1998 | 2000

Research for the Real World

University of Wisconsin Sea Grant Institute

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1998-2000 Program Directory

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UW Sea Grant Publication No. WISCU-Q-98-001

This work was funded by the University of Wisconsin Sea Grant Institute under grants from the National Sea Grant College Program, National Oceanic & Atmospheric Administration, U.S. Department of Commerce, and from the State of Wisconsin. Federal grant no. NA46RG0481, project C/C-1.

Printed in the United States of America
First Printing, October 1998

Contents

Introduction

The University of Wisconsin Sea Grant College Program is a statewide program of basic and applied research, education, and technology transfer dedicated to the wise stewardship and sustainable use of the nation's Great lakes and ocean resources. It is part of a national network of 29 university-based programs funded through the National Sea Grant College Program, National Oceanic & Atmospheric Administration, U.S. Department of Commerce, and through matching contributions from participating states.

More than 170 faculty, staff, and students are currently participating in UW Sea Grant-funded projects at six UW System campuses (UW-Madison, UW-Milwaukee, UW-Green Bay, UW-Manitowoc, UW-La Crosse, and UW-Superior). Sea Grant specialists—strategically located at Advisory Services offices on UW campuses in Green Bay, Madison, Manitowoc, Milwaukee, and Superior—convey research needs and research results between academic community and coastal resource users.

During 1998-2000, UW Sea Grant is supporting more than two dozen research, outreach, and education projects across a host of issues and concerns: enhancing Great Lakes sport and commercial fisheries; improving freshwater aquaculture; analyzing the ecosystem effects of zebra mussels; exploring the potential of biotechnology and other advanced technologies for marine and Great Lakes applications; analyzing related socio-economic issues and advising coastal communities and businesses; enhancing safety for recreational scuba divers; and investigating the cycling of toxic contaminants in Great Lakes systems and developing strategies for pollution remediation.

The collapse of Lake Michigan's yellow perch fishery will receive special attention from Sea Grant during the next two years. Both the Illinois-Indiana and Michigan Sea Grant programs have joined UW Sea Grant in funding a coordinated perch research program involving more than a half-dozen university scientists.

Since its creation nearly 30 years ago, Sea Grant has proven to be a sound investment. The national Sea Grant network offers an established infrastructure for university research and technology transfer to the marine sector of the national economy. It is the only Great Lakes and ocean program in the United States that combines research and outreach to bring scientific information to state, regional and federal resource managers, the public, and industry.

The UW Sea Grant program is internationally recognized for its cutting edge research in many disciplines: fisheries, toxic contaminants and water quality, aquaculture and seafood technology, biotechnology, estuarine and coastal processes, diving physiology, policy studies, and innovative research initiatives. Reflecting the fact that solving real-world problems requires multidisciplinary expertise, our current projects are grouped here by the problems or opportunities they address: Lake Superior Initiative; Yellow Perch Initiative; Nonindigenous Species; Aquaculture for the Great Lakes Region; Chemical-Biological Interactions in Aquatic Species; Terrestrial-Aquatic Coupling—Managing for Ecological Stability; The Science, Technology, and Economics of Water and Sediment Remediation; Safety at Sea; Application of Innovative Technology to Aquatic Environments.

Lake Superior Initiative

Lake Superior is a vital economic and environmental resource. It is also a fragile ecosystem threatened by toxic chemicals, exotic species, and human exploitation. Although environmental protection and restoration are vital, economic development is also critical to communities in the Lake Superior basin.

R/LR-76 **Application of Microsatellite and Mhc Markers to Stock Identification in Lake Superior Lake Trout**—Ruth Phillips

The rehabilitation of lake trout in Lake Superior is one of the Great Lakes' brightest success stories. Through the efforts of scientists and managers, the once-decimated populations of trout have rebounded significantly. As these populations continue to recover, it is important to determine the stock structure so the fish can be managed for a sustainable harvest.

Lean and siscowet lake trout are closely related salmonids in Lake Superior. Although distinct as adults, the young fish look the same. In order to monitor the trout fishery better, managers need a way to tell the two fish apart at all ages.

In this project, researchers will identify genetic markers to aid in stock identification and to distinguish between young lean trout and young siscowet trout. This work also will lead to development of a noninvasive DNA test—important because fish won't have to be killed to obtain genetic samples.

State, federal, and tribal agencies involved with rehabilitation programs can use such technology to manage the recovering lake trout fishery in Lake Superior more efficiently.

R/LR-77 **Causes and Impediments of Lake Trout Recovery in Lake Superior**—Michael Hansen

In March 1996, fishery managers on Lake Superior declared victory in the restoration of lake trout and decided to cease stocking after more than 35 years. Now fishery managers need tools that reliably predict the ability of wild stocks to sustain themselves in the future.

Wild lake trout are currently declining in numbers, and the prospects for natural reproduction are uncertain. To respond to this situation effectively, fisheries managers urgently need to understand the dynamics of survival and recruitment.

This project will produce quantitative models that describe the principal mechanisms and impediments driving lake trout restoration in Lake Superior. The models will help determine why the population of lake trout has declined in the last decade, and to what extent wild lake trout contribute to the population. The models will determine the significance of multiple factors such as densities of wild and stocked lake trout, predators and competitors, and large-mesh gill-net fishing effort. The results will enable management agencies to enact such strategies as habitat enhancement and fishery regulation to enhance lake trout recovery.

R/LR-78 **Fisheries and Food Web Dynamics in Lake Superior**— James Kitchell

Restoring native fish communities remains a long-term goal of Great Lakes fisheries managers. The goal is to establish a state resembling that which existed prior to the major decline in fish stocks due to over-exploitation and invasion of the parasitic sea lamprey, which requires a means for collecting, synthesizing, and analyzing some basic information.

This project will gather data and provide tools for the analysis of Lake Superior fisheries. Researchers will develop a bioenergetics model for populations of key species in Lake Superior — lake and steelhead trout, chinook and coho salmon, and burbot. This model will provide important information about the Lake Superior food web, as well as estimates of contaminant bioaccumulation in the system. Researchers will also assess current and future effects of predation and fishing pressure. This research will prove invaluable to managers charged with restoring sustainable fisheries in Lake Superior. The findings will help guide continued lake trout restoration efforts, design of salmonid stocking programs, implementation of fishery regulations, and development of sea lamprey control strategies.

R/MW-77 **Watershed Export and Speciation of Trace Metals in the Lake Superior Basin**—David Armstrong and William Sonzogni

Lake Superior is the cleanest of the Great Lakes, and people want to keep it that way by eliminating as many contaminants as possible. These include metals like lead, cadmium, arsenic, mercury, zinc, and others. Even at very low concentrations, some of these metals can exert toxic effects. However, toxicity is strongly dependent on the chemical and physical form (species) of the metal.

Watersheds are major reservoirs of metals, and rivers draining these watersheds are major sources of metals that enter Lake Superior. This project will assess key factors controlling the mobility and fluxes of a dozen different metals in representative tributaries of Lake Superior. Researchers will study trace metal transport and relationships to stream geochemistry, watershed characteristics, and hydrologic events. They will also examine the relative importance of natural and human-produced sources. The use of newly developed "ultra-clean" sampling and analysis methods will enable researchers to measure metal concentrations and forms present in tributaries throughout the Lake Superior Basin.

This information will aid regulators and managers in developing and enforcing realistic standards governing trace metal pollution in Lake Superior and elsewhere.

R/PS-51 **Sustainability, Uncertainty and the Management of the Lake Superior Fisheries**—Richard Bishop

Economic research informs public debate and decision-making on policies for Great Lakes fisheries. To date, economic models have focused almost exclusively upon efficiency based on maximizing the present value of the fisheries. More and more, however, communities and resource managers are working to build and protect the sustainability of their resources, so they can continue producing into the future.

This project will build an economic framework that integrates the concept of sustainability with that of efficiency. This model will be applied to the fisheries of Lake Superior, informing policy-makers of the implications of planning for and achieving a sustainable fisheries resource.

R/PS-53 **Analysis of Persistence and Change in Apostle Island Boating 1975-1977**—Thomas Heberlein

The Apostle Islands region of Lake Superior has been a popular recreational boating site for many years, but the numbers of boaters and their characteristics are constantly evolving. These changes affect northern Wisconsin's natural and economic environments.

A group of Apostle Island-area boaters were surveyed in 1975 to learn what factors influenced their participation in recreational boating. They were surveyed again in 1985 and in 1997. Another group was surveyed in 1985 and in 1997, and a third group was surveyed only in 1997. Researchers will analyze these three complex data sets and will collect the secondary data necessary to help interpret observed changes.

As one of few long-term panel studies in the recreation research field, this project will provide information about how people's recreational lives change as they age. It also will reveal changes in how society regards and uses wilderness. This study will show how recreational boaters have affected the Apostle Islands area and how that area has changed and developed to suit the boating population.

Understanding the recreational choices made by this aging population will reveal what individual, societal, and site-related factors affect people's decision-making processes. These findings will help policy-makers, resource managers, business owners, and the public make informed decisions related to recreational and economic development in northern Wisconsin.

Yellow Perch Initiative

Yellow perch have long been a commercial and sport fishing favorite in Lake Michigan. For nearly a decade, however, populations have drastically declined, and the causes remain poorly understood. To address this problem, UW Sea Grant has joined forces with state, federal, and tribal agencies around Lake Michigan in an intensive research effort.

R/LR-75 **Recruitment Mechanisms in Yellow Perch (*Perca flavescens*): Interactions among Growth, Condition and Predation**—Fred Binkowski

For nearly a decade, young yellow perch in Lake Michigan have been failing to survive to adulthood, and no one knows why. This project will examine several factors that may be responsible for this recruitment failure.

Researchers will assess the fish's size, condition, growth rates, and survival, and they will determine the causes and consequences of variation in these factors. The team will also develop an individual-based model of the interactions among perch size, growth, condition, and predator size and abundance. This model will be used to develop and test hypotheses about the effects of these factors on perch populations.

This study will provide much-needed insight into the dynamics of recruitment among yellow perch. With a better understanding of the factors limiting recovery of the perch population, fisheries managers will be able to address this serious problem more effectively.

R/EC-5 **Recruitment Decline of Yellow Perch in Green Bay, Lake Michigan: Evaluation of Environmental Influences and Predation**—Fred Binkowski

While young yellow perch in greater Lake Michigan are failing to survive to adulthood, recruitment is still evident among yellow perch of Green Bay. Comparing the relatively successful Green Bay yellow perch to their counterparts in other Lake Michigan locations may be the best way to understand the recruitment failure observed in most of the lake.

Researchers will compare the effects of temperature on egg survival, hatching success, sac-fry survival, and larval survival in perch from Green Bay with corresponding effects on perch from other locations. In the field, they will examine interactions of perch and their predators and compare their relative abundance, growth, and survival. The investigators expect these comparisons to identify those factors that are responsible for widespread recruitment failure.

This knowledge may help fisheries managers aid the recovery of Lake Michigan's yellow perch population and better manage other fish species.

R/LR-74-PD **ELHP Early Life History of Perch** —Fred Binkowski

Many proposed explanations for the decade-long failure of young Lake Michigan yellow perch to survive to adulthood involve biological factors in early life. However, it is very difficult to monitor egg and larval stages in the field. Laboratory investigations of perch eggs and larvae can determine whether differences in the quality of the gametes from Lake Michigan, Green Bay, Lake Ontario, and an inland perch population influence their growth and survival.

Researchers will compare the early life stages of perch from Lake Michigan, Green Bay, Lake Ontario, and the inland lake stock in laboratory experiments. They will examine fertility, hatching success, first feeding, swim bladder inflation, growth rates, survival, and other factors. They will also examine potential differences between hatchery and naturally spawned perch eggs. Finally, the team will establish a captive

broodstock of Lake Michigan strain yellow perch using the progeny of the Lake Michigan fish.

These investigations will help clarify whether the observed recruitment failure of Lake Michigan perch is related to factors that influence the survival and growth of the egg, larval, and post-larval stages. If differences in development are found between the strains of perch in this study, they may be traceable to contamination of parental populations. If, however, differences are not found, it will suggest that other, in-lake conditions are determining the different survival rates observed in the populations under study.

Nonindigenous Species

The Great Lakes have been invaded by more than 130 species of plants and animals, but the recent invasion of zebra mussels has arguably had the widest impact. The mussels damage human structures and also impact aquatic ecosystems by altering nutrient cycling, contaminant cycling, and habitat features.

R/LR-63 **The Effect of Zebra Mussel Infestation in Inland Lakes on Pelagic Benthic Coupling**—Russell Cuhel and David Edgington

As zebra mussels spread from the Great Lakes to Wisconsin's inland lakes, they can cause major ecological changes. By altering nutrient availability, these prolific nonindigenous mollusks could transform lake systems based on plankton-fish interactions into systems dominated by zebra mussels and bottom-feeding fish.

This study will help fish managers keep ahead of the zebra mussels. Researchers will investigate the effect zebra mussel infestations have on energy transfer between primary producers, like phytoplankton and plants, and higher-level consumers. Also, they will determine what characteristics make a lake susceptible to zebra mussel colonization.

Results of this research combined with long-term data from Wisconsin's lakes will contribute to an understanding of how zebra mussels could alter specific inland lakes. This information will help managers predict the probability of zebra mussel infestations and will suggest management strategies for lakes that appear susceptible.

A/AS-41 Transferring Sea Grant Zebra Mussel Research and Outreach Results to the Nation Using a World Wide Web Server and Compact Disks—Allen Miller

To control the threat of zebra mussels, Eurasian ruffe, round goby, and other aquatic nonindigenous species (NIS) effectively, knowledge about these troublesome animals must reach the people who can facilitate control efforts. This project will transfer research and educational information on aquatic NIS from those who produce it to those who need it most—resource managers, industrial facilities operators, the public, and other water users in the United States, Canada, and elsewhere.

Project leaders will accomplish this by expanding the Sea Grant nonindigenous species World Wide Web site (**sgnis**).* This database will now include research and outreach materials from Sea Grant and many other agencies, including the National Oceanic and Atmospheric Administration, the Great Lakes Environmental Research Laboratory, the U.S. Coast Guard, and the U.S. Corps of Engineers. The research explores basic biology, effects on ecosystems, means of prevention, and costs and benefits of control strategies. Outreach efforts focus on the education of industrial facilities operators, resource managers, and the public.

The project will ensure the scientific integrity and utility of all information added to the web site by submitting each document for review by recognized scientists. It will produce and market an updated compact disk of **sgnis** information for industries, governments, and individuals that do not have access to the internet. This wealth of information will play a vital role in reducing the impact of nonindigenous species around the country.

* The site can be found at **http://www.ansc.purdue.edu/sgnis**

Aquaculture for the Great Lakes Region

Wisconsin and the Great Lakes region have abundant resources and existing markets that are well-suited to commercial aquaculture. Aqualculture is vital to the valuable Great Lakes commercial fishing industry, which depends on hatchery production and fish stocking.

R/AQ-31 **Steroid Regulation of the Stress Response and Immune Function in Salmonid Fishes**—Terence Barry and Jeffrey Malison

Researchers know that physiological stress decreases the health, growth, and reproductive performance of cultured fish. In fact, stress is one of the most important problems in aquaculture and fisheries management.

In this study, researchers will administer reproductive steroids to cultured coho salmon and rainbow trout. Then they will measure cortisol levels to determine the steroids' impact on the fishes' response to stress. This work will contribute to the ongoing development of "least-stress" husbandry techniques and the breeding of stress-resistant strains of fish. Additionally, the research will contribute new information on the relationship between stress and reproduction, which will be useful for improving egg quality and larval fish survival. The work will also increase understanding of the mechanisms by which physiological stress causes post-spawning mortality in Pacific salmon and accelerates the normal rate of aging in all vertebrates.

The two species targeted in this study are of great economic importance to commercial aquaculture in the Great Lakes region and elsewhere.

R/AQ-32 **Conversion of Fish Processing Waste and Underutilized Fish into Value-Added Protein Hydrogel**—Srinivasan Damodaran

Fish industries in Wisconsin and throughout the United States are currently unable to use large portions of the fish they catch—up to 50 percent of a trawl may be trash fish by-catch, and processing the marketable fish generates large amounts of protein-rich material that goes to waste.

This project will investigate ways in which by-catch and waste material might be converted into valuable products. Specifically, it will evaluate the possibility of producing hydrogel polymers from fish. These hydrogels would be extremely absorbent and could be used in diapers, removal of heavy metals from effluent, carriers for agricultural herbicides and pesticides, and other applications.

Researchers will synthesize novel fish protein-based superabsorbent hydrogels, study their water absorbing and heavy metal binding properties, and evaluate their ability to biodegrade.

The resulting technology could boost the economic vitality of the fish industry, creating valuable products from aquatic resources that are currently wasted.

R/AQ-33 **Mitigation of the Consequences of Stress in Yellow Perch Aquaculture**—Jeffrey Malison

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 for evaluating 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.

R/BT-10 The Production of Fast-Growing, Sterile Walleye Hybrids through Genetic and Endocrine Technologies—Jeffrey Malison

The walleye is one of the most highly valued food and sport fish in the Great Lakes region. Because of its high market value and limited supply, this species is an excellent candidate for commercial aquaculture. However, the commercial production of food-size walleye is constrained by the fish's slow growth when reared under intensive culture conditions.

This project will investigate the potential of three technologies to be used in combination to produce walleye strains with significantly improved growth. Hybrids, monosex female populations, and genetic triploids (i.e., individuals with three sets of chromosomes) of other species have shown advantages in growth and survival rates, total size, docility, and adaptability.

Researchers will develop methods for producing monosex female hybrid walleye; they will develop and test methods for inducing in them triploidy at high rates; and they will compare the growth, feed conversion, and reproductive development of these hybrids to diploid hybrid and purebred walleye.

The resulting techniques will produce fish strains with significantly improved growth, thereby spurring the development of a commercial food-size walleye aquaculture industry. These technologies will also be useful tools for enhancing recreational fisheries in and around the Great Lakes.

A/AS-39 **Wisconsin's Aquaculture Technology Education Research Services (WATERS)**—Fred Binkowski

Aquaculture is the fastest-growing sector of the U.S. agricultural economy, and consumer demand for fish products continues to increase. Wisconsin's aquaculture industry needs more research and technical support if it is to continue to grow.

Since 1992, more than 3,000 people have received technical information and assistance through UW Sea Grant's aquaculture outreach programs, and the number of workshop participants is increasing. UW Sea Grant sponsors workshops on recirculating aquaculture systems, spawning techniques, feeding strategies, intensive rearing methods, and the economic parameters for these topics.

UW Sea Grant's Advisory Services aquaculture specialist provides technical, on-site assistance to aquaculturists and demonstrates new techniques for domesticating yellow perch brood stock and implementing intensive aquaculture strategies.

Advisory Services works with other state agencies and Wisconsin's aquaculture industry to develop and promote acquaculture in Wisconsin and other sites throughout North America.

Chemical-Biological Interactions in Aquatic Species (Endocrine Disrupters)

Researchers recently have noted a class of chlorinated chemical compounds that disrupt normal endocrine functions in Great Lakes fish and wildlife. Affected animals suffer impaired developmental and reproductive ability.

R/MW-58 **Ah Receptor-Mediated Developmental Toxicity in Zebrafish**—Richard Peterson and Warren Heideman

Dioxin and related chemical pollutants that are found in the environment interfere with early life stage development in fish, but the mechanisms by which they act are not well understood.

In this project, researchers will evaluate the effects of dioxin-related chemicals on fish development. They will also examine the molecular mechanisms by which these effects occur. This group of chemicals, which binds to aryl hydrocarbon receptors (AhR), causes deformities in young fish. The researchers will work with zebrafish, a nearly transparent fish that is easy to work with and has a well-known developmental pattern.

Understanding the effects of dioxins in fish is important for understanding dioxin-related environmental risks. Zebrafish will provide a way of understanding dioxin's impact on fish development and revealing the molecular mechanisms of AhR-mediated toxicity.

R/MW-76 **Impact of Contaminants on Sexual Development and Reproduction of Amphibians in Great Lakes Ecosystems**—William Kasarov

Researchers suspect a relationship between water contamination and low amphibian diversity and abundance in the Green Bay ecosystem. Toxic polychlorinated biphenyls (PCBs) are particularly suspect, but the relationships have yet to be determined.

This investigation will determine whether amphibian diversity and abundance in the Green Bay ecosystem is notably low compared with similar sites elsewhere in Wisconsin. It will test the hypothesis that chronic exposure of amphibian eggs to contaminants in water from Green

Bay and its major tributary, the Fox River, reduces hatchability and survival of three particular species. Researchers will also check for abnormal sex organs in amphibians raised in these waters. Results of this work will be used to assess to what extent contaminants can explain the variation in amphibian species diversity and abundance in wetlands in the Green Bay ecosystem.

The work will enable managers at state and federal resource management agencies to address the question of whether amphibians, one of the least-studied classes of vertebrates, are adequately protected by regulations based on bird, mammal, and fish species. The research will also provide landscape ecologists with information necessary to evaluate the effectiveness of wetland restoration efforts.

R/BT-11 **Identification of the Endogenous Ligand for the Aryl Hydrocarbon Receptor**—Richard Peterson and Margaret Clagett-Dame

Dioxin is a well-known environmental contaminant that adversely affects fish and wildlife, but the biochemical mechanisms underlying the toxic response caused by dioxin are not fully understood. Researchers do know that dioxin's toxic effects are dependent on a particular aryl hydrocarbon receptor (AhR), which is ultimately responsible for inducing or repressing genetic commands.

To understand how dioxin disrupts the system, researchers first need to understand the proper operation of the AhR signaling system. A major unknown is the existence of an endogenous ligand or ligands for the AhR. Endogenous ligands are chemicals that occur naturally in animal tissue and activate the AhR. If such an endogenous ligand is isolated and identified, it could provide greater insight into AhR's normal biological functions.

In this project, researchers will identify an animal tissue that is a rich source of the ligand, purify it and identify its structure. Identifying the endogenous ligand for AhR in animal tissue and determining its normal functions will lead to a better understanding of how dioxin exposure results in toxicity.

Information gained from this project will lead to better dioxin risk-assessment techniques. Knowledge of the chemical structure of an endogenous AhR ligand could ultimately aid in developing AhR antagonists to counteract dioxin's toxic effects.

Terrestrial-Aquatic Coupling—Managing for Ecological Stability

Coastal waters throughout the world are sites of intense biological, chemical, physical and geological activity. The effects of human activities on the aquatic environment are strongly felt and readily observed in these areas.

Within the next few decades, nearly half of the world's population will live within 100 miles of a coast. The Great Lakes aquatic systems are dominated by their coasts, and understanding the dynamic nature of these areas is crucial to proper management of Great Lakes resources.

R/EC-6 **Net Heterotrophy/Autotrophy in Coastal and Offshore Lake Michigan**—Russell Cuhel, J. Val Klump, and Carmen Aguilar

The near-shore zone of Lake Michigan supports vigorous recreational and commercial activities. Spawning and early recruitment of yellow perch into the fishery occur in the same shallow areas now favored by zebra mussels. Additionally, urban and agricultural runoff, eroded soils, and treated sewage affect water quality inshore. These influences alter nutrient cycling and productivity regimes, possibly changing relationships between producers (photoautotrophs) and decomposers (heterotrophs).

In such a biophysically complex environment, direct measurements may be highly variable among sites. The net outcome for growth of suspended and benthic algae (CO_2 and O_2 production) vs. bacterial consumption of organic matter (O_2 use, CO_2 production) should be recorded in dissolved gas concentrations. This may provide an integrative picture of microbial activity and ecosystem response to terrestrial inputs and exotic species invasion.

Scientists will directly measure rates of algal and bacterial growth in conjunction with dissolved gas signatures in coastal and offshore waters. The relative importance of benthic vs. water column production will be specifically emphasized.

Assessment of changes between near-shore/offshore and benthic/pelagic production and consumption will contribute insight into causes of persistently poor fisheries recruitment and consequences of introductions of undesirable species.

The Science, Technology, and Economics of Water and Sediment Remediation

UW Sea Grant's long history of research in the areas of microcontaminants and water quality has led scientists to find new ways to render persistent toxic contaminants harmless. These findings may be applied to the 41 Great Lakes "Areas of Concern" where contaminated sediments have been the cause of significant environmental degradation.

R/MW-78 **Changes in Patterns of PCB Contamination in Surficial Green Bay Sediments over the Past Decade: Applications to Sediment Remediation**

—David Armstrong and David Edgington

Remediation of Green Bay has been limited by the high cost of treating or removing PCB-contaminated sediments. Evidence from Sea Grant-supported work in 1990-1993 indicated that PCB levels in surficial (upper 3 cm) sediments were declining. Thus, levels should have declined over the past decade.

This project will determine whether concentrations of PCB levels have in fact continued to decline during this time. The researchers will assess the distribution of PCBs in the bay, quantify the reductions in amounts and concentrations during the last decade, and quantify various factors that determine PCB fates.

With this data, the researchers will estimate the time required to reach "acceptable" sediment PCB levels through natural remediation. They will also estimate the amount of PCBs delivered to Green Bay by the Fox River over the last 10 years. This information is needed to calibrate the sediment transport models used to predict PCB export from the Fox River and to assess the benefits of efforts to remediate PCB contaminated sediments in the Fox River.

R/MW-79 Degradation of Organic Contaminants in Sediments via Subcritical Water Extraction and Photocatalytic Oxidation over Supported Nanoparticulate Metal Oxides—Marc Anderson

Several techniques—including supercritical fluid extraction, near critical water extraction, and thermal desorption—have proven to be effective in extracting organic contaminants such as PCBs from sediments. Once extracted, subsequent oxidation of the toxic organic compounds can be accomplished by various advanced oxidation techniques including photocatalytic oxidation.

TiO_2-mediated photocatalytic oxidation has proven to be highly effective in oxidizing most toxic organic compounds but has several limitations that are preventing widespread commercial use for water treatment. Foremost of these is the difficulty in illuminating a large amount of the catalyst surface that is in contact with the contaminant to be degraded. Most aqueous photocatalytic studies have employed slurries of extremely fine TiO_2 powder. The small particle size of the photocatalyst requires centrifugation or microfiltration to separate the catalyst from the treated liquid. Attempts to immobilize the catalyst on a support or to use pelletized catalysts in a fixed-bed reactor have met with limited success as a result of the inefficient use of the incident UV radiation. Often, the UV radiation is completely absorbed near the tube wall, resulting in bulk mass transfer limits from the interior of the reactor to the outer illuminated zone.

In this study, researchers postulate that a thin film of the catalyst material supported on UV transparent silica particles will improve reaction rates by increasing light penetration depth in the fixed-bed reactor, resulting in a greater effective surface area of the catalyst for reaction. Successful development of a light-efficient fixed-bed photocatalytic reactor system would be a major step toward commercial application of this promising technology.

Safety at Sea

As recreational boating and scuba diving continue to increase in popularity, the risks associated with these activities become more evident. Continued public awareness of the dangers of these sports is integral to reducing injuries and fatalities.

R/NI-27 **Diver Health and Safety: Minimizing Decompression Risk**—Rudolf Tass Dueland

Recreational, scientific, commercial, and government divers sometimes engage in diving practices that carry significant physiological risks, such as bone necrosis and brain lesions associated with decompression sickness.

In this study, researchers will evaluate the high-risk diving behavior that provokes these sorts of injury in those who practice repetitive deep "bounce" dives. Divers who sustain limb bends decompression sickness can develop bone necrosis, known as dysbaric osteonecrosis (DON), in their long bones. The research will evaluate the use of delayed recompression treatment in preventing DON, continue to investigate DON prevalence in Maine scallop divers, and assess the risk of divers developing white-matter brain lesions and DON due to bounce dives.

Findings from this research will improve diving safety and efficiency by identifying diving practices with unacceptable risks, enhancing risk-prediction tools, and recommending therapeutic interventions.

Application of Innovative Technology to Aquatic Environments

The full application of cutting-edge technologies like biotechnology, computer science and new materials synthesis is still being realized. Sea Grant is exploring these exciting research areas and encouraging scientists to apply them to aquatic environments. UW researchers are developing polymers for special marine uses, designing intelligent robot systems for complex underwater tasks, and applying the principles of genetic engineering to solve environmental and industrial problems.

R/LR-80 **Assessing the Risk of Whirling Disease Becoming Established in the Great Lakes: Field and Laboratory Evaluation of a Novel Polymerase Chain Reaction Diagnostic Assay**—Daniel Sutherland

Whirling disease (WD) was once considered to be a problem only in fish hatcheries, but it has become a serious problem throughout populations of rainbow trout and cutthroat trout in the inter-mountain west, and 23 states are now known to have had fish infected with the parasite. Wisconsin waters are not yet infected, although WD recently has been detected in fish from the Au Sable and Manistee rivers in lower Michigan. Introduction of WD in Wisconsin and Minnesota would place at risk a multibillion-dollar annual Great Lakes sport fishery and a multimillion-dollar annual inland trout fishing industry. However, little is known about the potential for establishment of WD in Wisconsin.

Most information on WD deals with riverine environments. Virtually nothing is known about how *Myxobolus cerebralis* (Mc), the nonindigenous parasite that causes the disease, affects lake and reservoir salmonids. Likewise, the alternate host portion of the Mc life cycle in oligochaetes (the aquatic equivalent of earthworms) is poorly understood.

Researchers will evaluate the use of a new polymerase chain reaction assay for detecting the presence of Mc in salmon and trout from Wisconsin. They will sample steelhead tributary streams of Lakes Michigan and Superior for *Tubifex tubifex,* the only known oligochaete alternate host for Mc. They will also establish experimental infections of oligochaete alternate hosts.

This work will improve the capability of fish health specialists to diagnose fish for WD and will provide knowledge about the possible outcomes of WD becoming established in Wisconsin.

R/PS-52 **Interseasonal Comparisons of Static and Dynamic Economic Models of Recreational Salmonid Fishing on Lake Michigan**—Bill Provencher and Richard Bishop

It isn't easy to measure the value of a recreational activity like fishing, camping or hiking, but an accurate economic model can help policy and resource managers determine the best practices for managing these non-market resources and experiences.

In this study, researchers will gather data from Lake Michigan salmon and trout anglers for the 1999 fishing season. This information, combined with data from other years and sources, will help researchers build an economic model of angler activity in the area. With an understanding the dynamic decisions of recreational anglers, fisheries managers can use this model to analyze the economic impact of various policy options for managing the Lake Michigan fishery to achieve maximum economic returns.

R/NI-28 **Erosion Information System in Support of Coastal Zone Management and Science**—Frank Scarpace and Alan Vonderohe

Erosion and recession of coastal bluffs present tremendous problems in the management of developed coastline for property owners, zoning boards, and the insurance and banking industries. Coastal bluff erosion also affects water quality and sedimentation rates. Recent technological developments in geospatial information collection, processing, and presentation offer an unprecedented opportunity to update outdated tools for predicting natural coastal hazards and calculating inputs to models of water quality and sedimentation rates.

Researchers will work with the U.S. Army Corps of Engineers to develop effective, state-of-the-art technology that can be used to estimate and periodically re-estimate recent and long-term rates of coastal bluff recession with a minimum amount of uncertainty and error. They will also develop a prototype geographic information system (GIS) application and associated databases for analyzing recession rates of coastal bluffs.

This system will provide information and guidance to coastal planners and managers, coastal engineers, developers, homeowners, environmental scientists, contractors, and primary and secondary investors in coastal property and their agents.

A/AS-40 **Applications of Geographical Information Systems (GIS) to Coastal Zone Management: Building Local Capacity**—Stephen Ventura

Coastal communities and governmental agencies confront a host of problems unique to their geographical setting. Erosion from flooding and wave action often threaten the very land on which they exist. Urban and rural runoff and industrial and municipal discharges frequently degrade their water quality. These issues are of significant environmental and economic concern to such communities throughout Wisconsin and many other parts of the nation.

The emerging technologies known as geographical information systems (GIS) offer the possibility of monitoring and understanding these processes with unprecedented detail. This project will extend previous UW Sea Grant research into GIS applications to coastal management. It will develop models to enhance understanding and management of nonpoint source pollution, shoreline land use, shoreline recession, and floodplain mapping. Researchers will consult with local governmental staff and domain experts to learn their needs. These collaborators will evaluate product prototypes, with local staff looking at ease of use and technical experts looking at accuracy and value of information.

The researchers will train local governmental officials and staff to use GIS and will evaluate and improve upon existing user interfaces based on feedback from these groups. The tools that result will provide more objective local planning, management, and regulatory decisions.

C/C-3 **Sailing through Death's Door: Multi-Media Site Guides to Wisconsin's Lake Michigan Shipwrecks**—John Jensen and Stephen Wittman

People find shipwrecks fascinating. The Great Lakes hold about 5,000 well-preserved wrecks, and shipwreck preserves established in Michigan waters of the Great Lakes attract thousands of recreational scuba divers annually, bringing hundreds of thousands of dollars to the economies of adjacent coastal communities.

This project will develop a series of guides to Wisconsin's Lake Michigan shipwrecks. It will complement and build on similar guides to Wisconsin's Lake Superior shipwrecks developed by project personnel, the online version of which is already averaging more than 100 visitors per day.

The project will make Wisconsin Great Lakes shipwreck research results more readily available to archeologists, recreational

divers, educators, students, and the public in interesting, easy-to-use formats. Its goal is to foster improved stewardship and protection of Wisconsin's submerged cultural resources. It is hoped the project will help boost the economies of Lake Michigan coastal communities and benefit recreational divers, students, maritime museums, and others interested in Great Lakes historical maritime resources.

R/AQ-34-PD **Use of Fish Oils for the Production of Nutraceuticals Containing Omega-3 and Conjugated Linoleic Acid Residues**—Charles G. Hill, Jr.

Foods that incorporate both nutritional and other health benefits (e. g., preventive medicinal effects) are referred to as nutraceuticals. Ingestion of these foods may lead to reduced incidence of diseases, such as cancer and coronary heart disease. The health benefits of consuming omega-3 fatty acids and conjugated linoleic acids (CLA) are substantiated by an increasing body of scientific evidence. Combination of these substances in the same nutraceutical gives a value-added product with intriguing market potential for manufacturers of fish oils.

The research will investigate the technical feasibility of employing fish oil and corn oil as raw materials for production of acylglycerides (oils) enriched in residues of both omega-3 fatty acids and CLA. Rate expressions will be determined for both the (immobilized) enzyme-catalyzed reactions and the bioconversion (fermentation) step that are used in the process proposed for production of the indicated nutraceutical.

The resulting nutraceutical oils will have significant dietary implications for individuals who are high-risk candidates for carcinogenic, cardiovascular, or hypertensive problems. These oils may be incorporated into food products as bland oils or as powders in which the oil is encapsulated so that it disperses readily in the aqueous component of a variety of foods.

General Outreach & Education Projects

The UW Sea Grant Institute staff promotes Sea Grant's mission of encouraging the stewardship and sustainable use of the nation's Great Lakes and ocean resources. Staff members publicize research results and related information in the media, in classrooms and in the field.

A/AS-1 **Advisory Services: Program Coordination and Field Offices**—Allen H. Miller

The Great Lakes provide important economic and recreational opportunities that must be used wisely. UW Sea Grant Advisory Services specialists serve as a bridge between Great Lakes researchers and resource users by passing new research information on to the public.

The Advisory Services program employs eight specialists who provide statewide assistance in aquaculture, business, coastal engineering, fisheries, geographic information systems, marine education, nonindigenous species, water quality, and water safety. The specialists are located at UW-Madison, UW-Milwaukee, UW-Green Bay, UW-Superior, and UW Manitowoc.

In addition to providing technical and hands-on support to the public, Advisory Services specialists are involved in many of the projects associated with UW Sea Grant's 1998-2000research themes, including the Lake Superior Initiative, Nonindigenous Species, Aquaculture for the Great Lakes Region, Terrestrial-Aquatic Coupling, Safety at Sea, Application of Innovative Technology, and related programs. Advisory Services also offers summer courses for teachers and programs for the public.

C/C-1 **Communications Office and Subprogram Coordination**—Stephen Wittman

The goals of UW Sea Grant's Communications program are to enhance public appreciation for the value of Great Lakes' coastal and ocean resources; offer professional communications support to UW Sea Grant staff, specialists and researchers; and provide professional science communications experience to UW-Madison students via part-time employment as writers.

Led by UW Sea Grant's assistant director for communications, the office staff includes an art director, editor, radio producer, science writer, and two half-time student writers.

The Communications Office produces the UW Sea Grant Institute's bimonthly newsletter, *Littoral Drift*. It also annually distributes thousands of copies of science journal articles based on UW Sea Grant-funded research as well as hundreds of Sea Grant technical, public information and education publications.

In addition to providing general professional communications support to the UW Sea Grant program, Communications Office staff are directly involved in various projects associated with UW Sea Grant's 1998-2000 research theme areas, including the Lake Superior Initiative, Yellow Perch, and Application of Innovative Technology.

C/C2 **Earthwatch Public Service Radio Program** —Richard Hoops

"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, when the United Nations Environment Programme named "Earthwatch" to its Global 500 Roll of Honour.

Sea Grant and the UW-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 120 broadcast outlets in the eight Great Lakes states, the Canadian province of Ontario, and elsewhere. "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-to-1 on the federal Sea Grant investment.

E/E-1 **Special Marine Education Programs**—Mary Lou Reeb

UW Sea Grant provides opportunities for graduate and undergraduate students to participate in all aspects of the program's activities. In the belief that graduate education and research are inseparable, most of the program's investment in education is in the form of research and project assistantships funded through individual research projects.

The 1998-2000 program will provide annual support for 22 graduate and 39 undergraduate students who work as integral members of research projects in the various thematic areas. Through UW Sea Grant, students also receive special opportunities to go to sea, work at coastal research stations, and attend scientific meetings.

UW Sea Grant also educates the public about ocean and Great Lakes issues and provides training for anglers, boaters, coastal residents, K-12 teachers, port managers, and aquaculturists.

UW 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 are special projects jointly funded with 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, teacher training enhancements, radio programs, displays, workshops, and conferences for adults.

Community-based partnership projects, such as the Madison JASON Project (an annual high-tech international science education program adapted for Madison-area teachers and middle-school students), are also coordinated directly through Special Marine Education Programs.

E/E -31-SE **Recent Advances in Limnology and Oceanography**—Arthur Brooks

Each year since 1973, UW-Milwaukee's Center for Great Lakes Studies, with Sea Grant support, has invited a series of distinguished researchers to speak on topics in aquatic sciences, including aquaculture, global climate change, and the effects of nonindigenous species invasions. The series is the core of a graduate seminar course and enables Wisconsin faculty, students, and local professionals to exchange information with experts from other leading research institutions. It also provides a forum for public discussion of emerging Great Lakes and ocean issues.

The topics planned for the next three years of the seminar will be wide ranging, yet linked in many ways. The first year's seminar will examine the role that the Great Lakes have played in the settlement and economic development of the region, the use and misuse of the natural resources, and means of restoring and rehabilitating the ecosystem. The seminar will draw on the expertise of historians, economists, resource managers, and restoration ecologists.

The second year will address the role of predation and competition in structuring the food web of the Great Lakes. Year three will feature topics on the application of models in Great Lakes research and management, the use of stable isotopes in freshwater research, or other timely topics that may arise at the turn of the millennium. The 1999 series, which begins in February, will be held Thursday evenings at the Center for Great Lakes Studies in the UW Great Lakes WATER Institute, 600 East Greenfield Avenue, Milwaukee.

Table 1. Project matrix

Thematic Areas / Subprograms	Lake Superior Initiative	Nonindigenous Species	Aquaculture for the G.L. Region	Chemical-Biological Interactions	Terrestrial-Aquatic Coupling	Sediment Remediation	Safety at Sea	Yellow Perch	Application of Innovative Technology
Living Resources	R/LR-76 R/LR-77 R/LR-78	R/LR-63	R/LR-80					R/LR-74 R/LR-75	R/LR-80
Microcontaminants & Water Quality	R/MW-77			R/MW-58 R/MW-76		R/MW-78 R/MW-79			
Policy Studies	R/PS-51 R/PS-53								R/PS-52
Estuarine & Coastal Processes					R/EC-6			R/EC-5	
Biotechnology			R/BT-10	R/BT-11 R/BT-12					
Aquaculture			R/AQ-31 R/AQ-32 R/AQ-33						R/AQ-34
New Initiatives							R/NI-27		R/NI-28
Advisory Services		A/AS-41	A/AS-39						A/AS-40
Communications									C/C-3

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