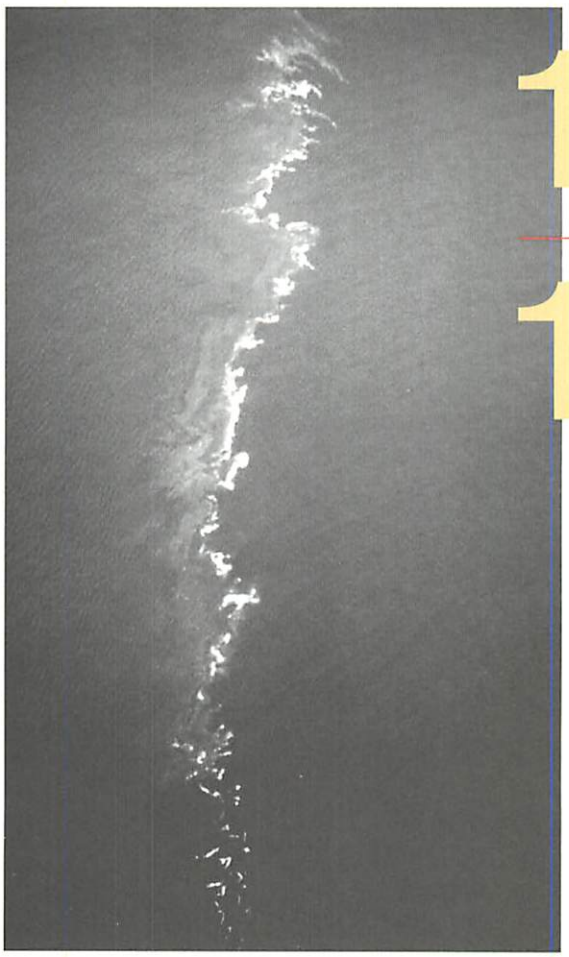
University of Wisconsin Sea Grant Institute



1994
1996

Program *directory*

1994-96 PROGRAM DIRECTORY

University of Wisconsin Sea Grant Institute

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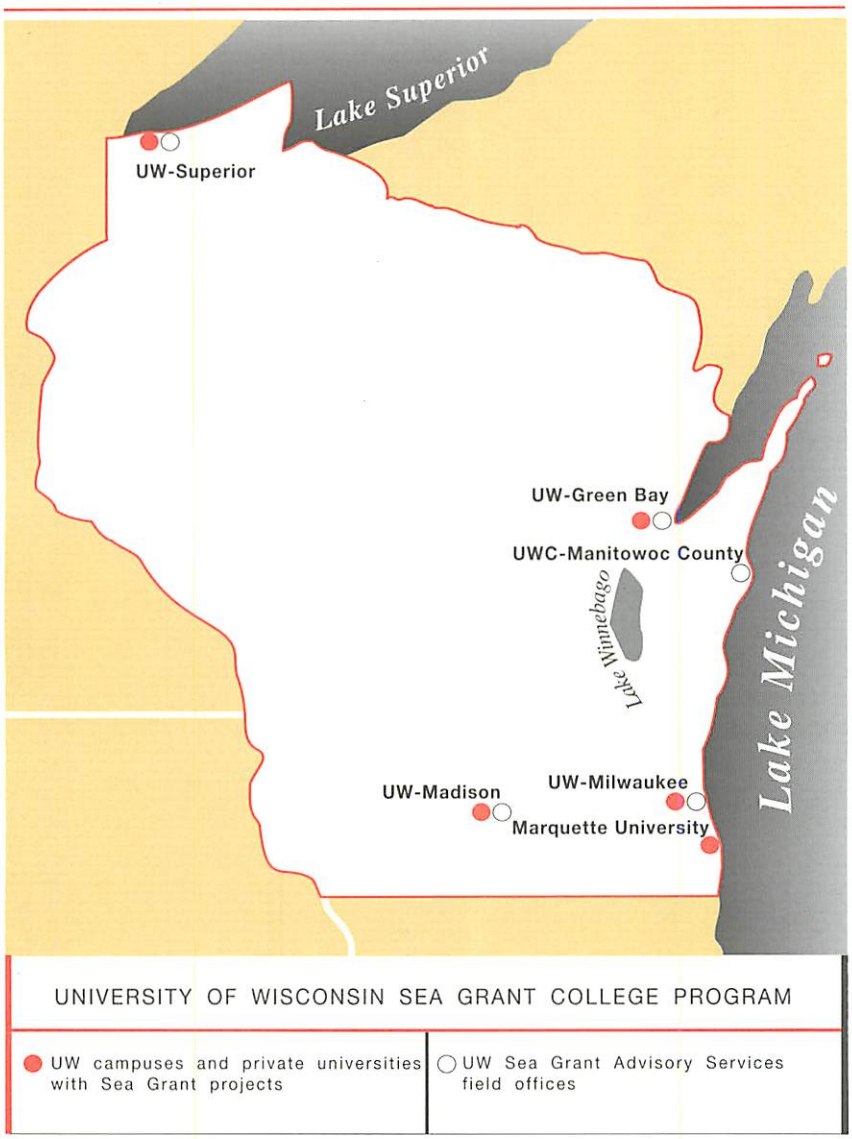
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Preface

Science in Public Service

Sea Grant is focused on making the United States the world leader in marine research and the sustainable development of marine resources. It also represents a national commitment to the protection and wise stewardship of our nation's marine and Great Lakes resources.

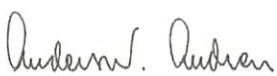
Our oceans, lakes and estuaries offer boundless potential for food, minerals and medicines. Coastal areas also offer a rich and diverse environment for human life. More than half of the U.S. population lives within 50 miles of its coasts, and many more enjoy the recreational and economic benefits of these natural resources.

Since 1966, when Congress foresaw the need for a coordinated national effort to explore the promise as well as address the problems of unused and misused marine resources, Sea Grant has focused attention on the study and understanding of the sea. From the outset, this effort has also included the Great Lakes — an immense, interconnected system of five inland seas that rank among North America's most valuable natural resources and the greatest freshwater systems on Earth.

In 1968, the University of Wisconsin established the first Sea Grant program in the Great Lakes region. Designated a Sea Grant College in 1972, the UW program continues to play a leadership role in the Great Lakes Sea Grant Network and is a major player in the national Sea Grant network as well. We have taken "The Wisconsin Idea" — the concept that the boundaries of the university are the boundaries of the state — and expanded beyond the state's 820 miles of shoreline to include the 6.4 million acres of Lakes Michigan and Superior that lie within Wisconsin's borders.

Over its first 25 years, UW Sea Grant has built an impressive record of accomplishments in creating and disseminating new scientific knowledge, particularly in the areas of Great Lakes fisheries management, contaminants and water quality, diving physiology, seafood science and freshwater aquaculture. We have provided direct assistance to the state's coastal communities and related industries and businesses, especially in the areas of sport and commercial fishing, coastal engineering, docks and marina design, tourism and aquaculture. To help increase public awareness and understanding of Great Lakes issues, we have distributed thousands of copies of hundreds of publications, and for 22 years we have coproduced a weekly series of regional "Earthwatch" public service radio programs. Over the last 25 years, we have also provided financial support and cutting-edge research experience to nearly 400 Ph.D. and Master's degree students in Wisconsin through paid assistantships on Sea Grant projects. Scattered across 43 states and 20 foreign nations, many of these former students now hold leadership positions in academia, state and federal government agencies, and in private industry.

As we move toward the 21st century, we will continue to build upon our record of accomplishments by exploring new issues and opportunities in such areas as biotechnology, prevention and conrol of nonindigenous aquatic species, environmental technology, remote sensing, geographic information systems, robotics and aquatic ecosystem restoration. We also hope to train increasing numbers of tomorrow's scientists, resource managers and entrepreneurs in the stewardship of these unique resources for the generations to come.



Anders W. Andren
Director

Introduction

1994-96 Project Directory

Sea Grant is a university-based state-federal partnership designed to provide scientific information for the protection and sustainable development of Great Lakes and ocean resources. The University of Wisconsin Sea Grant College Program is part of a national network of 29 ocean and Great Lakes research, outreach and education programs jointly funded by participating coastal states, industry and the National Sea Grant College Program, National Oceanic & Atmospheric Administration, U.S. Department of Commerce.

The National Sea Grant College Program has awarded UW Sea Grant a record $2.2 million for Great Lakes-related research, outreach and education for 1994-95, the first year of UW Sea Grant's approved 1994-96 program. The 1994-95 grant is the largest annual federal award to UW Sea Grant in its 26-year history.

Coupled with $1.4 million in matching funds from the State of Wisconsin, the federal grant will help support a total of 15 continuing UW Sea Grant research and outreach projects, and 18 new projects. Nine of these projects are in support of two national initiatives, in marine biotechnology and nonindigenous aquatic nuisance species.

As detailed in this booklet, UW Sea Grant's major research subprograms for 1994-96 include Living Resources, Biotechnology, Estuarine & Coastal Processes, Microcontaminants & Water Quality, Aquaculture & Seafood Technology, Policy Studies and New Initiatives. Its other major components include four general support subprograms — Advisory Services, Communications, Education and Administration.

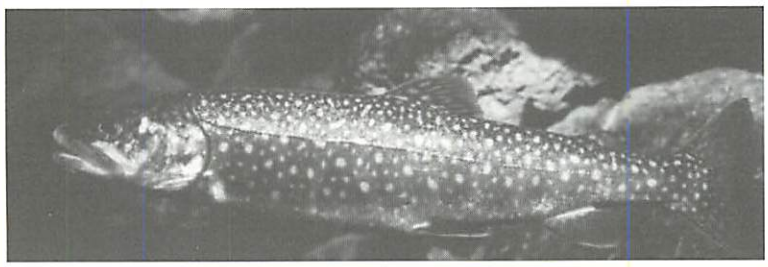
A total of 81 faculty and staff and 61 graduate and undergraduate students at five UW System campuses (UW- Madison, UW-Milwaukee, UW-Green Bay, UW Center-Manitowoc County and UW-Superior) and Marquette University will actively take part in the 1994-96 UW Sea Grant program.

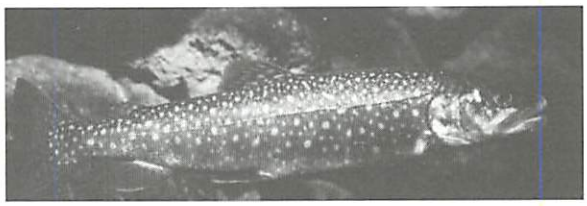
The UW Sea Grant College Program is administered by the UW-Madison Sea Grant Institute. Its research, outreach and education subprograms are managed by coordinators, each of whom is chosen on the basis of professional competence, leadership ability and high standing in their specialty area. Long-range program planning is conducted at the state level through a process involving institute staff, subprogram coordinators and an Advisory Council whose members represent other units of the university system, state and local government agencies, industry and the public. In 1992, a Committee on Advisory Services was formed to provide guidance to the program's outreach efforts. All project proposals are evaluated on a highly competitive, peer-review basis.

Based on national peer reviews, only 15 of the 41 new project proposals submitted to UW Sea Grant for the 1994-96 biennium were forwarded for federal funding, and only nine survived the competition for the limited amount of federal Sea Grant funding available at the national level. However, four other UW research proposals were awarded federal Sea Grant funding in connection with the new national initiative in marine biotechnology, and four more Wisconsin research projects and one outreach project received Sea Grant funding under a separate national initiative on zebra mussels and other nonindigenous aquatic nuisance species.

This project directory and program guide provides an overview of the major activities and key players in the 1994-96 UW Sea Grant program.

Living Resources





Coordinator: James F. Kitchell, University of Wisconsin-Madison

Virtually nonexistent 30 years ago, the Great Lakes sport fishery today generates more than $4 billion in regional economic activity. The Great Lakes also support a small but active commercial fishery with an annual dockside catch valued at $270 million. The rebirth of these fisheries has resulted in the economic revival of many Great Lakes coastal communities. In Wisconsin, healthy fisheries prompted massive waterfront revitalization projects during the 1970s and 1980s in the Lake Michigan coastal communities of Kenosha, Port Washington, Sheboygan and Kewaunee.

Great Lakes fisheries still face myriad challenges, however. The fisheries could not exist without continuous control of the parasitic sea lamprey. Many native fish species have been lost, and the sport fishery now is 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. Despite better controls, toxic contaminants like polychlorinated biphenyls (PCBs) continue to show up in some fish species. Recent declines in salmon catch rates and sporadic evidence of high mortality due to diseases raise the question of sustainability in these intensively managed systems. Balancing commercial and sport harvests remains a difficult policy issue. State and federal agencies must now deal with the conflict between growing public expectations and the poorly understood ecological constraints imposed by species interactions.

Great Lakes ecosystems are undergoing rapid and continuous change due in part to management actions that reduce nutrient and contaminant loading and those that alter biological communities. In addition, the invasion and management of exotic species can compromise long-term goals of restoring and rehabilitating native communities.

In order to best use our Great Lakes resources, we need to better understand how species interact within the ecosystem. The University of Wisconsin Sea Grant College Program will continue to be a leader in developing ecosystem perspectives for aquatic resource management. Research opportunities continue in the following areas:

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

- Restoring native fish stocks — a long-time goal of management — may conflict with the economic and ecological realities of sport fisheries based on maintaining 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. Designing tools to forecast these species' effects is a major emphasis of Wisconsin Sea Grant research.

- Developing ideas at the ecosystem scale requires that we study the ecological resistance developed by current and recovering populations of native species.

LIVING RESOURCES SUBPROGRAM

1. Understanding the food web to help manage sport fisheries

Stocking salmonid species like trout, salmon and whitefish in the Great Lakes has created a successful sport fishery. However, populations of alewife and smelt — the forage fish that feed salmonids — currently are declining while other species like bloater, yellow perch and lake herring are increasing. Fisheries managers need to better understand the interrelated population dynamics among these forage fish species.

James Kitchell and his colleagues are developing models of Great Lakes food webs that will help them estimate variables such as: recent population fluctuations among microscopic free-floating and bottom-dwelling organisms; the maximum populations of forage fish and salmonids that the lakes can support; the changes in habitat use associated with species shifts; likely future changes in species composition; and the rates at which these interrelated changes will occur.

Achieving these objectives requires using bioenergetics — the science that studies how organisms collect and expend energy. The researchers will apply bioenergetics models to all key fish species in Lakes Michigan and Superior. These computer-assisted models provide powerful tools to help focus field and experimental programs. Today, bioenergetics models are regularly used by fisheries resource managers to help them make judgements about stocking and harvest policies and to anticipate future changes due to new fisheries.

CONTINUING PROJECT: Compensatory Responses in Great Lakes Food Webs: Predicting Results of Species Interactions (R/LR-45)

James F. Kitchell
Center for Limnology
UW-Madison

2. Updating basic data on Lake Michigan fisheries

In order to effectively manage the Great Lakes' valuable salmonid (trout, salmon and whitefish) fisheries, scientists and managers need to keep track of the smaller forage fishes that salmonids eat.

The most recent data available on diets and distributions of bloater, alewife and other forage fishes in Lake Michigan, however, are now 6-12 years out of date. In the last dozen years, Great Lakes ecosystems have undergone rapid change due to both natural phenomena and human intervention, so these older data may no longer accurately reflect the food web dynamics occurring in Lake Michigan. Scientists and managers need more information to understand the causes of sustained alewife decline, recovery of native fishes, and

the potential for changing conditions — natural or management-induced — to reduce the overabundance of bloaters in the forage fish community.

This study will update necessary data by: assessing the age, diet, growth rate, size distribution and habitat use of offshore forage fishes, especially bloater, alewife and rainbow smelt; assessing densities of adult bloaters' primary bottom-dwelling prey species (*Mysis* and *Diporeia*); and characterizing the density, species composition and size of free-floating zooplankton prey relative to forage fish diets.

NEW PROJECT: Food Web Dynamics of the Lake Michigan Forage Fish Community: Causes and Consequences (R/LR-52)

James F. Kitchell
Center for Limnology
UW-Madison

3. Will zebra mussels thrive in rivers as well as they do in lakes?

Researchers are aware of the aquatic conditions under which zebra mussel populations thrive in still-water systems like lakes, reservoirs and ponds. Models developed to predict the spread of zebra mussels have been based on data obtained from such systems.

But how will zebra mussels fare in rivers, where water conditions are much more variable than in lakes?

This project will explore whether seasonal fluctuations in river water quality will restrict the spread of zebra mussels in rivers. Researchers theorize that spring and summer runoff into rivers, which reduces levels of pH and dissolved calcium, restricts the survival, growth, sexual maturation and spawning success of adult mussels.

In this project, researchers will expose zebra mussels to variable conditions of temperature, pH, and dissolved calcium — factors that influence zebra mussel survival. Several genetic strains of zebra mussel will be examined to determine if genetic adaptations are occurring that might influence colonization success.

Information derived from this project will help determine if river systems are as susceptible as lakes to zebra mussel colonization. If it is found that mussels cannot survive and reproduce in river systems, then state and federal agencies and private industries can more effectively focus their preventive resources on high risk areas.

NEW PROJECT: Range Expansion of Zebra Mussels: Are Rivers Less Susceptible to Colonization than Lakes? (R/LR-57)

Mary Balcer
Lake Superior Research Institute
UW-Superior

4. Zebra mussels' effects on Great Lakes snails

Despite the zebra mussel's rapid spread throughout the Great Lakes and connected drainage basins, its effects on the ecology of these habitats are unclear.

For example, native snails of the Great Lakes would seem to be at risk from the zebra mussel's propensity to attach to just about any hard surface. Though the role and importance of gastropods in Great Lakes ecology is not well understood, loss of snail species due to zebra-mussel adhesion or "fouling" may have repercussions that could cascade through the Great Lakes ecosystem.

In this study, researchers will determine the extent of zebra-mussel fouling on the snail fauna of southwestern Lake Michigan. In addition, this project will:

- Document the extent of fouling by zebra mussels on native gastropod fauna among habitats, among species and among individuals;
- Determine the population-level impacts of zebra-mussel fouling on native gastropod fauna;
- Determine impacts of zebra-mussel fouling on individual snail metabolic and life-history parameters such as consumption, respiration, reproductive capacity and growth; and
- Determine variables like behavior, shell characteristics and habitat that influence gastropod species' susceptibility to fouling.

NEW PROJECT: Population and Energetic Consequences of Zebra Mussel Fouling on Native Gastropod Fauna of Lake Michigan (R/LR-60)

Dianna K. Padilla
Zoology
UW-Madison

5. The inland invasion of zebra mussels

Despite widespread empirical information on the spread of zebra mussels through navigable waters, almost nothing is known about the potential rate and direction of the overland spread of zebra mussels to North American inland lakes.

In this project, researchers will look for zebra mussels in plankton samples collected from six regional "lake districts" in Wisconsin, Michigan, Indiana and Illinois. These districts differ in their potential exposure to sources of zebra mussels. Within each region, researchers will sample contrasting sets of lakes that differ in characteristics likely to make them susceptible to invasion. Information on boat transfer will also be collected from these sites.

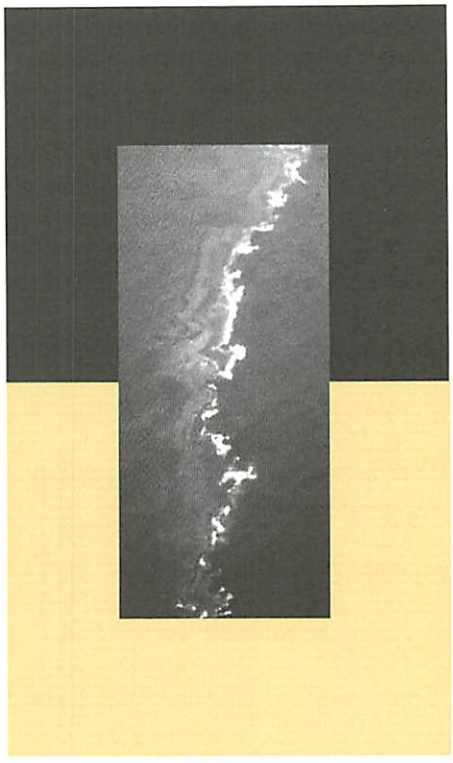
From these findings, researchers will seek to:

- Document the spatial and temporal pattern of zebra mussels' spread within local systems of inland waters;
- Compare the characteristics of invaded and non-invaded lakes to determine correlates of invasion susceptibility and infer likely dispersal mechanisms;
- Assess the relative importance of primary and secondary invasion events on the spread of zebra mussels within local systems of inland waters;
- Compare patterns of local invasions in different regions to determine the generality of any observed patterns, and test predictions of importance of the exposure of inland systems to nearby source populations; and
- Assess the effectiveness of educational and outreach programs.

NEW PROJECT: An Assessment of the Overland Dispersal of Zebra Mussels into Inland North American Lakes (R/LR-62)

Clifford Kraft
Sea Grant Institute
UW-Madison

Biotechnology



Coordinators:
Kenneth H. Nealson, University of Wisconsin-Milwaukee, Richard E. Peterson, University of Wisconsin-Madison

The United States leads the world in research expertise in marine biotechnology. However, our leadership faces stiff competition from other nations that are moving ahead with strong national investment and planning. Focused research in marine and aquatic biotechnology in concert with commercial development offers the promise of economic and social opportunities: it will lead to new industries and new jobs, it will help reverse a seafood trade deficit of $2.4 billion, and it will help upgrade and advance higher education to meet U.S. needs in an increasingly technical world.

This new UW Sea Grant research subprogram supports a national Sea Grant initiative in marine biotechnology approved by Congress in 1993. From a scientific standpoint, the study of freshwater organisms provides an essential complement to studies of marine organisms. For the Great Lakes region, which already supports a vibrant and growing biotechnology industry, biotechnology offers new opportunities for addressing such problems as the toxic contamination of Great Lakes fish and sediments, control of nonindigenous species, and enhanced production at public game fish hatcheries and at private bait and food fish farms. Home to more than 155 biotechnology firms, as well as the UW Biotechnology Center and the UW Biotechnology Genetics Center, Wisconsin is uniquely positioned to contribute to this important new national initiative.

The long-range goals of the Biotechnology Subprogram are to:

- Integrate biotechnology into existing UW Sea Grant subprograms;
- Provide innovative techniques to restore and protect aquatic ecosystems from biological and chemical contamination:
- Increase the food supply through aquaculture;
- Enhance seafood safety and quality;
- Open new avenues for monitoring health and treating disease;
- Expand knowledge of biological and geochemical processes in the Great Lakes and world ocean;
- Develop innovative approaches for assessing exposure to and evaluating the effects of chemical contaminants; and
- Evaluate the economic benefits and analyze the legal, economic, social and political issues associated with aquatic biotechnology.

BIOTECHNOLOGY SUBPROGRAM

1. Contaminant effect on trout genetics

Polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs) and biphenyls (PCBs) are widespread chemical contaminants that alter the expression of certain genes. In this study, researchers will develop a test to evaluate how mixtures of these chemicals cause changes in the genetic makeup of rainbow trout.

Current evaluative tests for these chemicals use a technology that cannot predict the toxic potencies of these contaminants in fish. This project will work to develop a fish-specific chemical test, or "bioassay," that can determine concentration of toxic substances by monitoring their effect on the growth of fish cells under controlled conditions.

Current analyses of PCDDs, PCDFs and PCBs in environmental samples are also quite costly — up to $1,500 per sample. The proposed bioassay would significantly reduce the cost of analysis, allowing state and federal agencies to greatly expand monitoring programs within current budgets.

NEW PROJECT: *In Vitro* Bioassay for Determination of Fish-Specific TCDD Equivalents by Assessment of TCDD-Regulated Genes (R/BT-1)

Richard E. Peterson
School of Pharmacy
UW-Madison

Judd M. Aiken
Animal Health & Biomedical Sciences
UW-Madison

2. Analyzing toxic algae

Frequent instances of water and seafood contamination by toxic algae point to a need to quickly analyze the toxins involved. Immunoassays — tests that analyze and identify toxic substances on the basis of their antigenic actions — are feasible for such purposes. However, wide application of immunoassays is hindered by low supply of immunochemical reagents — substances, chemicals or solutions used in the laboratory to detect or examine other substances. Antibodies for some of these toxins also are not available.

This research project will help resolve these problems by developing less costly but equally effective alternative methods for preparing needed reagents. The project also will work to develop antibodies for use as safe and effective vaccines.

Through comparative studies on how various antibodies interact with toxins and key receptors/enzymes, researchers will learn more about how the targeted toxins work. The reagents generated also will be used for various collaborative studies with other scientists nationwide who are studying toxicology and the safety of seafoods and drinking water.

NEW PROJECT: Immunochemical Studies on Selected Phycotoxins (R/BT-2)

Fun S. Chu
Food Microbiology & Toxicology
UW-Madison

3. Genetically designing contaminant-fighting agents

Researchers have known for some time that some microorganisms can be used to render certain toxic contaminants benign. This is one example of bioremediation — the practice of using biological organisms to eliminate contaminants from the environment.

In this study, Kenneth Nealson and Daad Saffarini will work to genetically design microbes for certain clean-up jobs. Specifically, the researchers will examine factors that control anaerobic respiration in the microorganism *S. putrefaciens*, a native inhabitant of Great Lakes sediments. They hope to genetically endow these microbes with the ability to better degrade toxic pollutants.

The goal is to develop a new agent of bioremediation, one especially fit to attack toxic contaminants in oxygen-poor sediment. Such anoxic environments are characteristic of many contaminated areas around the Great Lakes.

NEW PROJECT: Biotechnological Approaches to Bioremediation: Microbial Oxidation of Organic Pollutants Coupled to Iron Reduction (R/BT-3)

Kenneth H. Nealson
Center for Great Lakes Studies
UW-Milwaukee

Daad A. Saffarini
Center for Great Lakes Studies
UW-Milwaukee

4. Adding new properties to electrorheological fluids

Electrorheological (ER) fluids, used in the robotics and automotive industries, are composed of finely divided particles suspended in a carrier liquid, usually an insulating oil. When given a jolt of electricity, these special fluids can make the rapid transition from liquid to solid, and back to liquid again.

Electrorheological fluids show great potential for developing new stress-transfer devices. One problem in this area of technology, however, is that ER fluids currently cannot operate over a wide temperature range.

Daniel Klingenberg, Sangtae Kim and Kenneth Nealson have identified how certain proteins may significantly enhance ER properties. In this study, they will work to isolate proteins found in hyperthermophilic bacteria — those bacteria that require high temperatures for normal development. These proteins will be developed and tested for their ability to enhance the working temperature range of ER fluids.

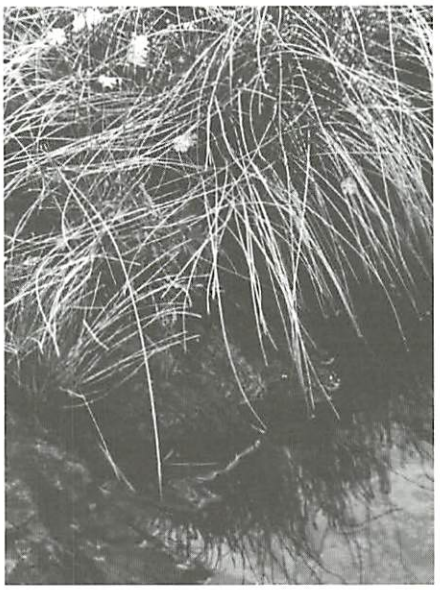
NEW PROJECT: Enhanced Electrorheological Fluids Using Hyperthermophilic Biotechnology (R/BT-4)

Daniel J. Klingenberg
Chemical Engineering
UW-Madison

Sangtae Kim
Chemical Engineering
UW-Madison

Kenneth H. Nealson
Center for Great Lakes Studies
UW-Milwaukee

Estuarine & Coastal Processes



Coordinator: J. Val Klump, University of Wisconsin-Milwaukee

The Great Lakes have more than 10,000 miles of seacoast-like shores in a series of four subbasins that drain an area totaling nearly 200,000 square miles. Historically, lake levels have fluctuated by about six feet on time scales of decades or less, making the coastal boundary one of the most dynamic interfaces in this system.

Despite their huge size, however, these freshwater inland seas are largely closed basins, so their waters are heavily influenced by interactions at the land-water interface. Consequently, changes in land-use patterns throughout the Great Lakes watershed since the early 1800s have also exerted a tremendous effect on the lakes by supplying nutrients, sediments, toxic contaminants and wastes via tributary streams, rivers and estuaries.

This coastal boundary represents not only a geologically, chemically and biologically dynamic environment, it is also the site of some of the most intense economic, social and political pressures within the Great Lakes basin. Throughout the Great Lakes, today's estuarine and coastal environments are often characterized as areas of intense development, urbanization and industrialization; areas of high biological productivity and natural diversity; and areas of high recreational value.

Coastal and estuarine ecosystems are thus regions of multiple, and often competing, resource uses. Efforts to sustain and enhance these resources are at the forefront of many environmental management strategies. Developing the scientific basis for sound management practice is an underlying goal of research within this subprogram. The Estuarine & Coastal Processes Subprogram encourages studies that have a broad perspective and take an ecosystem approach. Such studies include research on estuarine and coastal ecosystem dynamics in the areas of:

- Biogeochemical cycling and mass balances;
- Transport, fate and effects of toxic contaminants;
- Effects of changes in trophic structure;
- Food web structure and fisheries;
- Methods for cost-effective, long-term tracking of ecosystem change, including the application of new and emerging technologies like databases and remote sensing; and
- Nonsteady-state ecosystem models and methods for forecasting ecosystem response times.

ESTUARINE & COASTAL PROCESSES SUBPROGRAM

1. Tracking ecosystem changes in ecologically disturbed estuaries

This continuing project focuses on the role of Green Bay as a sink, or collection point, for nutrients like carbon and nitrogen. Nutrient pollution in water causes eutrophication — excessive plankton growth that depletes the water's supply of oxygen, resulting in an environment where little can survive.

This project will determine the amounts of carbon and nitrogen moving from Green Bay into Lake Michigan as well as the extent these elements move to and from the atmosphere. The overall goal is to improve understanding of the biogeochemical function of freshwater "estuarine" environments like Green Bay and Saginaw Bay. Previous work on biogeochemical cycling is being linked to new studies that use naturally occurring stable isotopes of carbon, nitrogen and sulfur. By using these isotopes as tracers in the system, researchers will:

- Estimate the amounts of carbon and nitrogen gained or lost to the atmosphere relative to the amounts permanently buried and exported from the system;
- Determine the efficiency and mode of carbon and nitrogen recycling in sediments;
- Define and follow changing food-web interrelationships and trophic structure, particularly the effects anticipated by the zebra-mussel invasion and the predicted shift in carbon and energy partitioning between benthic and pelagic zones; and
- Link changing food-web hierarchy to contaminant levels and movement within the system.

CONTINUING PROJECT: Carbon and Nitrogen Isotopes as Tracers of Food Webs and Biogeochemical Cycles in Perturbed Estuaries (R/GB-37)

J. Val Klump
Center for Great Lakes Studies
UW-Milwaukee

2. Studying PCBs in the Green Bay ecosystem

Green Bay is heavily contaminated with a variety of polychlorinated biphenyls (PCBs). While the extent of this problem has been well-characterized by the Green Bay PCB Mass Balance Study (GBMBS), the toxic threat of the PCBs is not well understood because the amount and type of coplanar PCBs — the more toxic PCB derivatives — have not been determined.

This research project will utilize data and sample extracts from the GBMBS to:

- Measure the concentrations and types of coplanar PCBs in Green Bay sediments;
- Determine the spatial and temporal variability of sediment coplanar PCBs;

- Evaluate the chemical structure of coplanar PCBs relative to other PCBs;
- Measure the concentration and type of coplanar PCB derivatives in Green Bay phytoplankton and fish, and compare the measurements to those of other PCB derivatives and total PCBs as measured by the GBMBS; and
- Compare the relative amounts of sediment coplanar PCB derivatives to those found in phytoplankton and fish to detect any selective transport through the ecosystem.

CONTINUING PROJECT: Coplanar Polychlorinated Biphenyls in the Green Bay Ecosystem (R/GB-38)

David E. Armstrong
Water Chemistry/Civil & Environmental Engineering
UW-Madison

William C. Sonzogni
Water Chemistry/Civil & Environmental Engineering
UW-Madison

3. The importance of wetlands to the Great Lakes ecosystem

Resource managers need to better understand the value of different types of coastal wetlands and to identify the "balanced" communities characteristic of healthy coastal wetlands as they are affected by activities in the watershed. Information on nutrient, sediment and contaminant movement through these systems is essential to understand the role played by different estuarine/wetland types.

Information generated in this study will help local and regional resource managers and policy makers work with wetland preservation and restoration, pollution remediation and non-point source pollution control.

This research project will assess how three distinct types of Great Lakes river/estuarine systems handle long-term loadings from upstream watersheds to Lake Michigan. The study will use naturally occurring radionuclides to quantify the relative effectiveness of different estuaries in trapping and retaining materials entering the system from upstream. A secondary objective is to link these tracer studies of particle transport and retention to the fate of elements of biogeochemical importance (i.e., carbon, nitrogen and phosphorus) in these freshwater estuaries.

NEW PROJECT: Terrestrial-Aquatic Coupling, Particle Trapping and Nutrient Biogeochemistry in Land Margin Systems of the Great Lakes (R/EC-2)

David N. Edgington
Center for Great Lakes Studies
UW-Milwaukee

J. Val Klump
Center for Great Lakes Studies
UW-Milwaukee

Microcontaminants & Water Quality

Coordinator: David E. Armstrong, University of Wisconsin-Madison

This subprogram was developed in response to the Great Lakes problems of chemical contamination and eutrophication — excessive algal growth and oxygen depletion due to nutrient pollution. Research focuses on Lake Michigan, but the results of these projects apply to all the Great Lakes and much of the coastal ocean environment.

Some toxic microcontaminants like polychlorinated biphenyls (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 Great Lakes fish. Other chemical contaminants may affect lower organisms and alter aquatic food webs and ecosystem health. Research in this subprogram is intended to provide a sound basis for assessing chemical contaminant impacts and managing problem microcontaminants.

Water quality also is affected by excessive algal growth. Algal populations are regulated by nutrient element loading and availability, and by consumption by zooplankton and small fish. Water-quality management requires an understanding of the importance of both essential nutrients and trophic interactions in controlling algal populations.

Research goals in this subprogram include:

- Determining the sources and fate of chemical contaminants and nutrients that degrade water quality or impair ecosystem health in the Great Lakes;
- Assessing threats to human health and aquatic life posed by toxic chemical contaminants in Great Lakes ecosystems; and
- Developing technologies and strategies to remediate areas degraded by chemical contaminants or nutrient overloading.

The expected benefits of this research subprogram are far-reaching. Research on contaminant sources, fate and remediation will help resource managers develop and evaluate remedial action programs and assess ecosystem response time to in-place contaminants. Investigating toxicological responses to contaminants will help managers evaluate the effects of contaminants on fish and amphibians and determine the effect of contaminants on the lake trout stocking program in Lake Michigan.

The fundamental advances in understanding chemical and biological processes ultimately will help us understand the risks these contaminants pose to humans and to freshwater and marine ecological systems. 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 managers developing remedial programs for the resource.

MICROCONTAMINANTS & WATER QUALITY SUBPROGRAM

1. Contaminant movement throughout Lake Michigan

Colloidal material — fine particles suspended in the water column — likely plays an important role in controlling the transport and fate of chemical contaminants in Lake Michigan. However, we know little about colloidal material and colloid-contaminant interactions.

The goal of this project is to determine the role colloidal material plays in regulating contaminant movement in Lake Michigan. The specific objectives of the study are to:

- Determine the abundance, distribution and properties of colloidal material;
- Identify and quantify major pathways of colloid production and removal;
- Determine the role of colloidal material in contaminant cycling; and
- Assess how colloid production influences contaminant mobilization in sediments.

The study involves both field and laboratory experiments. Researchers will collect colloidal material by lake sampling and particle concentration using ultrafiltration and ultracentrifugation, then characterize colloids by chemical and physical analyses. Field experiments also will investigate biological production of colloids using radiotracer-labeled substrates.

In the laboratory, researchers will evaluate colloid removal by coagulation and diagenesis, and investigate rates and mechanisms of contaminant interactions using radiotracer-labeled organic and inorganic contaminants. Additional experiments will assess colloid-mediated contaminant release from sediments.

CONTINUING PROJECT: Impact of Colloidal Material on Contaminant Fate in Lake Michigan (R/MW-50)

David E. Armstrong
Civil & Environmental Engineering
UW-Madison

2. How toxic hydrocarbons hurt lake trout populations

Great Lakes lake trout populations, devastated by the sea lamprey in the 1940s, have never recovered. In fact, by the mid-1950s, lake trout were deemed extinct throughout the Great Lakes, except for isolated populations in Lake Superior.

Today, though lake trout are stocked and the sea lamprey has been controlled, naturally reproducing populations of the lake trout have never rebounded. Though many factors may contribute to this problem, Richard Peterson and his research team hypothesize that a family of chemicals known as polychlorinated aromatic hydrocarbons (PAHs) — which includes polychlorinated biphenyls (PCBs) — may be involved.

This research project focuses on how PAHs affect lake trout during early life stages. Of the hundreds of related compounds in this group of chemicals, only a handful are considered extremely toxic; the most toxic member is tetrachlorodibenzo-*p*-dioxin (TCDD). This research will examine the mechanisms by which TCDD and TCDD-like compounds kill young lake trout. The project will also examine the toxic potencies of non-TCDD-like PAHs.

To achieve these goals, researchers will use rainbow trout 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.

Research has shown that certain PCB derivatives are less toxic in rainbow trout than expected. This project also will seek the reason for this lower PCB potency.

Once achieved, these research goals will help regulatory agencies better assess the dangers posed by PAHs to Great Lake trout development. In turn, research results could allow more efficient reestablishment of depleted lake trout populations.

CONTINUING PROJECT: Early Life Stage Toxicity of Polychlorinated Aromatic Hydrocarbons in Salmonids (R/MW-52)

Richard E. Peterson
School of Pharmacy
UW-Madison

3. Herbicide pollution in Green Bay and western Lake Michigan

The state of Wisconsin and some federal agencies have targeted a group of heavily used weed-control herbicides in an effort to determine these compounds' environmental fate and toxicity to humans, livestock and aquatic communities. These targeted herbicides are not removed by conventional water treatment, and several of these compounds have been detected in tap water in midwestern states.

Little work has been done on measuring inputs of these herbicides to the Great Lakes. In this study, researchers will determine the types and concentrations of these herbicides and their breakdown products, or metabolites, being transported via tributaries to Green Bay and western Lake Michigan.

The study also will consider the importance of groundwater as a source of herbicide transport to Green Bay and Lake Michigan. The researchers also will assess the potential toxicity of different combinations of these herbicides and their metabolites to determine the ecological impact the compounds may be having in Green Bay wetlands or Lake Michigan harbors. The study results should help determine whether herbicides are affecting, or could potentially affect, the Green Bay/Lake Michigan ecosystem.

CONTINUING PROJECT: Herbicide and Herbicide Metabolite Inputs to Green Bay and Western Lake Michigan (R/MW-53)

William C. Sonzogni
State Lab of Hygiene
UW-Madison

4. How pollution hurts Green Bay amphibians

Researchers agree that the Green Bay ecosystem suffers from pollution via toxins (such as polychlorinated biphenyls, or PCBs) and nutrients (the byproducts of organic waste like sewage and agricultural run-off). Research also has established that such pollution negatively affects fish, mammals and birds in Green Bay and the Great Lakes. However, little is known about these pollutants' effects on amphibians.

Amphibians in Green Bay undoubtedly are exposed to contaminants when they eat contaminant-laden algae and invertebrates. Because of their highly permeable skin and their aquatic development, amphibians may also be particularly susceptible to water-borne chemical pollutants via diffusion across their skin.

This investigation will measure contaminant levels in and determine survival rates of amphibian eggs, larvae and adults in Green Bay and its tributaries. The researchers will measure the rates at which toxins are accumulated by and cleansed from amphibians. They also will test whether particular PCB derivatives affect amphibian sexual development.

This project addresses an important gap in knowledge about the Green Bay ecosystem. Amphibian eggs, larvae and adults serve as prey for many fish, birds and mammals, and therefore play a role in transferring contaminants through the food web. Additionally, since little is known about amphibian ecotoxicology, it's not clear whether regulations meant to protect birds and mammals are adequately protecting amphibians.

CONTINUING PROJECT: Ecotoxicology of Amphibians in Green Bay (R/MW-54)

William H. Karasov
Wildlife Ecology
UW-Madison

5. A new way to destroy toxic organic compounds

Safely disposing of or destroying soil and sediment contaminated by toxic organic compounds is difficult, both from public policy and scientific standpoints. There is strong public resistance to incinerating toxins, but available remediation techniques often are costly or specific to only a narrow range of conditions. Some remediation options even produce byproducts more hazardous than the original contaminant.

One remediation technique, TiO_2-mediated photocatalytic oxidation, successfully renders benign a wide variety of organic contaminants. One problem with this method, however, is that it is usually done in a liquid medium, where results occur too slowly for viable commercial application.

This research project will adapt this oxidation technique to a gaseous medium. The researchers propose that if organic contaminants can be rendered into vapor, the remediation technique can be applied more quickly and efficiently.

In a single reactor, researchers will use a technique called supercritical fluid extraction (SFE) to separate organic contaminants from soil or sediment, vaporize them, then apply the oxidation technique. Researchers will evaluate the ability of such a reactor to combine SFE with TiO_2-mediated photocatalytic oxidation — and, hopefully, end up with an efficient, cost-effective new way to isolate and destroy soil- and sediment-bound toxic organic compounds.

NEW PROJECT: Coupled Extraction and Destruction of Organic Contaminants Using Supercritical Fluid Extraction and Photocatalytic Oxidation (R/MW-56)

Marc A. Anderson
Civil & Environmental Engineering
UW-Madison

Charles G. Hill
Chemical Engineering
UW-Madison

6. How fisheries management decisions affect PCB levels in sport fish

After the manufacture of polychlorinated biphenyls (PCBs) was banned in 1976, the concentrations of these toxic industrial compounds in Lake Michigan fishes steadily declined. In the last 20 years, PCB concentrations have decreased significantly. But while the rate of decline has slowed since the mid-1980s, none of the lake's fish species is completely free of PCB contamination.

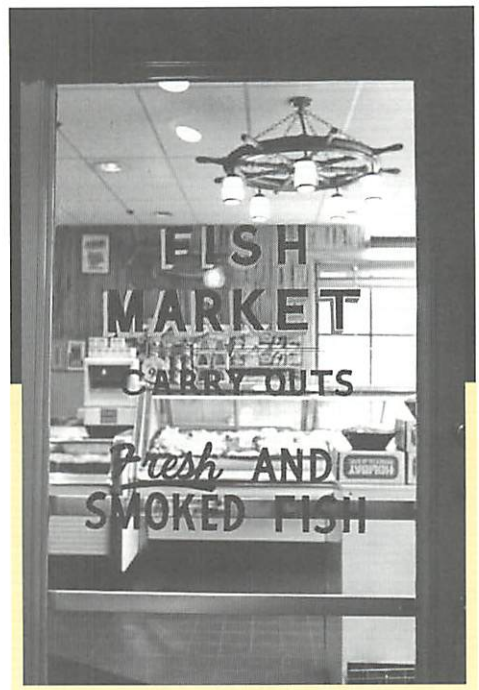
Though concentrations of PCBs in Great Lakes trout, salmon and whitefish are now nearly static, these concentrations are highly variable. Most of the variability is explained by differences in species, growth rate, age, size and location. Ultimately, Great Lakes fish managers' decisions about stocking levels, species composition and harvest levels affect PCB concentrations in the sport harvest.

Stephen Carpenter and his research team will assess the potential effects of fish management strategies on PCB concentrations in these fish species, and express these effects in terms of probability distributions useful for analyzing risks and decisions. These findings and models then will be transferred to fisheries managers at a regional workshop.

NEW PROJECT: Microcontaminant Cycling in Great Lakes Food Webs (R/MW-59)

Stephen R. Carpenter
Center for Limnology
UW-Madison

Aquaculture & Seafood Technology



Coordinators:
Fred P. Binkowski, University of Wisconsin-Milwaukee, Jeffrey A. Malison, University of Wisconsin-Madison

Aquaculture plays a key role in the management of fishery resources in the Great Lakes region and has a real potential for commercial seafood production.

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 also has a well-established aquaculture industry. According to the U.S. Department of Agriculture, Wisconsin is the nation's fifth-largest producer of rainbow trout. The state has more than 780 licensed fish farmers, who raise 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 should result in much greater private-sector involvement in propagating game and forage fish. Several of Wisconsin's large sport fishing clubs already operate fish hatching and rearing facilities, and more are planned.

Despite its successes, the Great Lakes 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 require more sophisticated seafood technology to produce, harvest, process and market fishery products.

The primary long-range goal of this research subprogram is to develop and improve the scientific and technological database necessary to propagate, culture, harvest, process and market cool-water species like perch, walleye and muskellunge, and cold-water species like trout, salmon and whitefish. Research areas include:

- Developing methods to assess physiological stress in cool-water fishes and using these methods to identify "least-stress" aquaculture procedures;
- Characterizing the ontogeny of the physiological stress-response system in rainbow trout and developing ways to produce trout highly tolerant of stressors commonly found in aquaculture and natural Great Lakes culture conditions;
- Expanding 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; and
- Improving the seafood product safety, stability and quality, and promoting developrnent and wise use of the nation's aquatic food resources.

AQUACULTURE AND SEAFOOD TECHNOLOGY SUBPROGRAM

1. Improving growth and survival rates of rainbow trout in aquaculture

The harmful 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 continuing research project combines both basic and applied physiological and endocrinological studies to address the problem. The investigators are documenting the anatomical and functional development of the hypothalamic-pituitary-interrenal axis (HPI axis) of the rainbow trout (*Oncorhynchus mykiss*). The interreaction among the hypothalamus — the brain region that regulates autonomic body functions — and the pituitary and interrenal glands determines a trout's rate of growth, metabolism and maturation.

The researchers also will 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. Additionally, investigators will apply environmental and biochemical treatments at the trouts' early developmental stages in order to permanently alter the responsiveness of the HPI axis.

The study aims to identify "least-stress" culture strategies for various life-cycle stages of fish and improve genetic-selection programs in order to help produce fish highly tolerant of aquacultural stresses. The studies focus on the rainbow trout because of its importance to commercial aquaculture in the Great Lakes region and elsewhere. The considerable information already available on the stress physiology of this species provides an important baseline for this research.

CONTINUING PROJECT: 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

2. Improving growth and survival rates of yellow perch and walleye in aquaculture

Growth of the walleye and yellow perch aquaculture industry is hampered by variable fish survival rates and poor fish growth. To a large extent, these problems can be attributed to the harmful effects of physiological stress.

The overall goal of this project is to characterize the physiological stress response of purebred and hybrid walleye and yellow perch, and to use measures of stress to evaluate various fish culture strategies and develop improved culture techniques. This research will

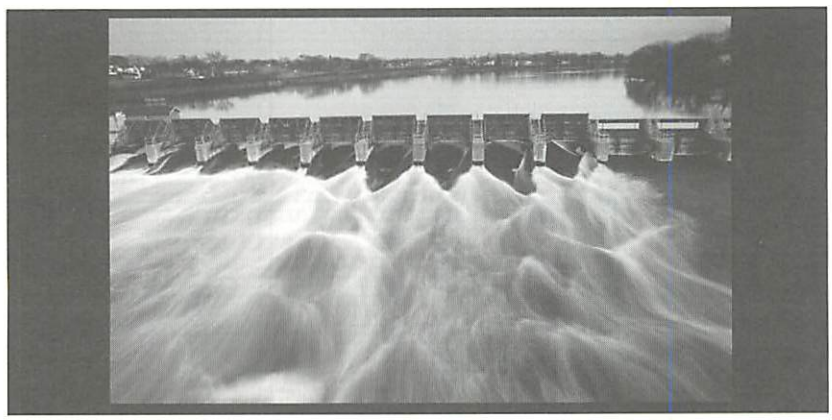
generate baseline information on the physiological stress responses of purebred and hybrid walleye and yellow perch, then evaluate the influence of selected rearing conditions and pond-harvest, transportation and fish-culture strategies on purebred and hybrid walleye and perch. The information will be used to develop practical "least-stress" methods to raise these fishes.

The use of "low-stress" procedures developed by this study should result in lower production costs for public and private hatcheries and fish farms, greater development of commercial aquaculture, and improved fisheries in the Great Lakes region.

NEW PROJECT: Assessment and Management of Physiological Stress in Cool-Water Fish Culture (R/AQ-22)

Jeffrey A. Malison
Food Science
UW-Madison

Policy Studies



Coordinator: Richard C. Bishop, University of Wisconsin-Madison

The University of Wisconsin Sea Grant College Program's tradition of research includes a strong social sciences dimension, focusing on research that helps solve 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.

To a large degree, policy studies must be reactive because they address policy issues as they evolve. High-priority research areas for the 1990s include:

- Developing alternative remediation strategies for Wisconsin "Areas of Concern" and other degraded Great Lakes ecosystems;
- Assessing the costs and benefits of alternative fishery management strategies for salmonids and cool-water fish species;
- Determining the implications of new seafood industry regulation;
- Developing new techniques to measure the benefits of Great Lakes resources;
- Determining current and future consumptive uses of Great Lakes water and the implications of climate change;
- Assessing and communicating the human health risks of eating contaminated Great Lakes fish;
- Developing alternative policies to reduce existing contaminant levels and minimize future problems with contaminants; and
- Determining responsibility and possible liability for pollution of the Great Lakes.

POLICY STUDIES SUBPROGRAM

1. Evaluating the risk of lakeshore development

Variable water levels of the Great Lakes make it hard to plan for protecting lakeshore property against damage from coastal erosion and flooding. With that in mind, this project's researchers will develop a decision-making model to help people calculate the risk of investing in lakeshore development.

The investigators will construct a function describing the net benefits resulting from various protection projects. This function will incorporate a lake-level prediction model, a shoreline protection facility cost function, and a shoreline facility damage function that depends upon lake levels and protective installations. These various components will be combined into a dynamic model to help people decide on the best investment decisions for the future.

The researchers will apply this conceptual framework to one or more case studies by gathering construction-cost and damage data from an existing installation. The resulting optimal investment decisions will be used in the second year of the project to develop an educational program to help people make better decisions about shoreline damage protection.

CONTINUING PROJECT: Conditioned Risk and the Evaluation of Great Lakes Projects (R/PS-43)

Erhard F. Joeres
Civil & Environmental Engineering
UW-Madison

Jay Coggins
Agricultural Economics
UW-Madison

2. The risks of eating sport-caught fish

Children are particularly vulnerable to toxic contaminants in sport-caught fish. Recent research suggests that polychlorinated biphenyls (PCBs) and other contaminants stored in the fat of these fish, if eaten in large enough quantities by women who subsequently become pregnant, can cause developmental problems in fetuses and infants. Toxins can accumulate in body fat and be passed to fetuses *in utero* and to infants via breast milk.

Adult men and women also may be vulnerable to contaminated fish. Most state and federal sport fish consumption advisories, however, concentrate on informing anglers about these risks, but do not target women in angling households who are not fishers.

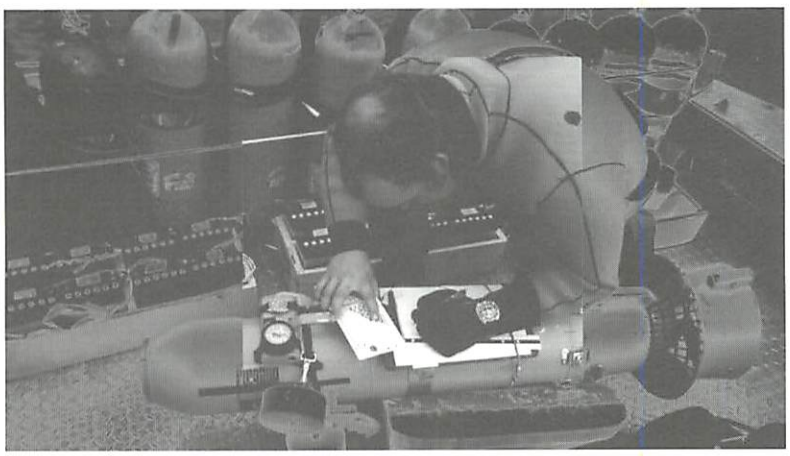
This study will explore ways of giving these women more direct access to information about the risk of eating sport-caught fish. The researchers will deliver risk information to

women in angling households via different channels, then examine how those channels influenced women's exposure to the message, their judgements about the importance of the issue, and their knowledge level about the risks.

NEW PROJECT: Communicating the Risk of Eating Sport-Caught Fish to Women of Childbearing Age in Wisconsin Angling Households (R/PS-44)

Sharon Dunwoody
Journalism and Mass Communication
UW-Madison

New Initiatives



Coordinator: Anders W. Andren, University of Wisconsin-Madison

Investigations of the Great Lakes and ocean environments 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 or generic problems.

Given the breadth of research possibilities, Great Lakes and ocean investigations often reach beyond the predefined goals of any single research subprogram and sometimes span two or more of the established subprograms. The New Initiatives Subprogram provides a starting point for scientists and engineers to undertake innovative and original research projects that fall outside the confines of existing subprograms.

Appropriate areas of New Initiatives research include the potential effects of climate change on Great Lakes hydrology and ecosystems, the role of oceans in climate change, the application of artificial intelligence techniques to marine resource utilization, diver health and safety, and satellite remote sensing applications to the oceans and the Great Lakes. Other regional issues might include the water budget of the Great Lakes, coastal erosion processes and the introduction of potentially harmful exotic species such as the zooplankter *Bythotrephes*, the European ruffe and the zebra mussel.

NEW INITIATIVES SUBPROGRAM

1. Designing robots for underwater exploration

Underwater exploration poses many hazards and complications for human divers. But what if a robot could be developed to handle difficult underwater tasks?

Vladimir Lumelsky is working on such a machine. His research addresses motion planning for automatic and semiautomatic robots used for underwater exploration. This project goal is to develop robot systems capable of geometric reasoning and motion planning in an unknown, complex underwater environment. Such a robot probe would be able to fully explore any given underwater area or large object, such as a sunken ship.

The robot's decision-making processes will be based on real-time sensory data gathered by range sensors and TV cameras. In automatic mode, the robot vehicle will plan its own path. In semi-automatic mode, a human operator will command general trajectories and goals, while the robot avoids collisions based on information from its sensors.

This project will capitalize on the University of Wisconsin Robotics Group's prior work and experience in sensor-based robot motion planning. By building on prior work, this project will produce theory and algorithms for sensor-based planning of underwater exploration tasks.

NEW PROJECT: Intelligent Robot System for Complex Underwater Exploration Tasks (R/NI-20)

Vladimir J. Lumelsky
Mechanical Engineering
UW-Madison

2. The risks of scuba diving

Although millions of Americans safely dive for recreational, scientific or commercial purposes each year, diving presents unique, life-threatening risks. Serious cases of central nervous system decompression sickness (DCS) are linked to repetitive deep dives. A condition called dysbaric osteonecrosis (DON), which can cause disabling bone injury, is linked to prolonged dives that induce persistent limb bends — a condition of discomfort and pain in the diver's long bones and associated joints.

This study will focus on these two diving risks. Research objectives include:

- Investigating the prevalence of DON in Maine scallop divers, whose diving practices closely match those of avid recreational divers in Wisconsin and elsewhere;
- Evaluating the risk of DON with rapid decompression from "saturation dives," such as those conducted at the National Oceanic & Atmospheric Administration's Aquarius saturation habitat at Key Largo, Fla.;
- Examining and describing the early development of DON for preventive, diagnostic and therapeutic purposes;

- Improving dive safety by evaluating DCS outcomes, especially central nervous system injuries; and
- Developing safer dive computer algorithms.

NEW PROJECT: Diver Health and Safety (R/NI-21)

Jerome A. Dempsey
Preventive Medicine
UW-Madison

Michael A. Wilson
Radiology
UW-Madison

3. Electrostatic control of zebra mussels

Numerous water intakes located along Great Lakes shorelines supply some 655 billion gallons of water each day for use by more than 25 million residents, thousands of crop and livestock farms, hundreds of lakeshore industries, and dozens of nuclear and fossil-fuel power plants. One of the most serious problems caused by zebra mussels is their propensity to attach to and clog water intake pipes and other water system components.

In the past, researchers have experimented using electrostatic fields to control zebra mussel attachment to hard surfaces. Electrostatic field methods tried thus far have employed low voltage fields or pulses of high voltage for short periods.

In this project, researchers will study how continuous high-voltage electrostatic fields with low currents might inhibit zebra mussel attachment. The effect of electrostatic fields on non-target organisms will be evaluated as well.

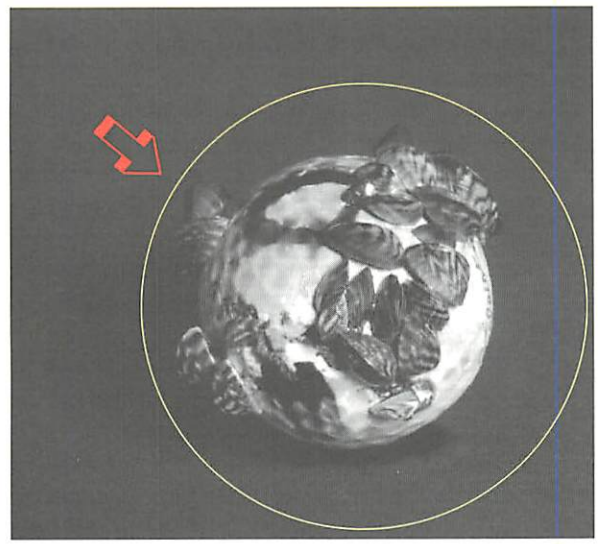
In the laboratory, researchers will first determine the optimal electrostatic field environment that discourages the attachment of larval and juvenile zebra mussels. The results of these laboratory experiments will be used to design a field apparatus that will be submerged 1.5 meters into the nearshore water of Lake Michigan. Researchers will conduct field studies using this apparatus during two late summer and fall seasons. The project's final report will include design data and operating recommendations for using high-voltage electrostatic fields for zebra mussel control.

NEW PROJECT: Effects of High-Voltage Electrostatic Fields on the Control of Zebra Mussels (R/NI-24)

Alphonse E. Zanoni
Civil & Environmental Engineering
Marquette University

James S. Maki
Biology
Marquette University

Advisory Services



Coordinator: Allen H. Miller, University of Wisconsin-Madison

The University of Wisconsin Sea Grant Advisory Services Subprogram bridges the gap between science and its application for Great Lakes users in Wisconsin and throughout the region and nation. Eight Advisory Services specialists, located on five UW campuses, provide technical advice on aquaculture, business management, coastal engineering, fisheries, geographic information systems, global change education, marine education, water quality, water safety, and zebra mussel monitoring and control. Four of the specialists also provide area support through field offices at Green Bay, Manitowoc, Milwaukee and Superior/Ashland.

Advisory Services Subprogram goals focus on four general areas:

Applying Advancing Technology Worldwide electronic communication systems with access to staggering amounts of information are now at our fingertips. This technology can serve Great Lakes users in economic endeavors and resource management issues. Current technology also will provide powerful new tools to help transfer science to the user communities. Applying geographic information systems, computer modeling of resource management issues, and interactive educational programs are just a few of the many new opportunities available through today's technology.

Advancing Science Education Studies show that teachers believe knowledge of Great Lakes-related subjects is important for high school graduates. These subjects include toxic contaminants, air pollution, water quality, and the relationship between the environment and the economy. However, teachers rank their knowledge of these topics consistently lower than their importance, and rank the current level of teaching about these topics lower still. Today's adults also lack understanding of basic sciences. More needs to be done to educate the public about world population growth, resource consumption and depletion, loss of biodiversity, and other globally significant issues.

Developing Economic Opportunities New economic opportunities are available in aquaculture, fisheries and coastal businesses. A diminishing wild fishery, coupled with public interest in healthy, environmentally safe fishery products, is driving the growth of aquaculture as a source of food; as a way to maintain fish stocks in rivers, streams and lakes; and as a source of bait for the recreational angler. The changing wild fishery and changing fishing regulations require commercial fishers to restructure traditional practices and to look to less-utilized species for new opportunities.

Transferring Emerging Resources Management Tools From fish stocks to clean water to lakeshore property, Great Lakes resources are under constant pressure. Resource managers need to clean up past mistakes and develop sustainable use patterns. Wise management practices must evolve from a basis of solid science. New processes such as fishery bioenergetics modeling, mass balance studies and geographic information systems are just a few of the emerging processes changing the paradigm of resource management.

ADVISORY SERVICES SUBPROGRAM

1. Turning science into practical answers

Wisely used, the Great Lakes offer opportunities for both recreational and economic fulfillment in a sustainable manner. Sea Grant works to increase understanding, address priority concerns and open new possibilities for the sustained, beneficial use of the Great Lakes.

University of Wisconsin Sea Grant Advisory Services applies university and other science resources to solve problems, provides new opportunities for Great Lakes users, and provides general scientific education on Great Lakes concerns to Wisconsin citizens. By using a network of specialists, Advisory Services both disseminates scientific information to Great Lakes users 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 audiovisual materials.

CONTINUING PROJECT: Advisory Services: Program Coordination and Field Offices (A/AS-1)

Allen H. Miller
Sea Grant Institute
UW-Madison

2. Alternative aquaculture strategies

Aquaculture-related business in Wisconsin has increased dramatically in the last several years, and opportunities in the business remain abundant. This advisory project will consolidate expertise on Great Lakes regional fish cultures and develop effective means of delivering this information. Specifically, the project will:

- Produce realistic financial models of alternative fish rearing strategies to help prospective culturists form business plans;
- Provide technical on-site advisory services with established commercial fish farm operations;
- Conduct hands-on workshops to provide specialized technical training to groups involved or interested in fish farming operations;
- Set up "demonstration units" of alternative aquaculture-production strategies at both the University of Wisconsin Great Lakes Research Facility and at cooperating private-sector facilities;

- Present lecture/seminar series concerning the practical and fundamental principles of aquaculture to individuals, government agency representatives and specialized groups; and

- Establish linkages with state and federal agencies responsible for policy, regulation, education and research supporting aquaculture development in Wisconsin.

CONTINUING PROJECT: Developing, Demonstrating and Promoting Alternative Aquaculture Strategies through Advisory Services (A/AS-29)

Fred P. Binkowski
Center for Great Lakes Studies
UW-Milwaukee

3. Preventing the spread of zebra mussels

Now that zebra mussel populations are established in the Great Lakes, most researchers agree there is no way to eliminate them. Instead, efforts focus on providing useful information about the mussels' control and impacts, as well as trying to prevent their spread.

The Zebra Mussel Watch project will:

- Provide Wisconsin's Great Lakes water users with information on whether zebra mussels are likely to cause problems at specific locations;

- Provide timely zebra mussel information to residents of Wisconsin and neighboring states;

- Provide a point of contact for reporting zebra mussel observations, and provide backup analysis for confirming observations;

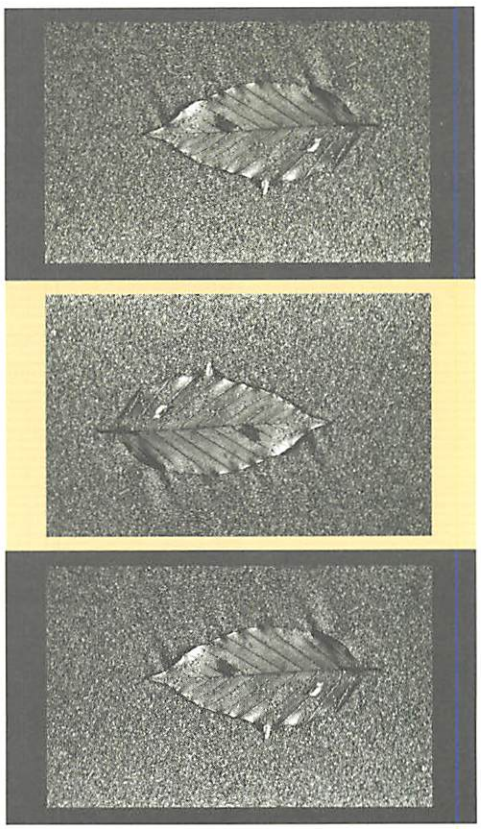
- Provide training for personnel at inland utilities and industries with water intakes; and

- Provide training assistance for individuals participating in an inland monitoring program coordinated by the Wisconsin Department of Natural Resources.

NEW PROJECT: Zebra Mussel Watch (A/AS-35)

Clifford E. Kraft
Sea Grant Advisory Services
UW-Madison

Communications



Coordinator: Stephen Wittman, University of Wisconsin-Madison

The University of Wisconsin Sea Grant Communications Office is widely recognized as a 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 benefit from the scientific, advisory and educational information generated by the National Sea Grant College Program.

The primary goal of all Communications Subprogram projects is to ensure broad dissemination of scientific, technical and advisory information resulting from Sea Grant research, outreach and educational activities. This includes providing professional communications support to Wisconsin Sea Grant staff and scientists, media relations, and public education projects.

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 developing quality products, targeting distribution of promotional materials, promptly responding to requests for publications, regularly submitting new publications to the National Sea Grant Depository, and cooperating with other university departments, government agencies and other Sea Grant programs nationwide.

Major goals of the Wisconsin Sea Grant Communications Subprogram through the 1990s are to:

- Continue to 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 current environmental issues such as the effects of invasions by nonindigenous species, global climate change, food web interactions, etc.; and
- 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 interactive multimedia.

COMMUNICATIONS SUBPROGRAM

1. Communications: a history of success

The University of Wisconsin Sea Grant Communications Office is the oldest and one of the largest in the Great Lakes region. Since its start in 1968, the Communications Office has produced 614 reports and distributed more than 707,000 copies of these and other Sea Grant publications. Since 1972, the communications staff has produced the award-winning "Earthwatch" public service radio program in cooperation with the Institute for Environmental Studies at UW-Madison. The University of Wisconsin Sea Grant Communications Office also has an award-winning tradition of quality in research news reporting, science writing, publications design, public relations, film production and radio programming. The office also maintains a video and film loan library featuring the six films and videotapes produced or supported by Wisconsin Sea Grant since 1976.

CONTINUING PROJECT: Communications Office and Program Coordination (A/AS-2)

Stephen Wittman
Sea Grant Institute
UW-Madison

2. Tuning in to science

"Earthwatch" uses the popular medium of radio 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. The program also raises public awareness about Sea Grant and its activities in Wisconsin and around the nation. "Earthwatch" has been cited repeatedly for excellence and received its most prestigious award at the 1992 "Earth Summit" in Rio de Janeiro, where the United Nations Environment Programme named "Earthwatch" to its "Global 500 Roll of Honour."

Sea Grant and the University of Wisconsin-Madison Institute for Environmental Studies jointly produce 10 two-minute "Earthwatch" programs every two weeks. These programs are distributed free of charge to more than 160 broadcast outlets in 16 states, including the eight Great Lakes states and the Canadian 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 $1 million a year — a payback of more than 22:1 on the federal Sea Grant investment.

CONTINUING PROJECT: "Earthwatch" Public Service Radio Program (A/AS-3)

Richard Hoops
Sea Grant Institute
UW-Madison

3. Communicating the risks of panic to scuba divers

A recent report by the National Underwater Accident Data Center indicated that 19 percent of reported diving fatalities probably involved panic. The cause of fatalities in an additional 22 percent of the cases is classified as unknown, and it is likely all or most of these cases involved panic behavior. Further evidence from a national survey of experienced male and female divers indicates that 54 percent had experienced panic or near-panic behavior while scuba diving. Nevertheless, the risk associated with scuba diving, as well as the increased risk due to panic, have been ignored or downplayed by members of the diving community.

The focus of this project is to package and disseminate existing research information involving anxiety and panic behavior in scuba divers to scuba instructors, recreational and commercial divers, personnel affiliated with the National Sea Grant College Program, and organizations concerned with the training and safety of scuba divers. This effort will include production and distribution of a fact sheet, articles in nationally distributed publications, radio spots, news releases, a comprehensive bibliography, diver workshops and a national conference.

NEW PROJECT: Dissemination of Information on the Role of Anxiety and Panic Behavior in Scuba Accidents and Fatalities (A/AS-33)

William P. Morgan
Kinesiology
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Philip E. Davis
Sea Grant Institute
UW-Madison

Education

Coordinators:
Anders W. Andren, University of Wisconsin-Madison, Mary Lou Reeb, University of Wisconsin-Madison

The University of Wisconsin Sea Grant College Program provides opportunities for graduate and undergraduate students to participate in all aspects of the program's activities. The program also provides students with special opportunities to go to sea, to coastal research stations and to scientific meetings. Finally, the program conducts activities to help educate the public on ocean and Great Lakes matters, and to educate and train specific marine audiences, such as fishers, boaters, coastal residents, K-12 teachers, port managers and aquaculturists.

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. The 1994-96 program will provide annual support for 30 graduate students. The majority of the program's expenditures for education thus appear as integral parts of the research subprograms.

The University of Wisconsin Sea Grant also supports innovative educational activities that enhance public awareness of the Great Lakes and oceans, including cultural or artistic works dealing with the marine environment, lecture series, workshops, films and museum exhibits. A number of these activities take the form of special projects funded by private foundations or corporations. A substantial amount of K-12 and public education activities are carried out in the Communications and Advisory Services subprograms via publications, video and other electronic media, radio programs ("Earthwatch"), displays, workshops and conferences.

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 (21 in 1993 vs. 50 in 1985). This decrease reflects a nationwide trend in graduate education in the natural sciences, engineering and, especially, the marine sciences. Recognizing that educating young scientists and engineers is essential to our nation's ability to compete worldwide and to maintain a vital society, we have established high priority long- and short-range goals to reverse this trend.

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 completing their theses after projects have been completed and research funding terminated:
- Continue to develop and enhance Great Lakes/ocean courses and to provide for special on-campus speakers and lecture series;
- Continue to help students 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 using innovative programming and state-of-the-art techniques;

- Identify and respond to marine education needs through publications, workshops, special exhibits, and K-12 and vocational-technical educational activities; and
- Vigorously seek additional sources of support for marine educational activities.

EDUCATION SUBPROGRAM

1. Special marine education programs

The University of Wisconsin Sea Grant College Program provides students and the general public with a variety of educational experiences and specialized training not available in a standard curriculum.

The 1994-96 program will provide annual support, funded through individual research projects, for 30 graduate students. In addition, this program will continue to provide partial support for a dozen or more students to go on the "Problems in Oceanography" field trip to Sapelo Island, Ga., and support for the UW-Milwaukee colloquium, "Recent Advances in Limnology and Oceanography Seminar."

Flexible research assistantships will be supported as opportunities arise. Students are also eligible for travel support to attend scientific meetings and present papers based on Sea Grant research.

This investment in student support has a history of great dividends. In the 25 years since the program began, UW Sea Grant-supported students have earned 396 graduate degrees (152 doctorate and 244 master's degrees). These students now are national assets and are already contributing to the management and stewardship of the nation's Great Lakes and ocean resources. University of 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.

UW Sea Grant will also continue to participate in state and regional K-12 science education efforts and, together with several other state Sea Grant programs, collaborate in a national effort to initiate an education program on global climate change and marine education. Realizing that public understanding of Great Lakes and ocean resource issues is crucial to the development of sound public policy, UW Sea Grant will also continue bringing its resources to the public through print and electronic media as well as by displays and exhibits.

CONTINUING PROJECT: Special Marine Education Programs (E/E-1)

Mary Lou Reeb
Sea Grant Institute
UW-Madison

2. Dean John A. Knauss marine policy fellowship program

The National Sea Grant Fellows Program/Dean John A. Knauss Marine Policy Fellowship was established in 1979 to provide a unique educational experience for students who have an interest in marine/ocean/Great Lakes resources and in the national policy decisions affecting those resources. This competitive program matches highly qualified graduate students with hosts in the federal legislative or executive branches, or in other appropriate associations/institutions in the Washington, D.C., area, for a one-year paid internship.

Over the last 12 years, six Wisconsin students have been selected to participate in the program. They have served with the U.S. Senate's Commerce, Science & Transportation Committee and Great Lakes Task Force; the House Subcommittee on Natural Resources, Agriculture Research & Environment; the Office of Ocean & Marine Services in the National Oceanic & Atmospheric Administration; and the Office of the Oceanographer in the Department of the Navy. In 1994, this project will support a Wisconsin student intern with the National Ocean Service Damage Assessment Center in the National Oceanic & Atmospheric Administration.

Through this project, the pool of graduates knowledgeable and interested in marine research and resource management careers is enriched. Furthermore, the project expands University of Wisconsin course offerings in the field of public policy, and it gives congressional staffers insight into academic research programs and resource issues pertaining to the Great Lakes and marine resources.

CONTINUING PROJECT: Dean John A. Knauss Marine Policy Fellowship Program (E/E-23)

Mary Lou Reeb
Sea Grant Institute
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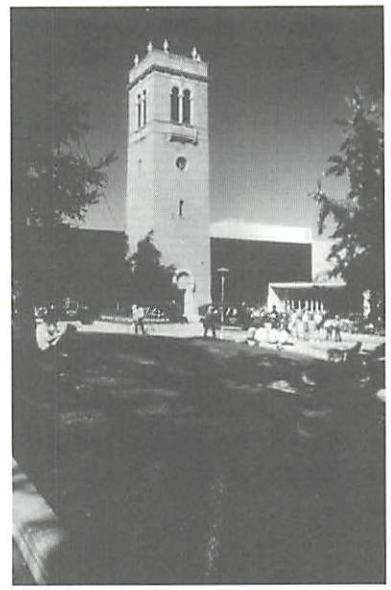
Program Administration



Coordinator: Anders W. Andren, University of Wisconsin-Madison

Management of the University of Wisconsin 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. Throughout its 25-year history, the Wisconsin 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, UW Sea Grant has held 14 major planning meetings that have focused on overall program management and direction as well as research and outreach subprogram goals and objectives. The next major planning meeting will be held in 1995 to develop the goals, objectives and directions for the University of Wisconsin Sea Grant College Program for the next five to 10 years. In addition, development of the 1994-96 Wisconsin Sea Grant biennial proposal also has been guided by the National Oceanic & Atmospheric Administration strategic planning document for 1995-2005 and input from regular meetings with the subprogram coordinators, the Wisconsin Sea Grant Advisory Council and program staff.

As noted in the 1992 biennial report of the International Joint Commission, the primary problem facing the Great Lakes continues to be the contamination of water, sediments and living organisms by persistent toxic organic chemicals. The importance UW Sea Grant attaches to this issue is reflected in the new Biotechnology Subprogram and its substantial Microcontaminants & Water Quality and Estuarine & Coastal Processes subprograms. Sea Grant also represents the best and possibly the only avenue for the basin-wide and interdisciplinary research and outreach on the exotic species problem and potential control measures.

In order to maintain a nationally recognized research and outreach program, the University of Wisconsin Sea Grant College Program will continue to be guided by these policies that have proven consistent and 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 levels;

- Working with industry, government and other user groups;
- Involving more social scientists to analyze policy issues;
- Sponsoring high-risk innovative research projects; and
- Seeking out other sources of support for the program.

PROGRAM ADMINISTRATION SUBPROGRAM

1. Growing in the right directions

Sound program management requires a degree of flexibility for undertaking new projects and augmenting ongoing projects as special opportunities arise. Program development funds enable Sea Grant to:

- Initiate quick-response projects that may be proposed during the grant term;
- Solicit projects in areas of high program priority;
- Augment existing projects and subprograms in cases of special need;
- Allow researchers to present papers based on Sea Grant research at national and international meetings; and
- Initiate new subprograms as appropriate.

CONTINUING PROJECT: Program Development (M/SGA-1)

Anders W. Andren
Sea Grant Institute
UW-Madison

2. Effective program management

Effective management requires successfully integrating research, education and advisory services, and holding all program components to professional standards of performance. The continued viability of and support for the program requires effective liaisons with state, federal and private industry sources of support.

Program management focuses on:

- Applying sound management and fiscal practices;
- Recruiting talented and creative staff;
- Seeking out innovative and high-risk research initiatives;
- Encouraging and developing effective advisory service, educational and communication programs;
- Maintaining a high level of quality control of all program activities;
- Evaluating research and outreach efforts to ensure a focused and responsive program; and
- Coordinating University of Wisconsin Sea Grant activities with Great Lakes and ocean research being conducted by other universities, and state and federal agencies.

CONTINUING PROJECT: Program Management (M/SGA-2)

Anders W. Andren
Sea Grant Institute
UW-Madison

3. Supporting the special needs of research projects

Many University of Wisconsin Sea Grant studies of the Great Lakes require the use of small boats, specialized technical assistance, and reliable research vessels equipped with specialized oceanographic equipment. This project funds ship time and related field support for UW Sea Grant projects that require field work on Lakes Michigan and Superior. To minimize expenses, field work for several projects often are conducted simultaneously on each cruise.

CONTINUING PROJECT: Ship Time in Support of Sea Grant Research Projects (M/SGA-3)

Anders W. Andren
Sea Grant Institute
UW-Madison

Related Projects

Related Projects Funded Through Sea Grant Institute

1. Chemical pollutants' effect on feral fish eggs

Fish living in freshwater environments and coastal waters often are contaminated with complex mixtures of polybrominated aromatic hydrocarbons (PAHs). These toxic chemicals accumulate in the tissue of female fish and then get transferred to their eggs. Sufficiently high egg concentrations of these contaminants may cause death to young fish and thus reduce fish populations in the wild.

Of the chemicals being examined in this project, the ones most toxic to young fish resemble 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 PAH derivatives and will rank the toxicity of these chemicals in terms of an equally toxic dose of TCDD.

With TCDD as the common denominator, the toxicity of different PAH derivatives will be described in terms of their TCDD equivalents concentration. Using this measure, the project investigators will develop a method for determining early life stage mortality in fertilized rainbow trout eggs that are exposed to pairs of PAH derivatives in order to determine if these chemicals interact in an additive fashion.

This work will allow regulatory agencies that measure the levels of these chemicals in fish eggs in the wild to understand the risk these levels pose to early life stage survival; it also will help scientists and managers determine acceptable levels of PAH derivatives in the Great Lakes.

CONTINUING PROJECT: Ecological Risk Assessment of Complex Mixtures of Polybrominated Aromatic Hydrocarbons in Feral Fish Eggs (R/MW-49)

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

Richard Peterson
School of Pharmacy
UW-Madison

2. Operation Pathfinder: Teaching teachers about marine science

Operation Pathfinder is a course designed to increase awareness and understanding of oceanography and coastal processes among elementary and middle-school minority teachers and teachers of minority students. The course will be conducted through the Sea Grant Advisory Services program.

Teachers from throughout the Great Lakes region will participate in an annual 12-day, three-credit graduate course on oceanography and coastal processes. The teachers will also learn and develop strategies to infuse these subjects into existing curricula. Course participants will develop a thematic instructional unit for use in their classrooms. They will also be expected to lead at least one teacher-training workshop or staff-development program, and to submit a journal article or present a paper at an education conference. Follow-up surveys will ensure that participants are transferring the information gained

about oceanography and coastal processes to the young people they teach, as well as to teachers with whom they work, thus significantly multiplying the impact of this project.

NEW PROJECT: Operation Pathfinder: Oceanography and Coastal Processes for Elementary and Middle School Teachers

Funding Sources: U.S. Naval Department, and Wisconsin Environmental Education Board

Allen H. Miller
Sea Grant Advisory Services
UW-Madison

James Lubner
Sea Grant Advisory Services
UW-Milwaukee

3. Zebra mussels in Duluth-Superior harbor

Although zebra mussel populations currently exist in the Duluth-Superior harbor, researchers don't know whether the populations are capable of long-term survival and reproduction in these waters. This research project will determine whether the mussels can survive, grow and reproduce within the ranges of pH, calcium and water temperature found in this western Lake Superior harbor.

Researchers will estimate the number of zebra mussel larvae and juveniles introduced to the harbor each year via ship ballast discharge and hull transport. These values will be compared to the quantity of young produced by the existing harbor population.

This project will provide valuable information on how zebra mussels go about colonizing areas where environmental factors work against them. If researchers find the constant reintroduction of zebra mussels to the Duluth-Superior harbor is helping establish a self-sustaining population, control recommendations may need to be developed.

CONTINUING PROJECT: The Role of Continuous Introductions in Establishing Zebra Mussel Colonies in Areas Where Environmental Factors May be Limiting (R/LR-47)

Funding Source: National Sea Grant College Program

Mary Balcer
Lake Superior Research Institute
UW-Superior

4. Educating the nation about global change

It is unlikely that international agreements, government programs and regulations, or research alone will resolve the global change dilemmas our planet faces. The success of any program will depend on support from a public that recognizes the links between human actions and Earth's responses.

To promote such citizen involvement, the Office of Global Programs at the National Oceanic & Atmospheric Administration (NOAA) has embarked on a three-year national

education effort through Sea Grant to provide regional workshops for adult educators on global change issues. Workshop participants will be trained as "Global Change Educators" and return to their home locations and train other educators, who in turn will educate youths and adults in the general public.

Seven regional workshops, held simultaneously in November 1994 and April 1995, will be integrated via a national satellite videoconference and link together informal educators and scientists from across the country to learn about and discuss global change issues. Educators from Canada and Pacific island nations will also be invited to participate.

The specific University of Wisconsin Sea Grant Advisory Services project will teach adult educators throughout the Great Lakes region. Anticipated benefits of this program include:

- Raising the awareness and understanding of climate and global change issues for program participants by translating current research into meaningful applications;
- Creating a "multiplier effect" with Global Change Educators training other educators, thereby increasing the number of individuals knowledgeable about the Earth system and how to effectively communicate their knowledge to other audiences;
- Providing participants a variety of resource materials to use when conducting complementary programs;
- Serving as a forum for interaction between educators and researchers within a region; and
- Promoting active electronic networking among educators and scientists nationwide.

CONTINUING PROJECT: NOAA National Program for Climate and Global Change Education

Funding Source: Office of Global Programs, National Oceanic & Atmospheric Administration

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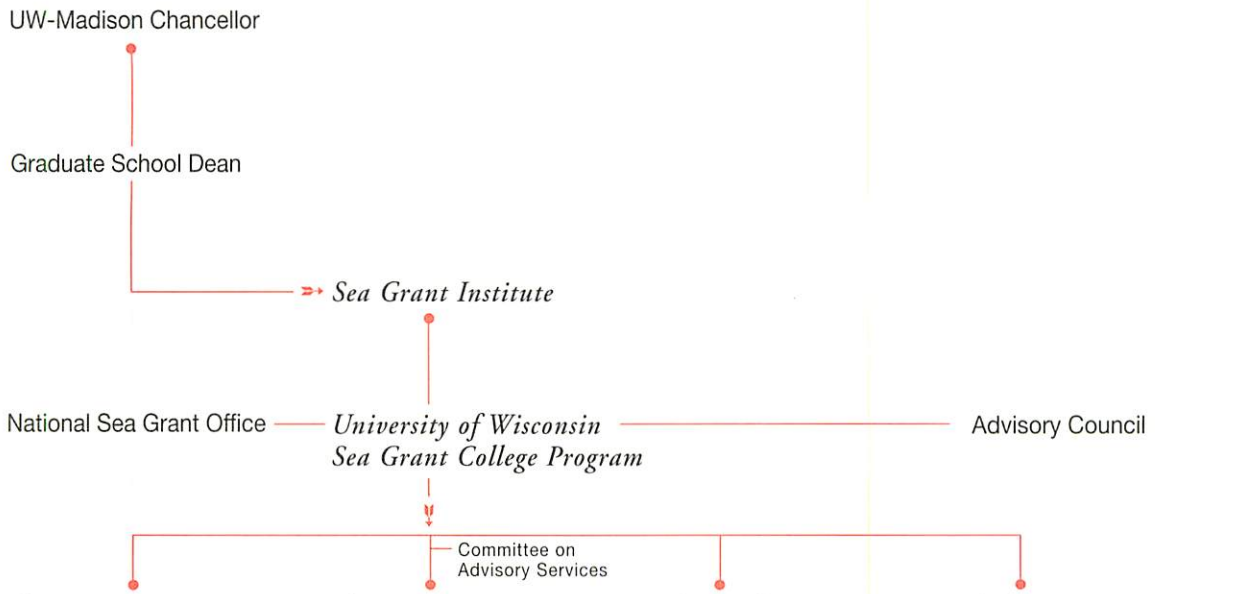
ORGANIZATIONAL CHART



Communications

Administration & Program Support:
Publications
Media Relations
Photo/Graphics Library

Public Information:
Publications
Film/Video Loan Library

Earthwatch Public Service Radio Program

Advisory Services

Administration / Coordination

Field Offices:
Superior/Ashland
Green Bay
Manitowoc
Milwaukee

Specialists:
Aquaculture
Business Education
Coastal Engineering
Fisheries
Geographic Information Systems
Water Quality

Research

Living Resources

Biotechnology

Estuarine & Coastal Processes

Microcontaminants & Water Quality

Aquaculture & Seafood Technology

Policy Studies

New Initiatives

Education

Graduate Assistants

Undergraduate Assistants

Course Development/ Seminar Speakers

Public Education

K-12 Education

Organizational Units and Departments Involved in the 1994-96 University of Wisconsin Sea Grant College Program

University of Wisconsin-Madison
Agricultural Economics
Animal Health & Biomedical Sciences
Aquaculture Research Center
Biodynamics Laboratory
Biotechnology Center
Biotron
Center for Aquaculture
Center for Health Sciences
Center for Limnology
Chemical Engineering
Civil & Environmental Engineering
College of Agricultural & Life Sciences
College of Engineering
College of Letters & Science
Comparative Orthopedic Research Laboratory
Environmental Toxicology Center
Food Microbiology & Toxicology
Food Science
Graduate School
Institute for Environmental Studies
Kinesiology
Land Information & Computer Graphics Facility
Mechanical Engineering
Medical School
Medical Sciences
Oceanography & Limnology Graduate Program
Orthopedic Surgery
Pathological Sciences
Preventive Medicine
Radiology
Research Animal Resources Center
School of Education
School of Journalism & Mass Communication
School of Pharmacy
School of Veterinary Medicine
Soil Science
State Laboratory of Hygiene
Surgical Sciences
Water Chemistry Program
Water Resources Management Program
Wildlife Ecology
Zoology

University of Wisconsin System
Great Lakes Research Facility

University of Wisconsin-Green Bay
Biology
Natural & Applied Sciences

University of Wisconsin Center-Manitowoc County

University of Wisconsin-Milwaukee
Aquaculture Institute
Biological Sciences
Center for Great Lakes Studies
Geosciences
Graduate School

University of Wisconsin-Superior
Lake Superior Research Institute

Marquette University
Biology
Civil & Environmental Engineering

Mystic Seaport Museum

North Carolina State University
Zoology

Purdue University-University of Illinois
Sea Grant Program

State of Wisconsin
Division of Health
State Laboratory of Hygiene

University of Connecticut
Sea Grant College Program

U.S. Department of Commerce, NOAA
Great Lakes Environmental Research Laboratory

U.S. Department of the Interior
National Park Service

U.S. Geological Survey

Williams College
Maritime Studies Program

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Racine County Planning & Development
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