion for Great Lakes coastal property, workshops to teach fishery managers and educators to use a computerized bioenergetics model of fish growth developed by UW Sea Grant Living Resources Subprogram investigators, exploration of satellite thermal imaging to locate sport fish, and improvements in the personal computing and electronic mail capabilities of Advisory Services field offices.

The Advisory Services Subprogram will continue to seek new opportunities to apply this technology to improving the way that both Sea Grant Advisory Services and its clients do business. An emphasis on local community involvement, research coordination and advanced technology will strengthen the ability of field agents and specialists to serve as catalysts of change.

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COMMUNICATIONS

Purpose

The Communications Subprogram helps ensure the broadest possible benefits from the scientific and advisory information generated by University of Wisconsin Sea Grant research.

Long-Range Goals

The UW Sea Grant Communications Subprogram plan for the next five to 10 years is to:

- Continue all current ongoing subprogram activities (see "Current Activities" section).
- Heighten public understanding of Great Lakes resources and related public policy issues. The intent is to reach a larger and broader audience in a timely and cost-effective manner. Specifically, the Communications Subprogram plans to encourage the production of video presentations in cooperation with public and private television stations and other video production facilities.
- Work with state and regional education agencies and science teachers associations to promote the use of existing marine-related teachers' guides and classroom materials for grades K-12.
- Initiate efforts to identify how new publishing technologies can be used to streamline publications production. This effort will include monitoring technological developments and implementing those that can increase our efficiency without sacrificing quality, including computerized layout and in-house production of camera-ready copy.
- Foster continued, steady growth in the number of radio stations broadcasting the Earthwatch/radio program.

Short-Term Objectives

Over the next two to three years, the objectives of the Communications Subprogram are to:

- Produce and distribute a biennial program report on UW Sea Grant research and the ecosystem approach to rehabilitating the Green Bay estuary.
- Coproduce and distribute *Earthwatching III*, a collection of Earthwatch/radio scripts featuring a teachers' guide to classroom activities for K-12 students.
- Produce teachers' guides, promotional materials and other support services for a joint Shedd Aquarium-UW Sea Grant exhibit on fish senses at the Neville Public Museum in Green Bay.
- Produce regular UW Sea Grant project reports, the *Littoral Drift* monthly newsletter and the biennial institutional proposal.
- Continue to produce and distribute an annually updated fact sheet on contaminant problems in Great Lakes game fish.
- Work with UW Sea Grant Advisory Services to increase the use of videotapes for instructional purposes and to evaluate the cost-effectiveness of using videotapes for that purpose.
- Establish for the use of researchers and staff an institute archive of every science journal article, technical report, unpublished project report, etc., produced as a result of UW Sea Grant research.

Current Activities

Top priority is given to publishing Great Lakes-related materials that meet the needs of specific groups of marine resource managers and users. Effective distribution is achieved through the use of targeted mailing lists, minimum pricing strategies, prompt response to requests for Sea Grant publications, submissions to the National Sea Grant depository and distribution through other university departments, government agencies and other Sea Grant programs nationwide.

To reach the general public and specially targeted audiences with information essential to the apprecia-

tion and wise use of Great Lakes resources, the Communications Subprogram:

- Coproduces the *Earthwatch/radio* program, which disseminates information about Great Lakes and marine resources via two-minute programs aired on more than 100 stations;
- Issues news releases that are published regularly by daily and weekly newspapers;
- Publishes public information reports on general interest topics that are based on or related to UW Sea Grant research;
- Assists Advisory Services, museums and other institutions in setting up and promoting UW Sea Grant workshops, seminars, displays and exhibts.

To reach targeted audiences in need of technical information—anglers and commercial fishermen, shippers, consumers, businessmen, environmental groups, industry associations, teachers, etc.—the Communications Subprogram publishes and distributes advisory reports and helps Advisory Services promote its seminars and workshops.

To enhance sharing of information with the scientific community and government officials, the subprogram prepares technical reports on UW Sea Grant research and reprints articles about Sea Grant research published in refereed professional journals.

To develop a pool of experienced, marine-oriented communicators, the subprogram provides talented graduate and undergraduate students with professional experience in science writing, broadcasting, and other informational and educational activities.

To provide support services for UW Sea Grant investigators in administration, research, outreach and education, the subprogram helps with writing, editing, graphics and audiovisual equipment. The final production, printing, packaging, distribution and marketing of all UW Sea Grant materials are the responsibility of the Communications staff. In fact, all UW Sea Grant publications and radio programs are, by policy, produced through Communications to ensure that materials undergo professional review and reflect the overall goals and activities of the program.

In response to information requests, the subprogram handles inquiries from the news media, state and federal government agencies, other universities, businesses and the public.

To evaluate the effectiveness of its information efforts, the subprogram:

- Conducts formal surveys of the usefulness and value of at least one major UW Sea Grant publication each year.
- Monitors how often UW Sea Grant news releases are published and by whom.
- Surveys regional radio stations annually to determine how Earthwatch/radio is used and how it may be improved.

■ *Benefits*

The UW Sea Grant College Program has become widely recognized as a credible and reliable source of information on Great Lakes issues. The publications and other information generated by the UW Sea Grant College Program through its Communications Subprogram are used by government agencies, industries, schools, businesses, other universities, private organizations and the public throughout the Great Lakes region and beyond.

Communications efforts of this kind are crucial to helping people understand, use and benefit from the scientific and advisory information generated by Sea Grant research.

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EDUCATION

Purpose

The Wisconsin Sea Grant College Program provides opportunities for graduate and undergraduate students to participate in all aspects of the program's activities. In addition, the program provides University of Wisconsin students with special opportunities to go to sea, to saltwater-coast research stations and to scientific meetings. Also, the program conducts diverse activities to educate the general public on ocean and Great Lakes matters. Finally, the program prvides highly focused workshops and informational materials for specific marine audiences, such as fishermen, boaters, coastal residents, port managers, underwater miners and aquaculturists, among others.

In the belief that graduate education and research are inseparable, most of the program's investment in education is in the form of research assistantships and project assistantships supporting graduate students in the program's various research areas. These awards also carry tuition credit. The majority of the program's expenditures for education thus appear as integral parts of the research subprograms.

Long-Range Goals

Despite nearly level financial support for the program, inflation of graduate education costs in the last few years has forced a 40 percent reduction in the number of graduate students supported (30 currently vs. 50 five years ago). This decrease reflects a nationwide trend in graduate education in the natural sciences, engineering and especially in the marine sciences. Recognizing that continued investment in the education of young scientists and engineers is essential to our nation's ability to compete worldwide and to maintain a strong and vital society, our highest priority long-range goal is to reverse this trend.

Over the next five years, the goals of the Education Subprogram are to:

- Increase the number of graduate students supported through individual research projects to 50.
- Employ exceptional students to work on Sea Grant research projects and support students in the completion of their theses after projects have been completed and research funding terminated.
- Continue to respond to the need for developing and enhancing Great Lakes/ocean courses and to provide for special on-campus speakers and lecture series.
- Continue to provide support to students for travel to professional meetings, present research papers, and acquire coastal marine environment or shipboard research experience.
- Enhance public understanding and appreciation of Great Lakes and ocean resources and issues by innovative programming and state-of-the-art techniques.
- Identify and respond to special marine education needs through publications, workshops, special exhibits and vocational-technical educational activities.
- Vigorously seek additional sources of support for marine educational activities.

Opportunities

The Wisconsin Sea Grant College Program supports innovative and unique educational activities which enhance public awareness of the Great Lakes and oceans. Such activities include cultural or artistic works dealing with the marine environment as well as lecture series, workshops, films and museum exhibits. A number of these activities take the form of special projects suggested by private foundations or corporations.

A substantial amount of public education activities are carried out in the Communications and Advisory Services subprograms via publications, radio programs (*Earthwatch*), displays, workshops and conferences. Both of these subprograms plan to make increased use of video and other new electronic media to reach both broader and more specific audiences.

■ ***Benefits***

In the 20 years since the Wisconsin Sea Grant Program began, 325 UW Sea Grant-supported students have received graduate degrees (116 Ph.D. and 209 Master's degrees). These graduates are major national assets who are make enlightened contributions to the use, management and conservation of the nation's marine environment. Some have moved into the executive suites of major corporations. Others are senior scientists in government laboratories. Still others have started their own businesses, are professors or serve in public office.

Shipboard or coastal ocean environment experiences provided through Wisconsin Sea Grant's Education Subprogram have influenced deeply a number of graduates. Several have reported that these experiences were the turning point in their education and resulted in their pursuing careers in marine fields.

The Communications Subprogram's award-winning public service radio project, Earthwatch/radio, now in its 17th year, has probably introduced more people to the importance and fascination of the Great Lakes and oceans than any other regional educational activity.

Education, and especially graduate education, is a risk-free investment that pays large and growing dividends to the nation's security, economic well-being and quality of life. Education is an investment we cannot afford to neglect. It will remain a primary goal of the Wisconsin Sea Grant College Program.

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APPENDIX: PROGRAM HISTORY, ORGANIZATION AND OPERATION

History

The National Sea Grant College and Program Act of 1965—modeled after the nation's Land Grant public university program of the 1800s—was created to meet the challenges of the oceans in the 1960s and beyond. Established in 1968, the University of Wisconsin Sea Grant Program was one of the first programs in what is now a national network of 30 Sea Grant programs partially funded by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. Just four years later—reflecting its success in integrating a high quality research program with effective educational and outreach programs—the University of Wisconsin in 1972 was designated a Sea Grant College, the fifth such college in the nation and the first in the Great Lakes region.

The University of Wisconsin Sea Grant College Program is a statewide program. Six units of the University of Wisconsin System (UW-Madison, UW-Milwaukee, UW-Green Bay, UW-Stevens Point, UW-Superior and UW-Extension) and one independent educational institution (Lawrence University) are actively taking part in the 1988-90 UW Sea Grant College Program (Table 1). Some 57 faculty members and academic staff and 61 graduate and undergraduate students in 48 departments and institutes are involved in the 1988-90 program.

Program Scope

The Wisconsin Sea Grant College Program is organized into eight research subprograms: Living Resources, Green Bay Estuary, Microcontaminants & Water Quality, Aquaculture, Seafood Technology, Policy Studies, Diving Physiology and New Initiatives, plus the program-wide subprograms of Advisory Services and Communications. Projects are selected via a rigorous program development and proposal process. Currently, about 60 percent of the resources of the UW Sea Grant program are directed towards research support—somewhat more than the average for Sea Grant programs nationwide. In the tradition of the University of Wisconsin, most of the program's educational activities are closely integrated with the research subprograms.

The program maintains strong working relationships with local, state and federal agencies; marine resource user groups and related industries, and coastal municipalities. These presently include the Wisconsin Department of Natural Resources, U.S. Fish & Wildlife Service, U.S. Environmental Protection Agency, National Oceanic & Atmospheric Administration, the Joyce Foundation, National Fisheries Institute, the paper industry, metropolitan sewerage districts, fish processors, commercial fishermen, sport fishermen, charter boat operators, marinas, coastal engineers, fish farmers, Great Lakes-related recreation businesses and regional ports. An active national network of Sea Grant institutions and the regional Great Lakes Sea Grant Network assures that useful information and methods developed by these programs will be shared with other universities and applied in other parts of the nation.

Policy and Operational Responsibility

Policy and operational responsibility for the Sea Grant College Program was formally transferred to University of Wisconsin-Madison under the University of Wisconsin System General Administrative Policy Paper #23 (GAPP #23) on December 1, 1978. At the same time, the Sea Grant Institute was created as an academic unit under the University of Wisconsin-Madison Graduate School. The institute was assigned the responsibility for administering the Sea Grant College Program for the University of Wisconsin System.

The director of the Wisconsin Sea Grant College Program serves as director of the Sea Grant Institute and reports to the dean of the Graduate School at the University of Wisconsin-Madison (Figure 1). Though the Sea Grant Institute is headquartered on the Madison campus, the Wisconsin Sea Grant College Program is System-wide and statewide in scope.

■ *Advisory Council*

The University of Wisconsin Sea Grant Advisory Council, appointed by the chancellor of the Madison campus, provides policy guidance within established institutional goals, approves the overall program plan and budget, and participates in program planning and the selection of subject areas within which project proposals are solicited. The council brings a wide variety of viewpoints to the program—from within the university system and from state and local government, industry and the public—and ensures accountability of the program to users and participants (Table 2).

■ *Management*

On a day-to-day basis, the Wisconsin Sea Grant College Program is managed by the institute staff (Table 3). Regular staff meetings—attended by the director, associate director, assistant director for administration, finance & budget officer, Advisory Services coordinator, Communications coordinator and administrative assistant—are held to coordinate staff activities and program management. This group also keeps UW Sea Grant Advisory Services field agents, campus-based specialists and the communications staff informed both of individual activities and of program developments as a whole. Financial management is handled through regular meetings of the director, associate director, assistant director for administration and finance & budget officer.

■ *Research Goals and Planning*

The research, education and outreach subprograms are managed by subprogram coordinators, each of whom is chosen for professional competence and leadership ability (Table 4). Research subprogram coordinators are also chosen on the basis of their standing in the scientific community. The subprogram coordinators work closely with their principal investigators and with the program director. They also consult with representatives from university, government, industry and citizen groups.

The research sponsored by the UW Sea Grant College Program is responsive to the needs of the nation as well as the state. State and university commitments to Wisconsin Sea Grant have continued to remain strong despite recently enacted federal budget reductions.

Although research projects are grouped in a subprogram format, much of the program's research addresses specific issues that cut across subprograms. In the larger research subprograms, the coordinator holds regular meetings for all principal investigators during which the subprogram's goals are reexamined and research objectives modified as needed. The Advisory Services, Communications and Education subprograms are program-wide in scope and are managed from within the Sea Grant Institute.

The initiatives and research goals and objectives of the program also stem from broad-based program retreats and multidisciplinary workshops, and program plans and goals are often tempered and augmented by input from various constituents and user groups. It is also a program policy to welcome and seek out innovative and high-risk research initiatives. Futhermore, as part of the Sea Grant Advisory Council's ongoing program planning effort, overall program balance and priorities are reevaluated by the council. These planning activities feed directly into the proposal solicitation process.

■ *Toward Brighter Horizons*

In the decades ahead, the University of Wisconsin Sea Grant College Program will remain dedicated to the protection and wise use of Great Lakes resources. Our committment is to a better future not just for the lakes themselves but also for the people who live and work along their shores.

TABLE 1: ORGANIZATIONAL UNITS & DEPARTMENTS INVOLVED IN THE 1988-90 WISCONSIN SEA GRANT PROGRAM

UW-Madison (UWMSN)
- Agricultural Economics
- Aquaculture Research Laboratory
- Biotron
- Center for Health Sciences
- Center for Human Systems
- Center for Limnology
- Chemical Engineering
- Civil and Environmental Engineering
- College of Agricultural and Life Sciences
- College of Engineering
- College of Letters and Science
- Division of University Outreach
- Engineering Professional Development
- Environmental Remote Sensing Center
- Environmental Toxicology Center
- Food Science
- Forestry
- Geology and Geophysics
- Graduate School
- Horticulture
- Institute for Environmental Studies
- Liberal Studies
- Marine Studies Center
- Medical School
- Meteorology
- Nuclear Medicine
- Oceanography and Limnology Graduate Program
- Pathobiological Sciences
- Physical Education/Dance
- Preventive Medicine
- Radiology
- School of Education
- School of Pharmacy
- Soil Science
- Sport Psychology Laboratory
- State Laboratory of Hygiene
- Statistics
- Surgical Sciences
- University-Industry Research Program
- Urban and Regional Planning
- Veterinary Medicine
- Water Chemistry ProgramWater Resources Center
- Water Resources Management Program
- Zoology

UW-Extension (UWEXT)
- Community Natural Res. and Economic Devel.
- Cooperative Extension
- Geology and Natural History Survey
- Recreation Resources Center

UW-Green Bay (UWGB)
- Biology
- Science and Environmental Change

UW-Milwaukee (UWMKE)
- Biological Sciences
- Center for Great Lakes Studies
- College of Letters and Science
- Geology
- Geosciences
- Graduate School
- Library--American Geophysical Society Collection

UW-Stevens Point (UWSTP)
- Biology
- College of Natural Resources
- Wisconsin Cooperative Fishery Unit

UW-Superior (UWSUP)
- Center for Lake Superior Environmental Studies

UW-System
- Great Lakes Research Facility

Cornell University
- Department of Natural Resources

Lawrence University
- Biology

North Carolina State University
- Zoology

SUNY-Buffalo
- Pharmacology
- School of Medicine

FIGURE 1: ORGANIZATIONAL CHART

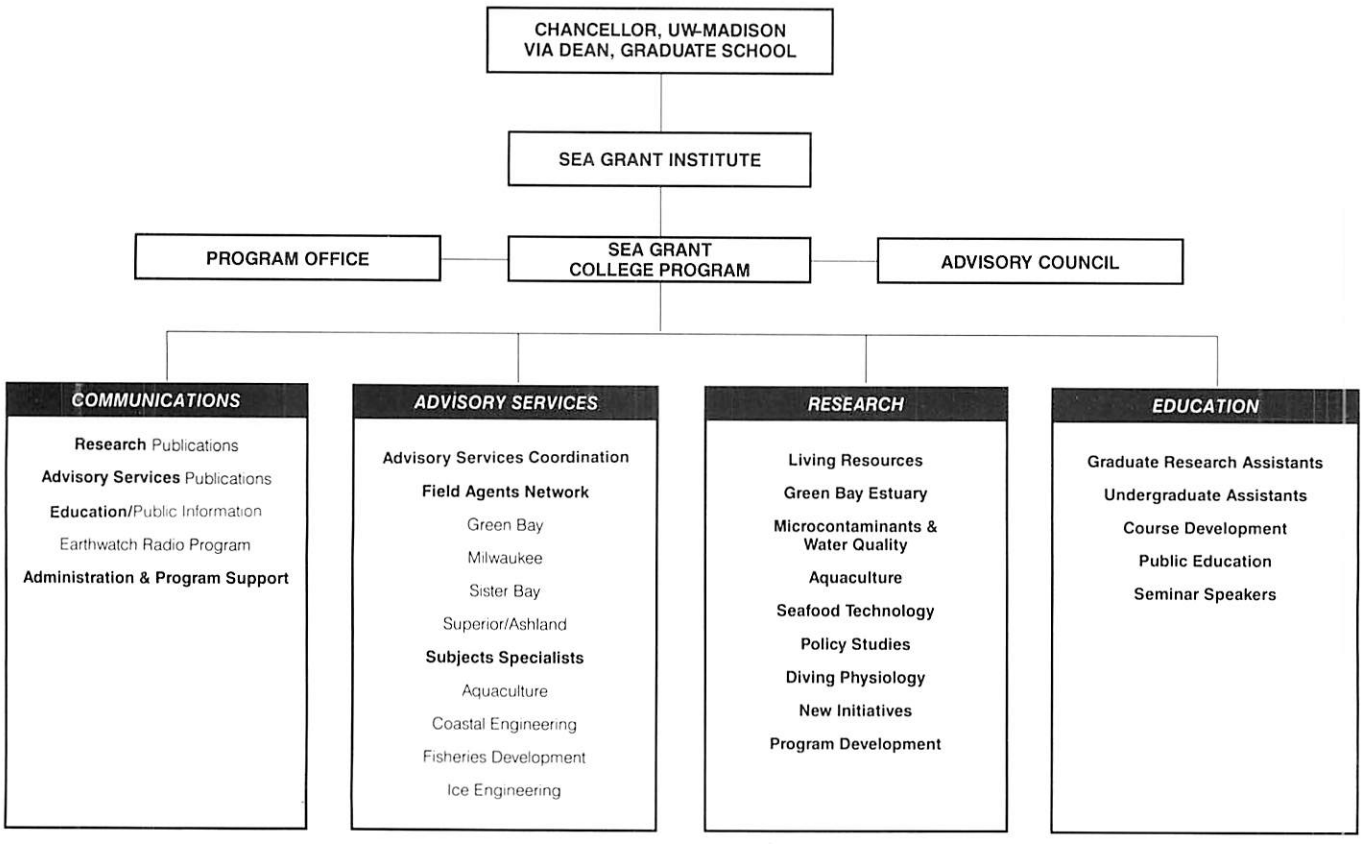

TABLE 2 . U.W. SEA GRANT ADVISORY COUNCIL, 1988

Stephen M. Born
Professor of Urban & Regional Planning
University of Wisconsin-Madison

Gordon Chesters
Professor of Soil Science
Director, Water Resources Center
University of Wisconsin-Madison

Arnold L. Clement
Planning & Development Director
Racine County Planning & Development
Sturtevant, Wisconsin

H. Jack Day
Professor of Earth Sciences
Chairman, Natural & Applied Sciences
University of Wisconsin-Green Bay

David Edgington (chairman)
Professor of Geological Sciences
Senior Scientist, Center for Great Lakes Studies
University of Wisconsin-Milwaukee

George Evenson
Citizen Representative
Sturgeon Bay, Wisconsin

Lee Kernen
Chief, Fisheries Management Section
Bureau of Fisheries Management
Wisconsin Department of Natural Resources
Madison, Wisconsin

Reuben Lorenz
Citizen Representative
Madison, Wisconsin

John J. Magnuson
Professor of Zoology
Director, Center for Limnology
University of Wisconsin-Madison

Dallas O. Peterson
Associate Vice President for Academic Affairs
University of Wisconsin System
Madison, Wisconsin

Robert A. Ragotzkie (ex officio)
Professor of Meteorology & Environmental Studies
Director, UW Sea Grant Institute
University of Wisconsin-Madison

Ayse C. Somersan
Dean, Cooperative Extension & Special Mission Programs
University of Wisconsin-Extension
Madison, Wisconsin

Daniel O. Trainer
Emeritus Professor of Wildlife
Emeritus Dean, College of Natural Resources
University of Wisconsin-Stevens Point

TABLE 3 . PROGRAM STAFF

Director
Robert A. Ragotzkie

Associate Director
Anders Andren

Assistant Director for Administration
Mary Lou Reeb

Finance and Budget Officer
Steven Schwoegler

Advisory Services Coordinator
Allen H. Miller

Communications Coordinator
Susie Isaksen

Coastal Engineer
J. Philip Keillor

Administrative Assistant
Delphine Skinner

Receptionist/Typist
Gloria Gardner

TABLE 4 . SUBPROGRAM COORDINATORS

Living Resources
James Kitchell, Center for Limnology, UW-Madison
Ross Horrall, Marine Studies Center, UW-Madison

Green Bay Estuary
J. Val Klump
Center for Great Lakes Studies, UW-Milwaukee

Microcontaminants & Water Quality
David Armstrong
Water Chemistry Program, UW-Madison

Aquaculture
Clyde Amundson
Food Science, UW-Madison

Seafood Technology
David Stuiber
Food Science, UW-Madison

Policy Studies
Richard Bishop
Agricultural Economics, UW-Madison

Diving Physiology
Edward Lanphier
Preventive Medicine/Biotron, UW-Madison

New Initiatives
Robert A. Ragotzkie and Anders Andren
Sea Grant Institute, UW-Madison

Advisory Services
Allen H. Miller
Sea Grant Institute, UW-Madison

Communications
Susie Isaksen
Sea Grant Institute, UW-Madison

Education
Robert A. Ragotzkie
Sea Grant Institute, UW-Madison

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