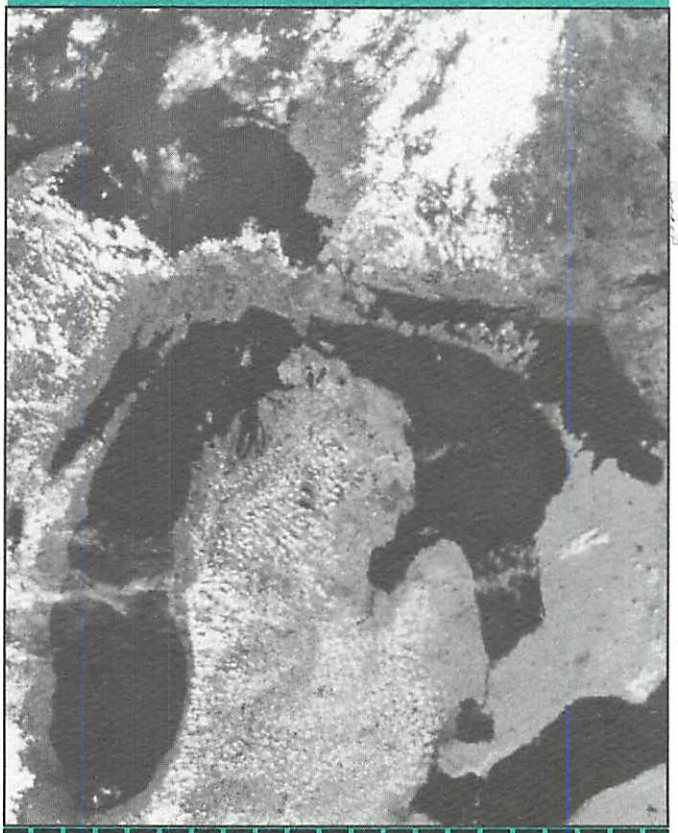
GREAT LAKES HORIZONS 2000

Navigating Through the Nineties



1992-94 Project Directory & Program Guide

UNIVERSITY OF WISCONSIN SEA GRANT INSTITUTE

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CELEBRATING
25 YEARS
AS A SEA GRANT
PROGRAM

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SEA GRANT AND THE GREAT LAKES

The Great Lakes

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 divided 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.

A National Resource

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 mid-continent manufacturing and agricultural industries.

The lakes also offer abundant recreational opportunities and provide employment for commercial and charter fishers, shipbuilders, longshore workers, 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 global ocean, the Great Lakes offer a resource and management model from which much can be learned. This is especially true with regard to understanding the fates and human health effects of toxic chemicals in the aquatic environment, 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 includes 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.

The Wisconsin Sea Grant Program

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 & 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. Today, the University of Wisconsin program is recognized as a national leader in research on microcontaminants and water quality, fishery and ecosystem dynamics, and estuarine systems and management.

Although many of the program's coordinated research activities center on the resources and problems of the Great Lakes, much of Wisconsin Sea Grant's research and outreach activities are national, even international, in scope. The intent of all projects, whether basic research or quick-response, is to provide information that will allow industry, government and the public to make wiser use of Great Lakes and marine resources, to find solutions to problems that threaten the sustained use of these resources, and to enhance their value.

The University of Wisconsin Sea Grant College Program integrates the traditional functions of a public university — research, education and outreach. Through its research program, as well as its interactions with industries and state and federal management agencies, the University of Wisconsin Sea Grant Institute has made significant contributions to a better understanding and use of Great Lakes resources. In addition, a continuous stream of well-trained and educated students 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.

Nationally, the Sea Grant partnership is now accepted as being essential to meeting our goals in economic competitiveness and improving the quality of life for our citizens. Sea Grant's focus on issues, rather than single disciplines within the sciences, has kept universities responsive to the needs of the nation and allows for creative individuals and groups of people to take advantage of opportunities and develop new initiatives.

At present, many of the campuses that constitute the University of Wisconsin System participate in the Wisconsin Sea Grant program. Seven units of the university system, plus two independent educational institutions, are actively taking part in the 1992-94 program — UW-Madison, UW-Milwaukee, UW-Green Bay, UW-Stevens Point, UW-Superior, UW-Manitowoc and UW-Extension, plus Silver Lake

College in Manitowoc and St. Norbert College in De Pere. Seventy-one faculty members and academic staff, 69 graduate and undergraduate students, and 60 university, state and federal departments are involved annually in the 1992-94 program.

Program Scope

The Wisconsin Sea Grant College Program for 1992-94 is organized into six research subprograms: Living Resources, Green Bay Estuary (to be replaced in 1993-94 with Estuarine & Coastal Processes), Micro-contaminants & Water Quality, Aquaculture & Seafood Technology, Policy Studies and New Initiatives, plus the program-wide subprograms of Advisory Services, Communications, Education and Administration.

Projects are selected via a rigorous program development and national peer-review proposal process. Currently, about 60 percent of the resources of the Wisconsin 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 a wide range of state and federal government agencies. These presently include the Wisconsin Department of Natural Resources, Wisconsin Division of Health, State Historical Society of Wisconsin, U.S. Fish & Wildlife Service, U.S. Environmental Protection Agency, U.S. Geological Survey, Los Alamos National Laboratory, National Fisheries Institute, National Oceanic & Atmospheric Administration, and the U.S.-Canadian International Joint Commission.

The program also maintains close ties with various coastal municipalities, marine resource user groups, and Great Lakes-related businesses and industries. These include the paper industry, metropolitan sewerage districts, electric power companies, fish processors, commercial fishers, anglers, charter boat operators, marinas, coastal engineers, fish farmers, recreation-related 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.

The primary goal of the University of Wisconsin Sea Grant College Program is to continue its high quality programs of research, education and advisory services.

LIVING RESOURCES

Coordinator: James Kitchell, UW-Madison

Virtually nonexistent 30 years ago, the Great Lakes sport fishery today is 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 numerous Great Lakes coastal communities. In Wisconsin, this prompted massive waterfront revitalization projects during the late 1970s and through the 1980s in the Lake Michigan coastal communities of Kenosha, Port Washington, Sheboygan and, most recently, Kewaunee.

The fisheries of the Great Lakes could not exist, however, without continuous control of the parasitic sea lamprey. 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.

Recent decline in salmon catch rates and sporadic evidence of high mortality due to diseases raise the question of sustainability in these intensively managed systems. State and federal agencies must now deal with the conflict between growing public expectations and the poorly understood ecological constraints imposed by species interactions.

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 IJC'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 aquatic 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's major research goals for the 1992-94 biennium include:

- Develop empirical and simulation models designed to estimate the ecological interactions that delimit carrying capacity for stocked salmonids;
- Formulate a comprehensive, individual-based model of larval fish growth and survival;
- Develop analytical approaches designed to forecast the ecological impact of zebra mussels;
- Investigate the structure of fish communities in lower Green Bay over the last 14 years as part of a statistical analysis of historical fisheries and environmental data. This study will demonstrate methods for assessing changes in fish assemblages, a necessary prelude to measuring ecosystem change and rehabilitation. Local fish population trends will be compared to both local environmental conditions and regional population trends to determine the existence of key environmental and biotic influences on these populations. Temporal dynamics both among years (to determine historical shifts) and within years (to determine phenological cycles) will be analyzed in conjunction with contemporary surveys of fish assemblages.

Opportunities

The primary emphasis of Great Lakes fisheries management and research has been and continues to focus on sea lamprey-salmonid-alewife interactions.

Restoration of native fish stocks — long a goal of management — may be in conflict with the economic and ecological realities of sport fisheries based on maintenance of exotic species such as alewife and Pacific salmon.

Other exotic species, such as zebra mussels and European ruffe, continue to appear at periodic intervals and flourish unpredictably. Tools designed to forecast their effects are a major emphasis of Wisconsin Sea Grant research.

Developing ideas at the ecosystem scale requires that our perspective expand to incorporate an understanding of the ecological resistance developed by current and recovering populations of native species. Many of these interactions involve littoral zone environments. By working with state and federal agency personnel, Wisconsin Sea Grant scientists will participate in both a series of collaborative research ventures and a new planning exercise designed to integrate the littoral-offshore environments in an effective and practical conceptual view that can provide guidance to research and management alike.

An Individual-Based Approach to the Survival of Larval and Juvenile Fish: Modeling and Experiments – R/LR-42

Fred P. Binkowski
Center for Great Lakes Studies
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Over the last decade, the investigator has used laboratory experiments, field studies and computer simulation modeling to explore the processes governing survival and recruitment of several key Great Lakes fish and of fish in general. Three key findings have emerged from this effort: (1) survivors are atypical individuals that can provide insight into causes of variable survival, (2) body size and growth rate are major factors influencing probability of survival of individuals and account for many species differences, and (3) variability among individuals can have a potentially major influence on population dynamics. Taken together, past and current experiments and modeling will allow the investigator to conduct a comprehensive evaluation of the importance of size-dependent interactions and individual variability in determining larval and juvenile fish survival. By comparing the individual-based simulation model approach with more traditional population and cohort modeling approaches, the investigator hopes to identify the most effective strategies for addressing these questions.

Temporal Variation in the Lower Green Bay Fish Community: Evaluating the Impacts of Remedial Action – R/LR-44

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The lower Green Bay Area of Concern (AOC) is a highly perturbed ecosystem. Given environmental variability and accidental ecological manipulations (e.g., introduction of zebra mussel and white perch), the potential for implementing management actions that produce identifiable changes in the AOC fish community can only be evaluated using available historical data, supplemented by limited field data collections. Temporal changes in the AOC fish community will be examined both within and among years with a variety of multivariate techniques. Analyses of the historical data will provide a retrospective understanding of fish community dynamics in the AOC as well as a reference for comparison with future changes. Field data collections will be used to evaluate limitations of the gear upon which historical data analyses depend. Data on fish community composition are available from surveys sponsored by the U.S. Fish & Wildlife Service and Wisconsin DNR for more than a decade.

Compensatory Responses in Great Lakes Food Webs: Predicting Results of Species Interactions – R/LR-45

James F. Kitchell
Center for Limnology
UW-Madison

Stocking salmonids in the Great Lakes has established a very successful sport fishery. However, the main salmonid forage species (alewife and smelt) are currently declining, while other species (bloater and yellow perch in Lake Michigan, lake herring in Lake Superior) are increasing. Understanding these compensatory responses is essential for fisheries managers charged with sustaining the sport fishery. The investigator will develop a series of models of these interactions that will enable him to estimate the magnitude of changes in planktivory and benthivory rates observed over the recent past, the carrying capacity of forage fish and salmonids, the changes in habitat use associated with species shifts, the likely future changes in species composition and the time lags involved in these compensatory responses. These objectives require implementing bioenergetics models for all key fish species in Lakes Michigan and Superior and developing new models to predict (1) functional responses of salmonids to changes in the forage base, (2) the spatial distribution of fish, (3) niche overlap structure within the forage fish community and (4) time lags for the interaction between key forage species. The investigator will use available software for bioenergetics models and develop new models for analyzing niche structure and spatial distributions. The modeling approach offers its first merits in the development of conceptual frameworks and in their use in focusing field or experimental programs. The first generation of energetics models served that purpose and have now matured to the point that they serve as one of the working tools regularly employed by fisheries resource managers in making judgements about stocking and harvest policies. The next generation of models could offer similar potential.

GREEN BAY ESTUARY/ ESTUARINE & COASTAL PROCESSES

Coordinator: J. Val Klump, UW-Milwaukee

Estuarine research in the University of Wisconsin Sea Grant program is expanding its focus from the Green Bay estuary to address a broader range of estuarine and coastal issues. This scientific enhancement will be reflected during the 1992-94 biennium as the Green Bay Estuary Subprogram evolves into the Estuarine & Coastal Processes Subprogram.

The Green Bay Estuary: A Vital Component

Lake Michigan's Green Bay, besides being a microcosm of the Great Lakes, is fairly typical of heavily used 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.

Historically high loadings to the bay from the Fox River have resulted in steep gradients in water quality, algal biomass and toxic contaminants in the bay. The rates of physical, chemical and biological processes fueled by these inputs are also high, resulting in a gradient of environments ranging from hypereutrophic and highly disturbed conditions within the estuary to more mesotrophic and stable conditions of the open lake.

These gradients facilitate the measurement and evaluation of ecological effects that could be due to changes in management of the bay over the last 100 years. It was because of these factors and UW Sea Grant data on contaminant transport and fate that Green Bay was chosen as the national focal point for a broad interdisciplinary study by the U.S. Environmental Protection Agency called the "Green Bay Mass Balance Study."

Estuarine and Coastal Processes: The Overall Perspective

The Great Lakes basin contains five freshwater seas that are bounded by more than 10,000 miles of shoreline. Historically, lake levels have fluctuated about six feet on time scales of decades or less — making the land-water boundary one of the basin's most dynamic interfaces. Despite the Great Lakes huge size, however, these freshwater inland seas are largely closed basins, so the characteristics of their waters are heavily influenced by interactions at the land-water interface. Changes in land use patterns throughout the Great Lakes watershed since the early 1800s have exerted a tremendous effect on the lakes by supplying nutrients, sediments, exotic contaminants and wastes via tributary streams, rivers and estuaries.

Estuarine and coastal processes in the Great Lakes basin not only represent a geologically, chemically and biologically dynamic interface but also characterize social, political and economic pressures on the environment. Throughout the basin, estuarine and coastal features include:

- development, urbanization and industrialization
- biological productivity and natural diversity
- recreational value

Land-water boundary ecosystems are regions of multiple and often competing resource uses. Wisconsin Sea Grant's expanded research on coastal and estuarine processes will enhance the scientific bases for resolving the management challenges posed wherever land and water meet.

Long-Range Goals

The Green Bay Estuary and Estuarine & Coastal Processes subprograms emphasize multidisciplinary research on the ecology, management, rehabilitation and preservation of land-water boundary systems. Long-range goals address both ongoing and emerging issues.

Continuing Research Priorities

- **The Dynamics of Ecosystem Change:** Understanding how estuarine and coastal systems respond to irregular perturbations and fluctuations in base properties requires both fundamental and applied research in the areas of:
  - biogeochemical cycling, nutrient flow and mass balances
  - transport, fate and effects of toxic contaminants
  - effects of changes in trophic structure
  - food web structure and fisheries
  - virtual elimination of toxic substances
  - methods for cost-effective long-term tracking of ecosystem change, including the application of such new and emerging technologies as databases and remote sensing
  - nonsteady-state ecosystem models and methods for forecasting ecosystem response times

- **Land-Water Interactions:** The effects of land use activities and landscape changes are critical in all estuarine and coastal regions. The extent to which waterbodies are linked to their catchments and the processes that control the fluxes of materials and biota from terrestrial environments through estuaries to coastal aquatic systems is an important area of study.

- **Ecosystem Rehabilitation and Socioeconomic Policy:** Methods for determining attainable levels of remediation, criteria for establishing remediation goals, cost-effective strategies and implementation techniques are needed. Remediation also involves social, economic and legal issues such as valuation and ownership, cost:benefit analyses, protection and preservation, and forging links between science and policy.

- **Contaminants:** Research on the highly toxic, coplanar, nonortho PCB congeners within the Green Bay ecosystem continues to be a high priority. Increasing evidence points to these congeners as the major cause of many human and ecosystem effects attributed to PCBs. Their distribution in Green Bay remains a major knowledge gap.

New Research Priorities

- **Coastal Dynamics and Engineering:** The land-water boundary throughout much of the Great Lakes basin is increasingly under the pressures of construction and development. Record-high lake levels in 1986-87 generated widespread coastal erosion, flooding and property destruction. Development and engineering guidelines are needed to protect against property loss and liability. Areas of interest include coastal geomorphology and geology as well as models of shoreline response, long-term lake level variations and climatic change.

- **Comparative Studies:** Investigations of system similarities and differences can be particularly useful in elucidating functional processes and constraints on ecosystems. Such studies also help to translate the understanding of basic ecological principles from one system to another.

Carbon and Nitrogen Isotopes as Tracers of Food Webs and Biogeochemical Cycles in Perturbed Estuaries – R/GB-37

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This study will focus on the role of Green Bay as a sink for nutrients. By tracking carbon and nitrogen movement, the investigator hopes to delimit the export of Green Bay primary production to Lake Michigan, and the loss to or gain of carbon and nitrogen from the atmosphere.The overall goal of this research is to improve understanding of the biogeochemical function of freshwater "estuarine" environments like Green Bay and Saginaw Bay. Previous work on biogeochemical cycling will be linked to new studies involving the use of the naturally occurring stable isotopes of carbon, nitrogen and sulfur. By using these as tracers in the system, the investigator will: (1) estimate the fraction of carbon and nitrogen that is gained or lost to the atmosphere relative to the fractions permanently buried and exported from the system; (2) determine the efficiency and mode of carbon and nitrogen recycling in sediments; (3) ascertain and follow changing food web interrelationships and trophic structure, particularly the major perturbation anticipated by the invasion of the zebra mussel and the predicted shift in benthic/pelagic carbon and energy partitioning, and (4) link changing food web hierarchy to contaminant levels and movement within the system.

Coplanar Polychlorinated Biphenyls in the Green Bay Ecosystem – R/GB-38

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Due to decades of unregulated discharge, the Green Bay ecosystem, particularly sediments of the bay, is contaminated with PCBs. While the extent of this problem has been well characterized by the Green Bay Mass Balance Study (GBMBS), the toxic threat of the PCBs is less well understood because the amount and type of coplanar, or toxic, PCB congeners has not been determined. The investigators will utilize data and sample extracts from the GBMBS to: (1) measure the concentrations and types of coplanar PCBs in Green Bay sediments, (2) determine the spatial and temporal variability of sediment coplanar PCBs, (3) evaluate whether coplanar PCBs are enriched or depleted relative to other PCBs, (4) measure the concentration and type of coplanar PCB congeners in Green Bay phytoplankton and fish and compare the measurements to those of other congeners and total PCBs as measured by the GBMBS, and (5) compare the relative amounts of sediment coplanar PCB congeners to those found in phytoplankton and fish so as to detect any selective transport through the ecosystem.

Population Dynamics and Stock Identification of Rainbow Smelt (*Osmerus mordax*) in Green Bay and Adjacent Waters of Lake Michigan – R/GB-36

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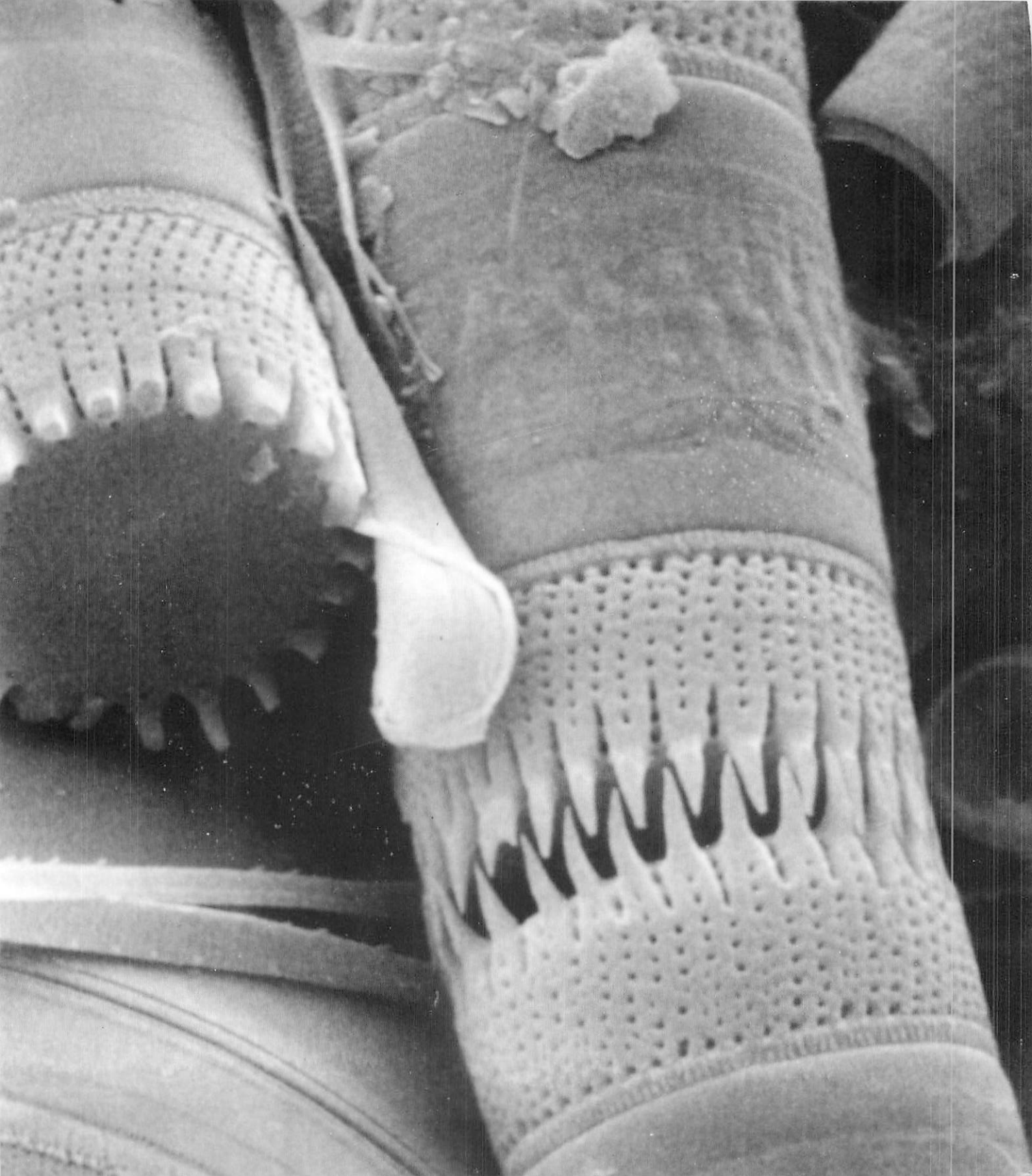
Rainbow smelt are a staple for trout, salmon, burbot and walleye in the Great Lakes as well as a mainstay of the region's commercial and sport fisheries. Recently, the coastal harvests of rainbow smelt from Lake Michigan and Green Bay have declined, while offshore harvests have increased. This suggests that the lake's smelt population is changing. Given the potential effect of this on the lake's other fisheries, a comprehensive smelt study is one of the Wisconsin Department of Natural Resources' biggest research needs. Offshore and coastal rainbow smelt harvest data will be used to estimate average size and age, growth rates, natural and fishing mortality rates, and total population. Understanding smelt population dynamics is a high priority for the Wisconsin DNR Lake Michigan Fisheries Management Plan, and this cooperative study—involving the Wisconsin DNR, U.S. Fish & Wildlife Service's Wisconsin Cooperative Fishery Research Unit at UW-Stevens Point and Wisconsin Sea Grant — is providing stock assessment data critical to sustained management of a diverse fish population. State, national and international agencies can use this information to manage smelt populations for the maximum benefit of the commercial and sports fisheries and the Great Lakes ecosystem.



MICROCONTAMINANTS & WATER QUALITY

Coordinator: David Armstrong, UW-Madison

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

Some microcontaminants like PCBs accumulate in aquatic organisms and become concentrated as they move up the food chain. These contaminants pose a potential health threat to aquatic organisms, fish-eating birds and mammals, and ultimately to people who consume fish from the Great Lakes. Other chemical contaminants may affect lower organisms and alter aquatic food webs and ecosystem health. Research in the Microcontaminants & Water Quality Subprogram is aimed at providing a sound basis for assessing chemical contaminant effects and managing problem microcontaminants.

Water quality is also affected by excessive algal growth. Algal populations are regulated by nutrient element loading and availability and by predation through organisms higher in the food web. 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 long-range goals of the Microcontaminants & Water Quality Subprogram are to:

- Determine the sources and fate of chemical contaminants and nutrients that degrade water quality or impair ecosystem health in the Great Lakes.
- Assess threats to human health and aquatic life posed by chemical contaminants in Great Lakes ecosystems.
- Develop technologies and strategies for remediation of areas degraded by chemical contaminants or nutrient overloading.

Short-Term Objectives

Research in this subprogram over the next four years will focus on chemical contaminants and will address aspects of each long-range goal. Specific objectives are:

Sources and Fate of Contaminants

- *To determine concentrations and loadings of high-use herbicides in tributaries to Green Bay and north-western Lake Michigan.* The compounds emphasized will include atrazine, alachlor, metribuzin, cyanazine and metolachlor. Transport and loadings will be evaluated in collaboration with the U.S. Geological Survey's National Water Quality Assessment research program on these tributaries as part of a proposed new three-year project to address this objective.
- *To determine the patterns of contaminant flux in Great Lakes food webs.* Population variability in contaminant concentrations among salmonids will be evaluated with individual-based models. Effects of food web structure on contaminant concentrations will be examined using food web models. The questions to be addressed include: "How can salmonid management alter food web structure to minimize chemical accumulation in sport fish?"

and "How will chemical accumulation in salmonids respond to changes in contaminant concentrations in water and sediment?" Two years of an overall effort remain on a project addressing this objective.

- *To determine the importance of colloidal material in regulating contaminant cycling in Lake Michigan.* The abundance, distribution and properties of colloidal material in Lake Michigan will be determined. Major pathways of colloid production and removal will be investigated. In addition, the influence of colloidal material on contaminant cycling and mobilization of contaminants from sediments will be evaluated. A four-year effort is planned.

- *To assess the dynamics of horizontal sediment transport and focusing in large lakes.* The distribution of select contaminants whose inputs are known to have decreased over the last 20 years will be compared. Vertical deposition models will be expanded to include the effects of horizontal advection. The resulting improved models will be used to predict the fate of transient contaminants and pulse inputs of persistent chemical contaminants. The work is scheduled for completion in the third and last year of a continuing project.

Effects of Contaminants

- *To determine the early life-stage toxicity of polychlorinated aromatic hydrocarbons in salmonids.* The site and mechanism of the action of TCDD in producing blue-sac syndrome will be investigated, including involvement of Ah receptor and P450IA1 induction. Developmental toxicity of PCB congeners that are not Ah receptor antagonists will also be investigated and interactions with TCDD evaluated. In addition, the cause of the low potency of TCDD-like PCB congeners will be determined. A four-year effort is planned for this research area.

- *To determine the ecotoxicology of amphibians in Green Bay.* Contaminant levels in egg, larval and adult stages of three species of amphibians will be obtained. The relationships of reproduction and offspring survival to contaminant levels will be determined. In addition, bioaccumulation and depuration rates of a model contaminant (PCB) and the toxicity of coplanar PCBs will be investigated. A new four-year project is planned.

Remediation Technologies and Strategies

- *To assess the interactions of bacteria with heavy metals.* A continuing project on isolating and characterizing bacteria resistant to heavy metals will be completed. This research includes development of biosensors that respond to heavy metals. The biosensors could be used to evaluate biologically available metals in environmental samples and the urgency for remedial action at contaminated sites. This will complete a three-year project.

Anticipated Benefits

The expected benefits of this research subprogram are far-reaching. Research on contaminant sources, fate and remediation will aid the development and evaluation of remedial action programs and provide an assessment of ecosystem response time to in-place contaminants. The investigations of toxicological responses to contaminants will advance our ability to evaluate the effects of contaminants on fish and amphibians and to determine the effect of contaminants on the lake trout stocking program in Lake Michigan.

The fundamental advances in understanding chemical and biological processes will be applicable to assessments of the fate of contaminants and the risks these contaminants pose to humans and other freshwater and marine ecological systems as well as the Great Lakes. In the Great Lakes region, improved understanding of the fate and effects of contaminants will benefit resource users concerned about exposure to toxic substances and be especially useful to managers developing remedial programs for the resource and programs for protecting its users.

Patterns of Contaminant Flux in Great Lakes Food Webs – R/MW-41

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An individual-based model (IBM) adequately explains the variability in size at a given age exhibited by lake trout in Lake Michigan. However, variability in size at age, model parameters, and PCB concentrations in water and prey cannot explain the variability in PCB concentrations observed in lake trout in Lake Michigan. Variability in lake trout PCB levels can be explained by assuming that lake trout sample the prey PCB distribution with bias. This bias causes some of the lake trout to feed on prey with relatively high PCB concentrations, while other lake trout feed on prey with relatively low PCB concentrations. The same general result was obtained for an IBM of dieldrin accumulation in lake trout. Both models lead to testable, quantitative predictions of the bias in prey selection. IBM simulations showed that lake trout PCB concentration decreased slightly in response to a decrease in size of stocked yearlings. However, this effect could be completely overshadowed by decreased survivorship of smaller yearlings. IBM analyses can yield probability distributions useful in risk assessments and parameters crucial for ecosystem models of contaminant flux through food chains.

Early Life Stage Toxicity of Polychlorinated Aromatic Hydrocarbons in Salmonids – R/MW-52

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The presence of PCB, PCDD and PCDF congeners is thought to be a possible reason for the lack of recruitment of early life stage lake trout into the general population throughout most of the Great Lakes. The potencies of many TCDD-like congeners have been determined, but the information remains incomplete. For this reason, the investigator will study the potencies of non-TCDD-like congeners in addition to determining the mechanism of TCDD-induced mortality in lake trout early life stages. The mechanism of TCDD toxicity will be studied using cytochrome P450 antagonists because these enzymes could be involved in mediating the toxic effects of TCDD and related congeners, and immunohistochemical techniques will be used to determine the site of action in lake trout early life stages. Certain PCB congeners have been determined to have much lower potencies in rainbow trout than expected based on mammalian systems. The investigator will seek to determine the reason for the lower PCB potency. These goals will be accomplished using rainbow trout egg microinjection as a model for lake trout, because rainbow trout are available year-round. Lake trout will be used to study the importance of colder spawning-reef temperatures in the early life stage toxicity of TCDD and to confirm key findings in rainbow trout once the egg microinjection method has been perfected for use with lake trout eggs. Achieving these research goals would improve the ability of regulatory agencies to assess the risk of recruitment failure posed by complex mixtures of PCB, PCDD and PCDF congeners in Great Lakes lake trout eggs and could allow more efficient reestablishment of depleted lake trout populations.

Ecotoxicology of Amphibians in Green Bay – R/MW-54

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The research will focus on amphibians in relation to Green Bay, Lake Michigan, ecosystem toxicology. Amphibians in Green Bay are undoubtedly exposed to toxicants and other stressors, such as excess nutrients, by diffusion across the skin and by consumption of contaminant-laden algae and prey. Relatively little is known, however, about toxicant bioaccumulation and its possible effects on amphibian survival and reproduction. The investigator will measure contaminant levels (including liver mixed-function oxidase activity) in, and determine the survival (using enclosure studies) of, amphibian eggs, larvae and adults along a contamination gradient in Green Bay and its tributaries. Laboratory measurements will be made of the rate of bioaccumulation from food (in adults) and water (in tadpoles) of a radiolabeled PCB congener, as well as rate of depuration. The research will also test the extent to which combinations of stressors (realistic field levels of a PCB congener plus ammonia) negatively affect amphibian development as compared with single stressors.

Distribution of Heavy Metal-Resistant Bacteria, Their Mechanism(s) of Resistance and Use of Biosensors (Genetic Fusions) to Determine Biologically Available Heavy Metals – R/MW-48

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Charles C. Remsen
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Toxic heavy metals, including lead, mercury, zinc and nickel, pollute many Great Lakes sites. Even very low concentrations can kill aquatic organisms and threaten human health. Some bacteria, however, are resistant to these toxic effects and could be useful for monitoring and controlling heavy metal pollution. Yet little is known about the growth of these bacteria in the low-oxygen, low-nutrient sediments where heavy metals accumulate. This project involves cataloging the resistant bacteria growing in sediments from contaminated sites, like Sheboygan Harbor, then studying how each strain handles heavy metals and determining whether localized application of the bacteria could assist remediation efforts. This research will also pursue two methods of using bacteria to monitor heavy metal contamination.

Herbicide and Herbicide Metabolite Inputs to Green Bay and Western Lake Michigan – R/MW-53

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Herbicide pollution of ground and surface waters, both from parent compounds and breakdown products (i.e., metabolites) has become a major new environmental concern. Very little work has been done on measuring the inputs of these herbicides to the Great Lakes. In the study, measurements will be made of high use herbicides and their metabolites that are being transported via tributaries to Green Bay and northwestern Lake Michigan. State-of-the-art immunoassays and high-resolution chromatography will be used in the analyses. The study will also consider the importance of groundwater as a source of herbicides to Green Bay and whether herbicides are transported in any appreciable quantities with particulates. Finally, bioassays will be used to determine the potential toxicity of combinations of herbicides likely to be found in Green Bay wetlands or Lake Michigan harbors. The results should be helpful in determining whether herbicides are affecting, or could potentially affect, the Green Bay/Lake Michigan ecosystem.

The Dynamics of Horizontal Sediment Transport and Focusing in Large Lakes – R/MW-46

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The fates of contaminants in aquatic systems are directly related to the deposition, transport and burial of the sediments with which they become intimately associated. In large lakes, estuaries, coastal embayments and seas, post-depositional sediment transport is a major redistribution process. Horizontal transport within the benthic boundary layer results in sediment focusing on time scales sufficiently long to significantly affect the residence times of persistent pollutants in the active sedimentary system. To date, this process has not been well quantified. Radionuclides give the investigators the means to empirically determine both the time and spatial scales of focusing in large depositional basins — a necessary step in predicting accurately the temporal fate of contaminants with varying persistence. The objectives are to: (1) quantify the time and spatial scales of long-term (years/decades) meso-scale horizontal sediment movements in large lake systems, especially in Lakes Erie and Michigan, (2) determine the role of horizontal transport and sediment focusing processes on the residence time of transient pollutant inputs in the biologically active sediment pool for both lakes, (3) refine the current one-dimensional models for sediment and contaminant deposition to include long-term horizontal effects and to test the efficacy of this model for predicting both the movement and character of sediments in the benthic boundary layer, (4) use the improved models to predict the fate of transient contaminants, including radionuclides, degradable organic compounds (with different decomposition rates) and pulse inputs of very persistent organic and inorganic compounds, and (5) estimate the system scales required for such horizontal transport to significantly affect contaminant residence times.

Impact of Colloidal Material on Contaminant Fate in Lake Michigan – R/MW-50

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Colloidal material likely plays an important role in controlling the transport and fate of chemical contaminants in Lake Michigan. However, information on colloidal material and colloid-contaminant interactions is very limited. The goal of this project is to determine the importance of colloidal material in regulating contaminant cycling and influencing sediment remediation in Lake Michigan. The specific objectives are to: (1) determine the abundance, distribution and properties of colloidal material, (2) identify and quantify major pathways of colloid production and removal, (3) determine the role of colloidal material in contaminant cycling and (4) assess the influence of colloid production on mobilization of contaminants in sediments. The approach involves both field and laboratory experiments. Colloidal material will be obtained by lake sampling and particle concentration using ultrafiltration and ultracentrifugation. Colloids will be characterized by chemical and physical analyses. Biological production will be investigated in field experiments using radiotracer-labeled substrates. Colloid removal by coagulation and diagenesis will be evaluated in laboratory experiments. Rates and mechanisms of interactions with contaminants will be investigated using radiotracer-labeled organic and inorganic contaminants. Microcosms experiments will assess colloid-mediated contaminant release from sediments.

AQUACULTURE & SEAFOOD TECHNOLOGY

Coordinators: Clyde Amundson and David Stuiber, UW-Madison

The U.S. seafood industry has been operating from a strong market position for more than a decade. Despite increasing prices, consumer demand for seafood products has remained high. To maintain its competitive edge, however, the U.S. seafood industry needs to investigate the use of new technologies designed to increase efficiency in the production of aquacultured stocks and in the harvest of wild stocks, and to improve the handling and processing of seafood products from both stocks. Such advances would mean more stable and affordable seafood prices for consumers and improve seafood product safety and quality as well. Growing consumer concern about toxic contamination and the mislabeling of wild stocks is generating new pressure for a federal seafood inspection program and may further increase demand for aquacultured seafoods as well.

In the Great Lakes region, the commercial fishing industry remains in a fragile state due to the limited number of fishable species, quotas and other restrictions. To improve income, commercial fishers and processors need to make more efficient use of the resources available to them, creating new markets for underutilized fish stocks as well as making better use of existing stocks. Improving the industry's competitive position will also require the development and use of new and more sophisticated technology to produce, harvest, process and market fishery products.

Aquaculture already plays a key role in the management of fishery resources in the Great Lakes region and has a real potential for significant seafood production as well. Resource management agencies throughout the region depend on aquaculture to support Great Lakes sport fisheries, which have 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 cool-water species, especially walleye and muskellunge. In Wisconsin and many other parts of the nation, cool-water 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 (USDA), Wisconsin is the nation's fifth largest producer of rainbow trout. The state has more than 780 licensed fish farmers, who raised a variety of panfish, bait, and cool- and warm-water game fish. A strategic 20-year plan recently developed by the Wisconsin Department of Natural Resources (DNR) should result in a 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.

Wisconsin Sea Grant personnel have played a leading role in the development of aquaculture and seafood technology at the state, regional and national levels. Subprogram investigators were instrumental in the creation of the Wisconsin State Aquaculture Plan, an economic development report presented to the governor in 1988 by the UW-Madison College of Agriculture & Life Sciences, Wisconsin Trout Growers Association, Wisconsin DNR and Wisconsin Department of Agriculture, Trade & Consumer Protection (DATCP). They were also active in the development of the National Sea Grant Aquaculture Plan and the USDA's regional aquaculture centers, including one

for the North Central region. Subprogram investigators also have contributed to advances in flavor identification and flavor stability in seafoods, including advances in the development of new packaging techniques for both fresh and frozen seafood products. In the process, they have developed innovative analytical techniques for isolating chemical substances for gas chromatographic analysis.

This merger of Wisconsin Sea Grant's Aquaculture and Seafood Technology subprograms into one subprogram is a logical progression representing the growing capability of Wisconsin's rapidly maturing aquaculture industry to become a major player in commercial seafood production. The principal aim of the Aquaculture & Seafood Technology Subprogram is to provide a vehicle for responding to the problems and concerns of the aquaculture and seafood industries.

Long-Range Goals

The primary long-range goal of the Wisconsin Sea Grant Aquaculture & Seafood Technology Subprogram is to develop and improve the scientific and technological database necessary for the propagation, culture, harvest, processing and marketing of cool-water species like perch, walleye and muskellunge, and of cold-water species like trout, salmon and whitefish.

The specific research goals of the Wisconsin Sea Grant Aquaculture & Seafood Technology Subprogram for the next five years are to:

- Produce hybrid crosses and develop methods of inducing (chromosomal) triploidy and tetraploidy in cool-water fishes, and to examine the potential of these genetic manipulations for enhancing growth and controlling reproduction.
- Develop methods of assessing physiological stress in cool-water fishes and to use these methods to identify "least-stress" aquacultural procedures and husbandry practices.
- Characterize the ontogeny of the physiological stress-response system of rainbow trout and develop methods of producing trout highly tolerant of stressors commonly found in aquaculture and well-adapted to culture conditions found in the Great Lakes region.
- Expand the information base on underutilized and traditional fish species and other seafood products to better determine quality, shelf life, safety and marketability of existing and new seafood items.
- Improve the safety, stability and quality of seafood products, and promote the development and the wise use of the nation's aquatic food resources.
- Provide on-site consultation and other outreach services in conjunction with UW Sea Grant Advisory Services personnel to Wisconsin's fish farmers, food industry and other private-sector investors.

Long-term plans for improving and expanding both the aquaculture research and production facilities at Lake Mills are currently being formulated in concert with the Wisconsin DNR and the UW-Madison College of Agricultural & Life Sciences. In line with these plans, in 1991 the Wisconsin DNR began a $1.5 million project to renovate and expand the lake water supply system and ponds at the hatchery.

Current Activities

Subprogram aquaculture research currently is focused on genetics, control of sex and reproduction, stress physiology, disease resistance and other factors affecting fish health and growth.

Subprogram investigators are characterizing the physiological stress responses of cool-water fish species and developing culturing methods that minimize stress and improve survival, growth and performance. They are also evaluating methods for producing strains of trout more resistant to disease, improving techniques for genetically manipulating cool-water fish, and assessing the effects of sex and reproductive state on growth enhancement of genetically altered fish.

Subprogram seafood scientists are continuing to contribute to advances in flavor stability and the suppression of off-flavors in fish oils and seafoods. Through

published results and presentations at scientific meetings and other public forums, these investigators have also helped increase the public's awareness of the benefits of seafoods and how to select, properly handle, preserve and cook these foods.

Wisconsin Sea Grant aquaculture research and advisory activities are conducted in cooperation with the UW Great Lakes Research Facility in Milwaukee, UW-Madison College of Agricultural & Life Sciences and College of Engineering, the Wisconsin DNR and DATCP, 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 DNR, the Lake Mills State Fish Hatchery serves as the primary site for Wisconsin Sea Grant aquaculture research. The Lake Mills hatchery has 24 ponds ranging in size from 0.3 to 3.8 acres, eight indoor and three outdoor raceways, a small shop and fish holding house, and an abundant supply of lake water, dechlorinated city water and well water. A wide variety of cold-, cool- and warm-water fish species are currently raised there.

Completely renovated in 1989, the UW-Madison Water Science & Engineering Laboratory provides the UW Aquaculture Program with analytical and wet laboratories and office space on the UW-Madison campus, which is particularly valuable for the training of graduate students.

Benefits

While many Aquaculture & Seafood Technology Subprogram research activities are designed primarily to serve Wisconsin, the knowledge gained and techniques developed as a result of these efforts are applicable to seafood enhancement programs and to commercial aquaculture nationally and worldwide.

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

Control of Growth, Sex and Reproduction in Great Lakes Cool-Water Fish by Genetic and Endocrine Manipulation – R/AQ-20

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Food Science
UW-Madison

Cool-water fish such as yellow perch and walleye have major recreational and commercial value throughout the Great Lakes region. Despite their value, however, the intensive culture of these fish has been impaired by several growth and performance characteristics associated (to a large extent) with sexual maturation and development. Experience in agriculture has demonstrated that endocrine and genetic manipulations such as sex control, polyploidy induction and hybridization can lead to tremendous improvements in production. The overall goal of this project is to develop and use such manipulations to produce strains of perch and walleye that have improved growth and performance characteristics. Specific objectives are to: (1) compare the growth of diploid and triploid perch and walleye reared to sexual maturity; (2) develop methods of producing sterile, all-female triploid perch, walleye and walleye x sauger hybrids; (3) evaluate different methods of inducing triploidy (by using heat shock and pressure shock, and by crossing tetraploids and diploids) and (4) assess the effects of exogenous estrogen on the growth of female triploids. The development of methods for producing all-females has been completed for perch and is in progress for walleye. The investigator has shown that walleye x sauger hybrids grow significantly faster than purebred walleye and are more adaptable to intensive culture conditions. Heat and hydrostatic pressure shocks used to induce triploidy have a negative effect on the growth of juvenile perch and walleye, an effect that is independent of ploidy status. Triploid perch and walleye could have improved performance traits if the negative effects of such shocks can be avoided. Methods of producing tetraploid perch and walleye embryos have been developed, and tetraploid perch are currently being reared to sexual maturity.

Ontogeny and Manipulation of the Physiological Stress Response System in Rainbow Trout (*Oncorhynchus mykiss*) – R/AQ-21

Jeffrey A. Malison
Food Science
UW-Madison

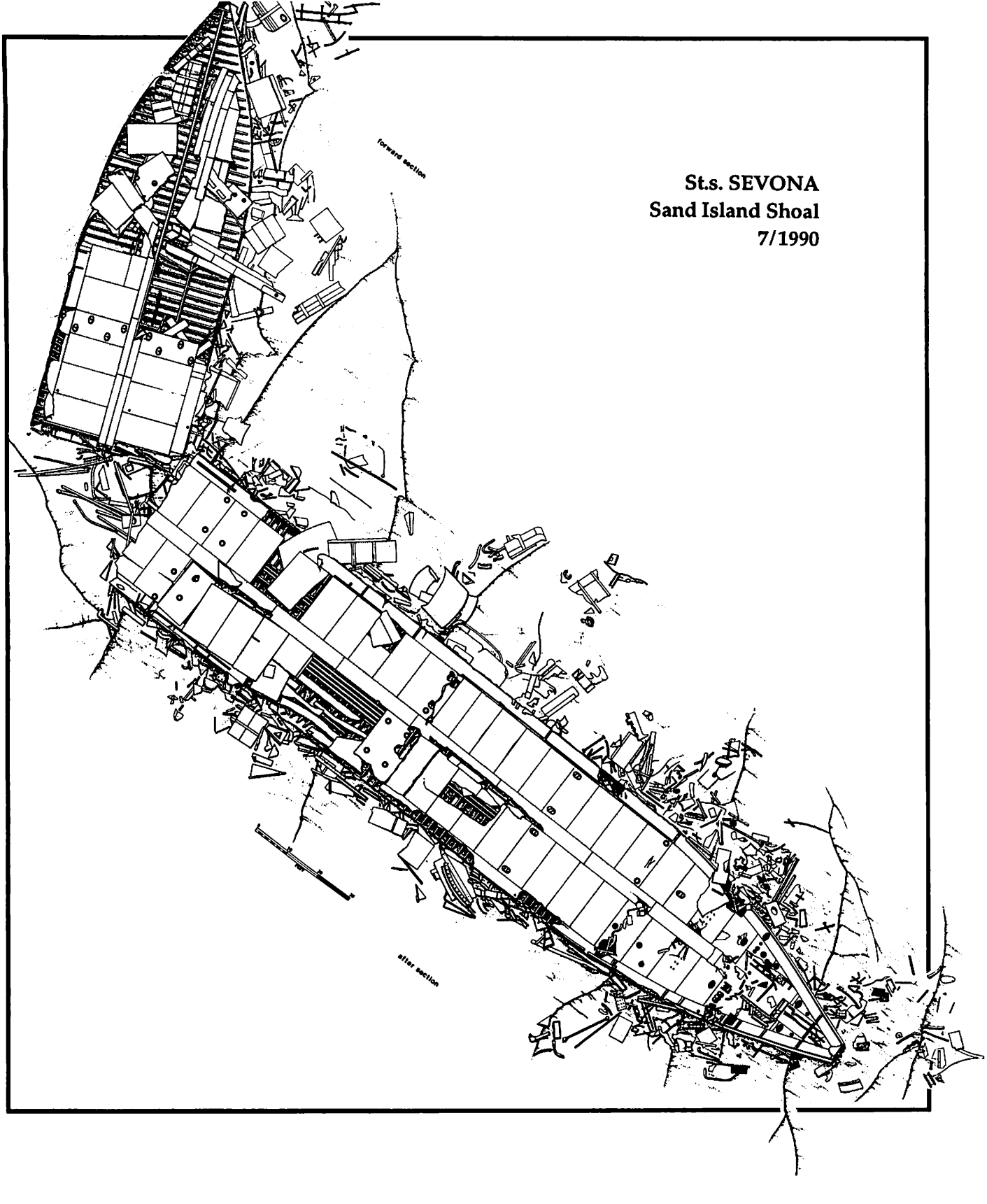
Terence P. Barry
Food Science
UW-Madison

The deleterious effect of physiological stress on the growth, health and survival of fish reared under intensive culture conditions is one of the most important problems in aquaculture. This innovative research will combine both basic and applied physiological/endocrinological studies to address the problem. The investigators will: (1) document the anatomical and functional ontogeny of the hypothalamic-pituitary-interrenal axis (HPI axis) of the rainbow trout (*Oncorhynchus mykiss*), (2) evaluate the extent to which the physiological stress responses of fish at early life-cycle stages predict or determine subsequent growth, disease-resistance and performance, and (3) develop methods to permanently alter the responsiveness of the HPI axis by applying select environmental and biochemical treatments at early critical stages of development. These studies will identify "least-stress" culture strategies for various life-cycle stages of fish, improve genetic selection programs and allow for the production of fish that are highly tolerant of stressors commonly encountered in aquaculture. The studies focus on rainbow trout because of its importance to commercial aquaculture in the Great Lakes region. In addition, the considerable information already available on the stress physiology of this species provides an important baseline for this research.

Suppression of Off-Flavors in Oxidizing Fish Oils and Seafoods – R/SF-3

Robert C. Lindsay
Food Science
UW-Madison

The benefits of this project relate to the seafood industry's ability to respond to consumer demands for foods with n-3 long-chain fatty acids that do not exhibit unpalatable fishy flavors. The suppression of fishy flavors would facilitate the provision of fish oils and their attendant health benefits to consumers. Additionally, the technology to limit the development of fishy flavors in seafoods generally is of great significance to the seafood industry, especially for fatty fish. This research will help advance the knowledge needed to control fishy flavors in fish and seafoods. The benefits include greater palatability of foods containing n-3 fatty acids for the consumer along with health benefits of long-chain polyunsaturated fatty acids as well as benefiting the seafood industry in providing technology to improve product quality. Basic information on the oxidation of fish oils will advance science and technology of seafoods and will provide potential means for indexing the quality of fish oils through an understanding of the contributions of individual compounds to unpalatable oxidized fishy flavors.



St.s. SEVONA
Sand Island Shoal
7/1990

POLICY STUDIES

Coordinator: Richard Bishop, UW-Madison

The 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 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 long-range goal of this subprogram is:

- To assess current and potential Great Lakes policy issues through a broad range of social science research projects on Great Lakes and ocean resources.

Current Activities

In addition to a continuing project on the valuation of Great Lakes fisheries, three new projects are funded during 1992-94. The first will study the role of communications in personal and public contaminant policy by examining the current fish consumption advisories and how they affect both anglers and members of anglers' families. The second new project involves additional field surveys of key historic shipwrecks and will provide a synthesis of survey results to date. The third project will develop innovative approaches combining modeling of lake levels with engineering and economic data to design coastal facilities under uncertainty. This project will build on the results of current Wisconsin Sea Grant-supported research to predict future lake levels conditional on current levels.

Future Research

Policy studies must, to a large degree, be reactive, dealing with policy issues as they evolve. Emerging high-priority research topics for the 1990s include:

- Alternative remediation strategies for the Wisconsin Areas of Concern and the other degraded Great Lakes ecosystems;
- The costs and benefits of alternative fishery management strategies for both the salmonids and cool-water species;
- The implications of ever-tightening seafood industry regulations;
- Developing new techniques to measure the benefits of Great Lakes resources; valuation, ownership and stewardship of fresh water;
- Current and projected consumptive uses of Great Lakes water and the implications of climate change;
- Assessment and communication of the human health risks of eating Great Lakes fish;
- Alternative policies to reduce existing contaminant levels and minimize future problems with contaminants, and
- Responsibility and possible liability for pollution of the Great Lakes.

Valuation of Great Lakes Fisheries – R/PS-38

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Agricultural Economics
UW-Madison

Three aspects of Great Lakes fishery valuation are being investigated. First, the validity of current methods of valuing sport fishing will be addressed by comparing such values to values from actual cash transactions for a sport fishing opportunity. Second, analyses of monthly supply and demand statistics for major Great Lakes commercial fisheries are being used to estimate fishery values for Wisconsin and the U.S. Great Lakes. Third, evidence from studies of other resources and from previous Great Lakes research indicated that a significant proportion of Wisconsin citizens would value the continued existence and further rehabilitation of the Great Lakes fishery resource, even those who were sure that they will never personally use the resource. Theoretical work under this project is a necessary preliminary step toward the eventual estimation of such existence values and their interpretation in the context of Great Lakes fishery policy.

The Role of Communication in Risk Judgements by Wisconsin Anglers and Their Families – R/PS-42

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UW-Madison

Agencies faced with the responsibility of advising anglers and their families about the health risks of consuming fish from polluted areas of the Great Lakes and contaminated inland waters do so with little systematic understanding of how individuals use such information to make their personal risk judgements. This study will provide that information about Wisconsin anglers and their families. The foci of the investigation will be on understanding (1) how anglers and their families reach conclusions about the personal hazard posed by eating fish from contaminated inland and Great Lakes waters and (2) how information about the risks of eating fish is culled from the various messages embedded in the welter of information channels available to them and incorporated into their personal understandings of risk. This study will draw on an already extensive literature in psychology that explores the multidimensional nature of individuals' risk perceptions and a newer literature in communication that has begun to look at how individuals use different channels of information (i.e., interpersonal vs. such mediated channels as newspapers and television) to "construct" a personal understanding of risk. The investigator will accomplish the study objectives by, first, engaging anglers and their family members in intensive, small-group discussions in order to explore, in some detail, their understanding of the risks of eating certain sport-caught fish. The investigator will then conduct a mail survey of a sample of Great Lakes and inland anglers, and a sample of anglers' family members, to explore more systematically their understanding of the possible risks of eating sport-caught fish and the information used to reach that understanding.

Conditioned Risk and the Evaluation of Great Lakes Projects – R/PS-43

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Jay S. Coggins
Agricultural Economics
UW-Madison

The variability of Great Lakes water levels makes decisions regarding protection against lakefront damage difficult. Predicting water levels in a systematic fashion, and using the predictions in a decision-making model that systematically incorporates attitudes toward the riskiness of shoreline protection projects, are the two primary thrusts of this research. The first objective is development of the decision-making model that depends critically upon a statistical lake level prediction model. The model, which uses conditional lake level predictions, will be applied to one or more example installations, and the framework and these specific results will be taken to decision-makers through an educational program. The investigators will construct a function describing the distribution of net benefits resulting from various protection projects. The function will incorporate a state-of-the-art conditional lake level prediction model, a shoreline protection facility cost function and a shoreline facility damage function that depends upon lake levels and protective installations. This distribution

will be the basis for a utility model that will incorporate the degree of aversion to risk into the decision-making process and that will highlight the trade-off between the expected returns to shoreline projects and their riskiness. The conceptual framework will be applied to one or more specific case studies by gathering construction cost and damage data from an existing installation and constructing the distribution function describing net benefits due to the protection device. These results will be used in the second year of the project to develop an educational program aimed at conveying practical applications of the model to decision-makers concerned with shoreline damage protection.

Archeological Assessment of Historic Great Lakes Shipwrecks – R/PS-41

David J. Cooper
State Historical Society of Wisconsin
State of Wisconsin

Since the 1970s, Wisconsin sport divers have become increasingly aware of an international concern regarding the preservation of historic shipwrecks. The development of marine preserves in adjacent Michigan, the realized economic benefits of protecting shipwrecks for sustained recreational usage, new state and federal laws strengthening protective measures for underwater archeological resources, and the development of public/private partnerships in submerged cultural resource management have all heralded and contributed to changing attitudes and ethics regarding maritime historical resources. The management of these resources, and education of the various user groups about preservation needs, depends a great deal on resource inventories and site assessments by researchers. Detailed archeological resource data are also a prerequisite to development of state or national marine preserve areas. The investigator will develop this information through a synthesis of existing data and the development and analysis of a shipwreck database. He will also conduct field investigations of high-priority (usually threatened) shipwreck sites, publish technical publications on survey results and integrate these data into maritime heritage public education efforts, site interpretation and submerged cultural resources management planning conducted by public agencies.

NEW INITIATIVES

Coordinator: Anders W. Andren, UW-Madison

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 Wisconsin Sea Grant subprogram and sometimes span two or more of the established subprograms. The 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

Appropriate areas of New Initiatives research include the potential effects of climate change on Great Lakes hydrology and ecosystems, the role of the oceans in climate change, the application of artificial intelligence techniques to marine resource utilization and management, new developments in biotechnology, and the application of satellite remote sensing to the oceans and the Great Lakes.

Regional issues might include the water budget of the Great Lakes, coastal erosions processes and the introduction of potentially harmful exotic species into the Great Lakes. The recent appearance in the Great Lakes of exotics like the zooplankter *Bythotrephes*, European ruffe and zebra mussel are of special note.

New Initiatives projects for 1992-94 include a continuing and a new project related to climate change. The continuing project involves analysis of air mass-based climate change scenarios for the Great Lakes basin; the new project is a study of the effect climate change might have on Great Lakes habitat use and potential invasions by exotic species.

Two other projects deal with diver safety — a new project aimed at modifying panic stress responses in scuba divers, and the conclusion of a continuing medical project on decompression sickness.

Current Activities

New Initiatives investigators are currently completing development of a hydrostratigraphical model of the interaction between Lake Michigan and southeastern Wisconsin coastal aquifers as well as a study of how Great Lakes waves and storm surges are related and how this might affect coastal design. Another global climate-related project is a feasibility study of a new method for remotely measuring heat transfer at the ocean-atmosphere interface.

Global Climate Change and the Great Lakes: Changes in Habitat Use and Potential Invasions by Exotic Species – R/NI-17

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Global warming could increase the potential for invasions into the Great Lakes and disturbances to existing aquatic communities. Prior knowledge of possible invasions would help to plan for, or respond to, subsequent changes in system structure. The investigator will examine the potential consequences of global climate change on fish and zooplankton in Green Bay by (1) modeling potential changes in the availability of suitable thermal habitat for major fish and zooplankton species, (2) determining potential changes in habitat use and growth of currently dominant species, and (3) examining the susceptibility to invasions by exotic species by comparing their expected habitat/resource use and predicted growth rates with those of currently important species. The investigator will simulate expected changes in lake physical properties and the distribution patterns and bioenergetics of warm-, cool- and cold-water fish and zooplankton in Green Bay, Lake Michigan. Comparisons will be made between current climatic conditions and those predicted by General Circulation Models for a doubling of carbon dioxide climate scenario. Future invasion susceptibility will be investigated through examination of potential changes in habitat use and growth for species of current importance and other species currently found in Green Bay in low abundance, in marginal habitats such as rivers and wetlands, or expected to eventually arrive in the Great Lakes. These will include fish species, such as white perch, European ruffe and roach, as well as zooplankton, such as *Bythotrephes cederstroemi* and *Eurytemora affinis*. This analyses will be an important first step in forecasting the effects of global climate change on the lakes. Testing models of habitat use will be a logical next step for future research on the Great Lakes.

Air Mass-Based Climate Change Scenarios for the Great Lakes – R/NI-15

Waltraud A.R. Brinkmann
Geography
UW-Madison

Most meteorologists agree that if global warming occurs, it will have its greatest effects in polar areas. In the Great Lakes region, that could mean average daily temperature increases primarily on the winter days when cold air masses move down from arctic regions; on days when temperate Pacific or tropical air masses dictate the weather, little or no change in average temperatures could occur. Yet, computer models used to study global warming lack daily regional variations, assuming instead that global warming will increase temperatures every day. The project will develop regional climate scenarios based on the differing effects of global warming in polar and temperate latitudes. Taking the individual air masses into account could improve modeling of global warming and of climate change in general. The research could also provide insights into the possible effects of global warming on Great Lakes water levels. Though focused on the Great Lakes region, the climate scenarios could provide a prototype for meteorologists in other regions.

Modification of Stress Responses in Scuba Divers – R/NI-18

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Physical Education and Dance
UW-Madison

The number of nonoccupational underwater diving fatalities reported in 1989 revealed a dramatic increase of 73% over the previous year. It has been reported that the number one cause of diving fatalities is panic, and epidemiological research has shown that 54% of the divers studied had experienced panic behavior while diving. It is possible to use standardized psychological questionnaires to predict those divers most likely to panic. Research has also shown that both psychological and physiological responses during scuba exercise are influenced in part by gender, protective clothing and water temperature. These findings support the view that modification of stress responses should lead to reductions in panic behavior. The primary purpose of this

research is to examine the efficacy of select cognitive strategies in modifying the stress responses of scuba divers. The specific objective is to quantify the psychological (e.g., anxiety), perceptual (e.g., effort sense) and physiological (e.g., respiration) consequences of selected cognitive strategies (e.g., somatic monitoring, biofeedback, autogenic training) during controlled scuba exercise. The results will be of potential value to: (1) instructors who teach scuba diving; (2) recreational divers (2 million-3 million in the United States alone) and (3) divers, physicians and employers in the commercial and military sectors.

Decompression and Diver Safety – R/DP-6

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Preventive Medicine / Biotron,
UW-Madison

Charles E. Lehner,
Preventive Medicine,
UW-Madison

The best known form of decompression sickness is the bends — sharp pains in the limbs and joints that divers experience when they surface too rapidly. There is mounting evidence, however, that other forms of decompression sickness, including osteonecrosis (bone death) and spinal cord injury, pose a much more serious and long-term threat to diver health. Both can be difficult to diagnose, and their precise relationship to diving is not well understood. This project will investigate diving's effects on motor coordination, the transmission of electrical signals by nerve cells and the microscopic structure of bone, using proven methods for studying decompression sickness in animals. The research will also investigate the relationship of nerve and bone damage to dive profile — the number, the length and the depth of a subject's dives. Shedding light on the physiological details of decompression sickness could provide insights into preventive measures and better treatments. Victims of spinal cord injuries and osteonecrosis could also benefit from this decompression sickness research.

ADVISORY SERVICES

Coordinator: Allen H. Miller, UW-Madison

The UW Sea Grant Advisory Services Subprogram provides a bridge between science and its application through four field agents, four subject-area specialists and support staff.

Four Advisory Services field offices — located on coastal UW campuses in Green Bay, Manitowoc, Milwaukee and Superior — provide support to public- and private-sector clients in aquaculture, coastal engineering, commercial and sport fisheries, waterbased businesses and industries, and Great Lakes-related recreation. Field agents provide information and assistance in solving Great Lakes-related problems through formal and informal classes, national and international conferences, regional and state workshops, field demonstrations, publications and direct one-to-one assistance.

The subprogram's subject-area specialists complement field activities by providing in-depth knowledge of aquaculture, coastal engineering, docks and marina design and maintenance, and fish processing. These specialists provide technical assistance to individuals as well as groups of businesses, and they share their expertise through conferences and workshops. They also conduct applied research both in the field and in the laboratory to assist clients in finding practical solutions to their problems.

Long-Range Goals

- To apply university and other science resources to solve problems and provide opportunities for Great Lakes users;
- To provide limited general scientific education on Great Lakes concerns to the citizens of the state.

Priorities and Emerging Issues

- Increased trade among nations has also increased the movement of plants and animals throughout the world. Deliberate as well as accidental introductions of nonindigenous species often have catastrophic effects on local ecosystems. A major concern for the Great Lakes and the continent's eastern freshwater systems is the introduction, the spread, and the economic and environmental impacts of several nonindigenous species, especially the zebra mussel (*Dreissena polymorpha*). Launched before special federal funding became available, UW Sea Grant's intensive effort to educate water users on the spread, effects and possible controls of zebra mussels is already in its third year. "Observing and Disseminating Information on the Spread and Control of Zebra Mussel in the Upper Great Lakes" (Miller, Kraft, Wittman and Frederick), now funded through separate sources, continues to provide leadership within both the state and the region.
- Growing consumer demands for quality and clearly labeled seafood products as well as public concern for fishing vessel safety and sustainable harvests have contributed to changes to the commercial fishing industry nationally as well as regionally. Beset with new catch quotas, new sanitary fish handling requirements, new food labeling requirements, new vessel safety requirements and potential damage to gear and boats caused by the invading zebra mussel, Wisconsin's commercial fishing industry has more than its share of change. To help the commercial fishing industry continue to offer quality products, Advisory Services field work for 1992-94 includes five new targeted projects:

- "Observing and Disseminating Information on the Spread and Control of Zebra Mussel in the Upper Great Lakes" (specifically, the mussel's effect on commercial fishing gear) (continuing), Frederick
- "Adjusting to Lake Superior Fishing Quotas" (new), Hoven
- "Establishing Green Bay Yellow Perch Fishery Quotas" (new), Kraft
- "Fishing Vessel Safety" (new), Lubner
- "Commercial Fishing Sanitation Workshops" (new), Frederick with Stuiber

- A diminishing wild fishery coupled with a public interest in healthy, environmentally safe fisheries products and an extremely high level of imported fish is leading to a growth of aquaculture enterprises as a source of food; for stocking of rivers, streams and lakes, and for bait. Many new fish farmers are from the business community, interested in developing new enterprises. Observers report the aquaculture industry in the Midwest is about to make a major leap forward. For Wisconsin to capitalize on aquaculture will require new directions and technologies. Advisory Services' past efforts to provide general information and limited support to aquaculturalists are clearly inadequate today. An enhancement of prior outreach efforts tailored to today's needs is described in the "Aquaculture Advisory Services for Great Lakes Fishes" (Binkowski) project. Complementing this specialist support is a field project, "Aquaculture in Northwest Wisconsin" (Hoven), targeted to provide additional resources to the Bad River Band of the Chippewa Indians.
- Wisconsin Sea Grant is a partner with several other state Sea Grant programs in a national effort to initiate an education program on global change. "Global Change Education for Teachers and Community Leaders: Part of a Cooperative National Sea Grant Venture" (Lubner and Miller) is one component of this broader effort to develop model programs for teachers and the adult public. No federal funds are currently available for educational programs on climate change; this and similar efforts by the Hawaii, Louisiana, Minnesota, Mississippi/Alabama, Oregon, Rhode Island and Washington Sea Grant programs currently are being supported only by the National Science Foundation and individual Sea Grant programs.
- "Door County Summer Education Program" (Miller) is a new field project initiated during the current biennium to educate summer tourists about the Great Lakes and other science issues. Working with the Wisconsin Department of Natural Resources (WDNR), Advisory Services conducts a number of education programs at state parks in the popular Door County peninsula, which attracts thousands of tourists each week.

Three Advisory Services projects are focused on making use of today's new technologies:

- "Continuing Education for Fishery Scientists: Computers in Fishery Management" (Kraft) is a continuing project that makes use of computer-based bioenergetics models developed during the 1980s by UW-Madison Sea Grant scientists. Successful delivery of this technology throughout the United States and Canada has resulted in continuing demands for workshops and tailoring the model to specific situations.
- A new project, "Model Application and Software Development for Establishing Green Bay Yellow Perch Fishery Quotas" (Kraft), is a cooperative venture with the WDNR to apply the model to the bay's most important commercial fishery.
- The third project, "Managing Coastal Resources with the Aid of Geographic Information Systems" (Miller) will explore the application of geographic information systems to issues in coastal management. Physical resource data collected by federal, state and local agencies and industries can now be integrated with cultural information that was collected during the 1990 census, also stored in a geographical format.

User Advisory Committee

To keep the Advisory Services Subprogram responsive to users' needs, a Users Advisory Committee was established in 1992 to counsel the subprogram's coordinator, specialists and field agents on current projects and future directions.

The committee is composed of nine members representing Wisconsin Sea Grant's major client groups and diverse geographic service area.

Advisory Services Special Projects , 1992-94

Allen H. Miller, Madison Headquarters

- Global Change Education for Teachers and Community Leaders: Part of a Cooperative National Sea Grant Venture (with Lubner)
- Observing and Disseminating Information on the Spread and Control of Zebra Mussel in the Upper Great Lakes (with Kraft and Wittman)
- Door County Summer Education Program (new)
- Managing Coastal Resources with the Aid of Geographic Information Systems (new)

Field Agents

Lynn Frederick, Manitowoc Field Office

- Technical Assistance in Composting Fisheries By-Products
- Fisheries Education
- Zebra Mussels & Commercial Trap Nets
- Safety Education for Divers: Panic and Other At-Risk Behaviors (with Lubner) (new)

Harvey Hoven, Lake Superior Field Office

- Economic Assessment of Marine-Related Businesses
- Lake Sturgeon Study and Aquaculture Plan
- Assistance to Lake Superior Commercial Fishers (new)

Clifford Kraft, Green Bay Field Office

- Continuing Education for Fishery Scientists: Computers in Fishery Management
- Observing and Disseminating Information on the Spread and Control of Zebra Mussel in the Upper Great Lakes (with Miller and Wittman)
- Model Application and Software Development for Establishing Green Bay Yellow Perch Fishery Quotas (new)

James Lubner, Milwaukee Field Office

- Recreational Water Safety
- Global Change Education for Teachers and Community Leaders: Part of a Cooperative National Sea Grant Venture (with Miller)
- Safety Education for Divers: Panic and Other At-Risk Behaviors (with Frederick) (new)
- Fishing Vessel Safety: A Response to Changing Federal Regulations (new)

Specialists

Fred Binkowski, UW-Milwaukee

- Aquaculture Advisory Services for Great Lakes Fish (new)

Philip Keillor, UW-Madison

- Coastal Engineering Advisory Services

Sue Sadowske, UW-Extension

- Managerial Assistance for Great Lakes-Based/ Allied Businesses (new)

David Stuiber, UW-Madison

- Fisheries Development

C. Allen Wortley, UW-Madison

- Docks and Marinas Advisory Services

Advisory Services: Program Coordination and Field Offices – A/AS-1

Allen H. Miller
Sea Grant Institute
UW-Madison

Wisely used, the Great Lakes can provide citizens with opportunities for both recreational and economic fulfillment, while maintaining the ecology of the lakes. Sea Grant and other physical and social scientific knowledge can furnish the latest information and technology to increase understanding, address priority concerns and open new possibilities for the sustained, beneficial use of the Great Lakes. UW Sea Grant Advisory Services (1) applies university and other science resources to solve problems, (2) provides new opportunities for Great Lakes users and (3) provides limited general scientific education on Great Lakes concerns to citizens of the state. By using a network of four field agents and four subject area specialists, Advisory Services disseminates scientific information applicable to resolving issues of concern to the users of the Great Lakes — and conveys to the research community the need for new applied research. Applicable information is delivered through adult instruction, hands-on training, demonstrations, individual technical assistance, field research and written and audio-visual materials.

Coastal Engineering Advisory Services – A/AS-24

Philip Keillor
Sea Grant Institute
UW-Madison

This project provides: (1) assistance to Wisconsin agencies, businesses and communities in making decisions on marine construction that account for the natural coastal hazards of flooding, erosion and storms; (2) information about dredging, dredged material disposal and contaminated sediment remediation techniques to assist coastal communities and management agencies with engineering approaches and techniques to clean up and/or maintain recreational and commercial harbors and (3) information and assistance to industrial and municipal water intake owners, consulting engineers and contractors on ways to exclude zebra mussels from water intakes. The priorities of this proposal have changed with the completion of earlier work and the emerging need to help in dealing with zebra mussel infestation of water intakes and to help with clean-up of toxic sediments in the Milwaukee Estuary. Assistance with dredging methodology remains a priority because of the greatly expanded recreational harbor facilities in the Great Lakes and because of continuing average and below-average lake levels that increase the need for maintenance dredging.

Fisheries Development Advisory Services – A/AS-8

David A. Stuiber
Food Science
UW-Madison

This project has been part of the continuing Advisory Services effort required to meet UW Sea Grant commitments to the state seafood industry and other clientele groups for more than 22 years. During that span of time, the state seafood industry has received help in the areas of product development, sanitation control, seafood safety, marketing and process management assistance. Both the industry and the public at large have been the beneficiaries of a great deal of assistance and good sound advice.

Docks and Marinas Advisory Services – A/AS-20

C. Allen Wortley
Engineering Professional Development
UW-Madison

This Advisory Services project is helping solve engineering problems related to designing, building and operating safe and efficient docks and marinas, which provide needed public access to recreational waters. Several problems being addressed include ice actions on structures, which cause extensive damage; new product developments, and boat wastes, which have public health significance. Field observations are being made, conferences are being planned and conducted, and advisory services reports and videotapes are being produced and distributed. During 1990 and 1991, four conferences were conducted; observations were made in small-craft harbors throughout the Great Lakes; two bibliographies were published; three videotapes were produced and many presentations, including papers, were made.

Developing, Demonstrating and Promoting Alternative Aquaculture Strategies through Advisory Services – A/AS-29

Fred Binkowski
Center for Great Lakes Studies
UW-Milwaukee

Aquaculture-related business in Wisconsin has increased dramatically in the last several years. Activity in this industry is on the verge of making a quantum leap forward. This is evident in the requests for information channeled through the UW Sea Grant Aquaculture Advisory Services project. A new demand and broader interest regarding all kinds of technical information and aquaculture services have evolved. As novices enter aquaculture, they seek guidance from knowledgeable and experienced persons. To realize aquaculture opportunities, interested parties need access to sound advice concerning the development and operation of aquaculture ventures. Most expressed a need for more readily available specific advice on aquaculture above and beyond that available in short lecture sessions. Some individuals suggested the need for a regional "clearinghouse" of information, for reading lists of pertinent literature, audiovisuals and problem-solving workshops and for specific hands-on training. This is where the UW Sea Grant aquaculture extension program can play a vital role. The primary goal of this project is to consolidate specialized expertise on the culture of Great Lakes fish and to develop effective means of delivering this information through the Wisconsin Sea Grant Advisory Services Subprogram. A lecture series will provide general information relating to the technology of culturing Great Lakes fish, while specialized sessions will include information on species selection, site selection, water requirements, hatchery design, permitting and species-specific information on spawning, hatching and rearing. Emphasis will be placed on packaging this program in formats that could be circulated and used throughout the state and the Great Lakes region by the various Advisory Services specialists."How to" manuals and workbooks will be developed for regionally specific aquaculture practices. Practical aquaculture demonstrations will be organized at both academic and private industry sites. Audiovisual materials for group lectures and traveling exhibits displays will be used to enhance information transfer. A program of hands-on workshops to provide training and consultation will also be developed for individuals with a serious interest in developing aquaculture facilities as well as to assist in problem-solving relative to existing fish farm operations. A more effective packaging of information on all aspects of aquaculture appropriate to the Great Lakes region will help bridge the gap between user groups and aquaculture scientists in Wisconsin. The high visibility of such outreach programs will also foster the public awareness of UW Sea Grant's role in the development of aquaculture for the Great Lakes region.

Managerial Assistance for Great Lakes-Based/ Allied Businesses – A/AS-30

Sue Sadowske
Recreation Resources Center
UW-Madison

The Great Lakes give rise to numerous small, water-based recreation enterprises. In addition, there are numerous small businesses allied with the lakes' resource base, such as motels, restaurants, bait shops, etc. Typically, these businesses are in need of improved management and marketing. Collaborative efforts such as cross-marketing and packaging are not utilized extensively. Further, a shared positive community vision within the private sector and between the public and private sectors is often lacking. This project will develop two workshops annually (one for the Lake Superior and one for the Lake Michigan coastal counties) directed to small business operators and community leaders in coastal communities, examining the business potential offered by the Great Lakes resource, collaborative efforts and combined marketing opportunities. The workshops should improve business operations, ultimately contributing to their profitability. Increased profitability will result in less turnover, more stable business and a stronger community economic base. Potential visitors will benefit by continued availability of Great Lakes-related business services and products. Increased collective efforts will contribute to a broader sense of community and enhance the community as a product, creating greater appeal to potential Great Lakes users.

COMMUNICATIONS

Coordinator: Stephen Wittman, UW-Madison

The prime directive for projects in the Communications Subprogram is to ensure the broadest possible dissemination of scientific, technical and advisory information resulting from Sea Grant research, outreach and educational activities. Objectives serving this directive include providing professional communications support to Wisconsin Sea Grant staff and scientists, media relations and public education projects.

Long-Range Goals

The major goals of the Wisconsin Sea Grant Communications Subprogram for the next five to 10 years are to:

- Continue and build upon current core activities, particularly publications production and the "Earthwatch radio" program.
- Develop a timely and cost-effective capability for producing and distributing instructional videotapes and television public service announcements.
- Work with state and regional education agencies and science teachers associations to develop and promote the use of K-12 educational materials that use Great Lakes examples to illustrate general ecological concepts and current environmental issues, such as the effects of invasions by non-indigenous species, global climate change, cascading trophic interactions, etc.
- Identify and implement state-of-the-art communications production and delivery technologies, including desktop publishing, computerized graphics production and presentation, electronic mail, online databases and laser discs capable of presenting combinations of text, static illustrations and "living" graphics, and photographic and videotaped images.

Short-Term Objectives

Specific objectives of the two Communications projects for the next biennium are to:

- Produce and distribute more than a dozen publications resulting from or based on Wisconsin Sea Grant research and Advisory Services projects.
- Continue to produce and distribute the regional "Earthwatch" radio program.
- Continue to produce and distribute an annually updated fact sheet on PCB contamination of Lake Michigan fish, including a version in Spanish, in cooperation with the Wisconsin Division of Health and state Department of Natural Resources.
- Continue to produce and distribute informational materials regarding the zebra mussel in cooperation with state and regional agencies and the Great Lakes Sea Grant Network. This includes producing Zebra Mussel Watch cards for public distribution and 12 issues of the free *Zebra Mussel Update* newsletter for distribution to more than 2,000 subscribers regionwide.
- Produce and market a multi-author book summarizing the findings of Wisconsin Sea Grant's 20-year research effort towards rehabilitating the Green Bay, Lake Michigan, estuary.
- Update the institute's graphics library to ensure that current photographs and appropriate illustrations are readily available to news media and magazines and for Sea Grant publications and exhibits.

Core Activities

Top priority is given to publishing Great Lakes-related materials that meet the needs of specific groups of

Great Lakes resource managers and users. High distribution rates are achieved through an emphasis on quality, targeted mailings of promotional materials, promptly responding to requests for publications, regular submissions of new publications to the National Sea Grant Depository, and cooperative production and distribution arrangements with other university departments, government agencies and other Sea Grant programs nationwide.

Specifically, the Communications Office:

- Provides professional communications support to UW Sea Grant Institute staff, Advisory Services specialists and scientists, including production of the biennial institutional proposals, periodic program and project reports, a monthly newsletter, photography and graphics production, publicity and printed materials for workshops and conferences, displays and exhibits, and media relations.
- Coproduces the "Earthwatch" radio program, which disseminates information about Great Lakes, science and environmental news via five two-minute programs per week aired by more than 170 stations throughout the Great Lakes region.
- Annually issues an average of 20 news releases, which are published regularly by daily and weekly newspapers throughout Wisconsin and the Great Lakes region.
- Generates public information reports on general interest topics that are based on or related to Wisconsin Sea Grant research and the Great Lakes.
- Provides talented UW-Madison graduate and undergraduate students with professional marine science writing experience through project assistantships and hourly employment.

Benefits

The Wisconsin Sea Grant Communications Office has become widely recognized as a credible and reliable source of information on Great Lakes issues. The publications, radio programs, exhibits, films and videotapes created and disseminated via the Communications Subprogram are used by government agencies, news media, industries and businesses, schools and 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 the National Sea Grant College Program.

Communications Office & Program Coordination – A/AS-2

Stephen Wittman
Sea Grant Institute
UW-Madison

The UW Sea Grant communications project is the oldest and largest in the Great Lakes region. Since its start in 1968, the communications project has produced 514 reports and distributed more than 650,000 copies of these and other Sea Grant publications. Since 1972, it has produced the "Earthwatch" public service radio program in cooperation with the Institute for Environmental Studies at UW-Madison. The UW Sea Grant Communications Office has an awarding-winning tradition of quality in research news reporting, science writing, publications design, public relations, film production and radio programming. The Communications Office also maintains a video and film loan library featuring the six films and videotapes produced or supported by UW Sea Grant since 1976.

"Earthwatch" Public Service Radio Program – A/AS-3

Richard Hoops
Sea Grant Institute
UW-Madison

"Earthwatch" uses the popular medium of radio (1) to give the public concise, objective and timely information about science and the environment, especially in regard to the Great Lakes and the nation's marine resources and (2) to raise public awareness of the Sea Grant program and its activities in Wisconsin and around the nation. Sea Grant cooperates with the UW-Madison Institute for Environmental Studies to produce 10 two-minute "Earthwatch" programs every two weeks and to distribute them to 170 broadcast outlets in 16 states, including the eight Great Lakes states and the province of Ontario. "Earthwatch" is broadcast more than 660 times a week over these outlets: If this free public service airtime were purchased at commercial rates, it would cost more than $800,000 a year. In addition to disseminating Sea Grant information to the public, "Earthwatch" also serves as a model for radio projects at other Sea Grant programs.

EDUCATION

Coordinator: Anders W. Andren, UW-Madison

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. Finally, the program conducts diverse activities for the general education of the public on ocean and Great Lakes matters, and for highly focused education and training for specific marine audiences, such as fishers, boaters, coastal residents, port managers 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 projects. The 1992-94 program will provide annual support for 27 graduate students. These awards also carry tuition remission. 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 drastic reduction in the number of graduate students supported (less than 30 currently vs. 50 in 1985). This decrease is a reflection of 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 both to compete worldwide and to maintain a strong and vital society, our highest priority long- and short-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 or more.
- 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 to 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 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 that enhance public awareness of the Great Lakes and oceans, including 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 in the future.

Benefits

In the 24 years since the Wisconsin Sea Grant Program began, 377 Wisconsin Sea Grant-supported students have received graduate degrees (141 Ph.D. and 236 Master's degrees). These students are major national assets and are already making a major contribution to the management and conservation of the nation's marine resources and environment. Wisconsin Sea Grant graduates have moved into the executive suites of major corporations, become senior scientists in government laboratories, started their own businesses, become professors and been elected to public office.

The opportunity for shipboard or coastal ocean environment experience provided through Wisconsin Sea Grant's Education Subprogram has deeply influenced a number of graduates. Several have reported that this experience was the turning point in their education and resulted in their pursuing careers in marine fields.

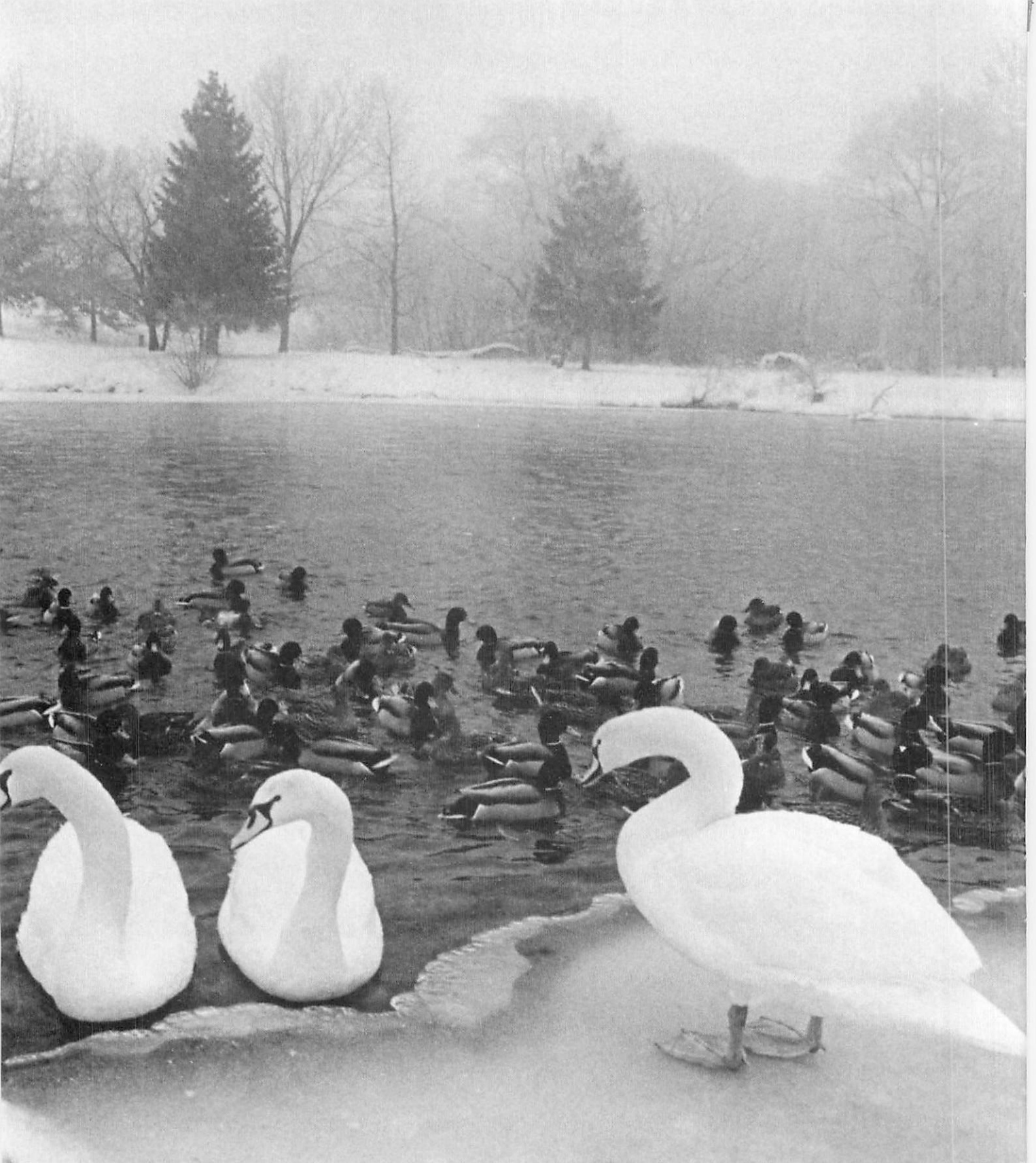
In addition, the Communications Subprogram's award-winning public service radio project, "Earthwatch," now in its 20th year, has probably introduced more people to the importance and fascination of the Great Lakes and oceans than any other regional educational activity.

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, and education will remain a primary goal of the Wisconsin Sea Grant College Program.

Special Marine Education Programs – E/E-1

Anders W. Andren
Sea Grant Institute
UW-Madison

Hands-on experience, new courses and guest lecturers are all valuable supplements to the standard educational process. Exceptional students and graduate thesis work often merit special support. Public understanding of Great Lakes and ocean resource issues is crucial for development of sound public policy. This project provides educational experience and specialized training not regularly provided in the course of participation in research projects and broadens perspectives of students through guest speakers, seminars and the like. Sea Grant-supported graduate students have gone on to jobs in the private and public sectors, where they continue to apply the results of Sea Grant research. These graduates are a major national asset to the competitiveness and economic health of this country.



PROGRAM ADMINISTRATION

Director: Anders W. Andren, UW-Madison

The Wisconsin Sea Grant Program began in 1968, and just four years later, reflecting its success in integrating a high quality research program with effective educational and advisory services programs, became the fifth program to be designated a Sea Grant College Program in the nation and the first in the Great Lakes.

The overall management of the UW Sea Grant College Program includes program planning, project and subprogram evaluation, proposal development, research coordination, program reporting, administrative functions, and leadership for the program as a whole. The UW Sea Grant Program has remained responsive and accountable to the public and user groups it serves through strong university, community and societal interaction. Since its inception, Wisconsin Sea Grant has held 13 major planning meetings that have focused on overall program management and direction as well as research subprogram goals and objectives.

In July 1991, for example, Wisconsin Sea Grant conducted a major two-day program planning meeting that assessed the scope and balance of the program's research initiatives; its partnerships with industry, communities and government, and its Advisory Services and Communications efforts. Participants included Wisconsin Sea Grant program staff, subprogram coordinators, members of the Wisconsin Sea Grant Advisory Council and experts from outside the program representing industry, government, communities, university faculty and user groups. The results of this meeting were used to develop the goals, objectives and future of Wisconsin Sea Grant research subprograms described here.

The 1991 planning meeting, along with regular meetings with the subprogram coordinators, the Wisconsin Sea Grant Advisory Council and program staff, helped shape the Wisconsin Sea Grant 1992-94 biennial proposal, which also serves as the basic planning document for the University of Wisconsin Sea Grant College Program for the next five to 10 years.

In order to maintain a nationally recognized research and outreach program, the Wisconsin Sea Grant College Program will continue to be guided by a set of policies that have proven to be consistent and highly effective in the University of Wisconsin environment:

- Taking a long-term research perspective.
- Supporting graduate studies in multidisciplinary research programs.
- Applying an ecosystem approach to research and synthesizing research results.
- Maintaining the scientific integrity of its research.
- Emphasizing research and technology transfer and maintaining a strong outreach and communications program.
- Coordinating Wisconsin Sea Grant efforts with other university, government and industrial efforts on the local, state, regional and national level.
- Involving more social scientists to analyze policy issues.
- Working with industry, government and other user groups.
- Sponsoring high-risk innovative research projects.
- Seeking out other sources of support for the program.

These policies form the foundation for sound management and a high-quality, forward-looking program. They also present a framework for Sea Grant to capitalize on the talents and strengths of the University of Wisconsin System as new problems and opportunities emerge. As the only coherent U.S. Great Lakes research programs, the Great Lakes Sea Grant Network and the National Oceanic & Atmospheric Administration's Great Lakes Environmental Laboratory (GLERL) now play a key role in meeting the United States' research commitments under the recently amended 1978 Water Quality Agreement. Sea Grant and GLERL research programs are highly responsive to the requirements of the agreement, and they also anticipate future problems and needs.

As noted in the 1990 biennial report of the International Joint Commission, the primary problem facing the Great Lakes is and will continue to be the contamination of their waters, sediments and living organisms by persistent toxic organic chemicals. The Wisconsin Sea Grant program reflects the importance of this issue by its substantial Microcontaminants & Water Quality subprogram as well as aspects of the Green Bay Estuary and Living Resources subprograms. Education, Advisory Services and Communications subprogram activities complement the strong ongoing research program on this issue.

The inadvertent introduction of undesirable exotics like *Bythotrephes*, the European ruffe and the zebra mussel into the Great Lakes have raised serious concerns about ecosystem integrity. Monitoring and control of these pests have just begun, and their eventual effects are unknown. Sea Grant represents the best, and probably the only, avenue for the basin-wide and interdisciplinary research and outreach on the exotic species problem and potential control measures.

Wisconsin Sea Grant subprogram coordinators are frequently called upon to serve on advisory boards for the region's federal agencies and laboratories and on Great Lakes Sea Grant Network committees. Wisconsin Sea Grant Program Director Anders W. Andren was recently appointed co-chair of the IJC Science Advisory Board and also served as co-chair of its Virtual Elimination Task Force. Andren also serves on several committees of the U.S. EPA's Science Advisory Board and is national chair of the the EPA's Office of Extramual Research Peer Review Panel on the Physics & Chemistry of Aquatic Systems. In addition to working closely with the IJC and its advisory bodies, Wisconsin Sea Grant cooperates closely with the international Great Lakes Fishery Commission. Here also, Sea Grant plays an important role, through both the many technical committees and the conduct of innovative fisheries research. Wisconsin Sea Grant fishery scientists have taken a leadership role in bringing together Canadian and U.S. scientists to discuss and implement new approaches to management of a multispecies fishery.

Through sound management and fiscal practices, the University of Wisconsin Sea Grant College Program will continue to pay dividends to the state, region and nation for decades to come.

Program Management – M/SGA-2

Anders W. Andren
Sea Grant Institute
UW-Madison

Effective management requires a high level of integration of research, education and advisory service activities, and high professional standards of performance. Maximum program impact requires coordination with other related programs. The continued viability of and support for the program requires close and effective liaison with both state and federal sources of support as well as with private industry. This project focuses on (1) the application of sound management and fiscal practices; (2) the maintenance of a high level of quality control on all program activities; (3) seeking out innovative and high-risk research initiatives; (4) encouraging and developing effective advisory service, educational and communication programs, and (5) recruiting talented and creative staff. Managerial evaluation of research and outreach efforts ensures a focused and responsive UW Sea Grant program.

Program Development – M/SGA-1

Anders W. Andren
Sea Grant Institute
UW-Madison

Sound program management requires a degree of flexibility for undertaking new projects and augmenting ongoing projects as special opportunities arise. This project focuses on consultation with faculty, agency officials and private industry leaders as well as review of requests and peer review for new projects to: (1) initiate projects that may be proposed during the grant term, (2) solicit projects in areas of high program priority, (3) augment existing projects and subprograms in cases of special need or emergency and (4) initiate new subprograms as appropriate.

Ship Time in Support of Sea Grant Research Projects – M/SGA-3

Philip Keillor
Sea Grant Institute
UW-Madison

Many Wisconsin Sea Grant studies of the Great Lakes require reliable research vessels equipped with specialized oceanographic equipment. This project funds ship time on two UW research vessels — the *Aquarius* and the *Neeskay*, based at Sturgeon Bay and Milwaukee, respectively — for Sea Grant projects that require field work on Lakes Michigan and Superior. To minimize expenses, several kinds of field work are often conducted simultaneously on each cruise.

APPENDICES

Related Projects Funded through the University of Wisconsin Sea Grant Institute

Ecological Risk Assessment of Complex Mixtures of Polybrominated Aromatic Hydrocarbons in Feral Fish Eggs – R/MW-49

Richard Peterson
School of Pharmacy
UW-Madison

Fish that live in freshwater environments and coastal waters often are contaminated with complex mixtures of polybrominated aromatic hydrocarbons. These chemicals accumulate in the tissue of female fish and then get transferred to their eggs. If egg concentrations of these contaminants are sufficiently high, they may cause mortality of fish during early life stage development and reduce populations of fish in the wild. Of the polybrominated congeners being examined in this project, the ones most toxic to young fish behave in a way similar to TCDD, a chemical widely known as dioxin. This project will examine the early life stage mortality of rainbow trout exposed to graded egg doses of polybrominated aromatic hydrocarbon congeners and will rank the toxicity of these chemicals in terms of an equally toxic egg dose of TCDD. With TCDD as the common denominator, the toxicity of different polybrominated aromatic hydrocarbon congeners will be described in terms of their TCDD equivalents concentration. Using egg TCDD equivalents concentration as a yardstick, the project investigators will develop a method for determining early life stage mortality in fertilized rainbow trout eggs that are exposed to pairs of congeners in order to determine if they interact in an additive fashion. This will allow regulatory agencies that measure the levels of these congeners in fish eggs in the wild to understand the risk that these levels pose to early life stage survival; it also will help them determine acceptable levels of brominated congeners in the Great Lakes.

Funding Source:
Coastal Ocean Program, National Oceanic & Atmospheric Administration

Exotic Species Invasions: Population Dynamics and Community Consequences of the Zebra Mussel (*Dreissena polymorpha*) – R/LR-41

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The Eurasian zebra mussel may have wide-ranging economic and ecological consequences in North America. Precise predictions from within the wide range of possible effects of the mussel would allow Great Lakes managers to anticipate the invader's impacts, design programs to monitor the invasion and its ecological consequences, and improve estimates of the economic costs of control and removal of zebra mussels from human structures. Quantitative predictions of the ecological impacts of the mussel can be made by analysis of published European data on zebra mussel physiology, life history and ecological interactions. The investigators are developing statistical and simulation models to predict zebra mussel abundance, distribution, population dynamics and ecological effects based on data from European studies and the environments of the lakes inhabited by the mussel. Predictions of the effects of zebra mussel populations in the Great Lakes will be prepared by using data on the biotic and abiotic environments of these lakes. Factors identified by these models as important determinants of zebra mussel population performance can be targeted for further study to improve the models' predictions. The approach of predicting the potential range expansion and ecological effects of exotic species based on existing knowledge of their physiology, life history and ecological interactions also will be an important management tool for future invasions.

Funding Source:
Nonindigenous Aquatic Nuisance Species Prevention & Control Act special appropriation to National Sea Grant College Program, National Oceanic & Atmospheric Administration.

Monitoring and Disseminating Information on the Spread of Zebra Mussels in the Upper Great Lakes – A/AS-28

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Since its discovery in the Lake St. Clair near Detroit in 1988, the zebra mussel has spread to each of the five Great Lakes and to major river systems throughout the northeastern quadrant of the United States. The mussel's potential for colonizing much of North America, clogging industrial and municipal water intake pipes, and smothering native mollusk populations makes it one of the most noxious aquatic exotics to invade American waters. The principal objectives of this project are to: (1) monitor the spread of zebra mussels to Wisconsin waters of the Great Lakes; (2) educate industries, municipalities and the public about the mussel and possible control measures, and (3) train personnel in government management agencies and potentially affected industries and municipalities how to identify the mussel and its larvae. In 1992, this included the regular sampling of water intakes, harbors and substrate from Lakes Michigan and Superior, lower Fox River and Lake Winnebago for analysis by scientists at UW-Milwaukee, UW-Green Bay, UW-Superior, UW-Madison and Silver Lake College, Manitowoc. The sampling results and other information is reported via the *Zebra Mussel Update*, a periodic newsletter distributed free of charge to more than 2,000 subscribers throughout the region. This project also supports the production and statewide distribution of zebra mussel fact sheets, broadcast public service announcements, boater advisories and wallet-sized "Zebra Mussel Watch" cards.

Funding Sources:
Nonindigenous Aquatic Nuisance Species Prevention & Control Act special appropriation to National Sea Grant College Program, National Oceanic & Atmospheric Administration. Additional funding provided by Fort Howard Paper Company, Green Bay; Lands' End, Dodgeville; Wisconsin Electric Power Company, Milwaukee; Wisconsin Power & Light Company, Madison; Wisconsin Public Service Corporation, Green Bay, and Wisconsin Valley Improvement Company, Wausau.

Lake Michigan Water Quality Education

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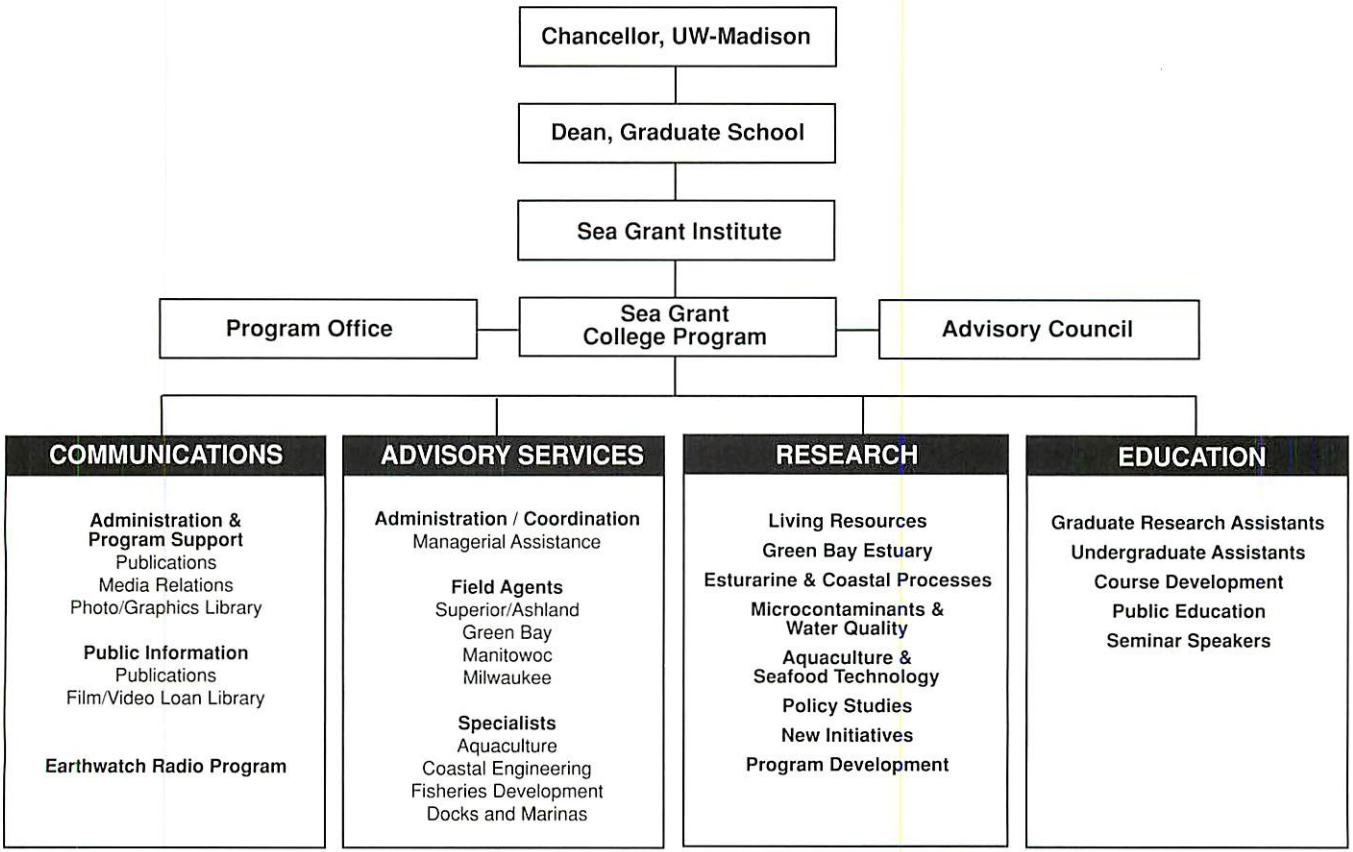
This effort by UW Sea Grant Advisory Services will improve public knowledge of Lake Michigan water quality and increase public participation in development of a plan by the U.S. Environmental Protection Agency to control pollutants in the lake. With support from an EPA grant, Sea Grant hired an outreach specialist to (1) conduct adult education workshops, (2) provide information to people on ways they can help develop the Lake Michigan Lakewide Management Plan (LaMP) and (3) write public information materials on Lake Michigan water quality. The EPA plans to develop LaMPs for each of the five Great Lakes in an attempt to reduce pollutant loadings. The LaMPs are mandated by the U.S.-Canadian Great Lakes Water Quality Agreement, and the EPA is the lead U.S. agency for developing them. EPA is writing the LaMP for Lake Michigan first because it is the only Great Lake entirely within U.S. jurisdiction. Wisconsin Sea Grant is cooperating with the Michigan and Illinois-Indiana Sea Grant programs to provide public information as part of this endeavor.

Funding Sources:
Great Lakes National Program Office and Region 5 Office, U.S. Environmental Protection Agency

Organizational Chart



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- Aquaculture Research Laboratory
- Biodynamics Laboratory
- Biotron
- Center for Health Sciences
- Center for Limnology
- Civil & Environmental Engineering
- College of Agricultural & Life Sciences
- College of Engineering
- College of Letters & Science
- Comparative Orthopedic Research Laboratory
- Engineering Professional Development
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- Water Chemistry Program
- Water Resources Center
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- Wildlife Ecology
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University of Wisconsin System
- Great Lakes Research Facility

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- Graduate School

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- Center for Lake Superior Environmental Studies

North Carolina State University
- Zoology

St. Norbert College
- Biology
- Division of Natural Resources

Silver Lake College
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- Pharmacology
- School of Medicine

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