



Annual Progress Report, 2000

Programmatic Accomplishments and Benefits Achieved

University of Wisconsin Sea Grant College Program
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PREFACE

The University of Wisconsin Sea Grant Institute requires an annual report describing progress toward meeting project objectives for all projects funded through the UW Sea Grant College Program. Continuation of funding is dependent upon submission of a satisfactory progress report. Specifically, we request that investigators describe their progress toward meeting project objectives, significant interactions with resource managers and user groups, students supported and degrees granted, papers published, presentations and workshops held, patents/copyrights awarded or pending, and notable applications of project results. We also ask them to note any significant partnerships, funding or in-kind support to their projects from non-Sea Grant sources.

These progress reports are reviewed and evaluated by the appropriate subprogram science advisor(s) and UW Sea Grant Institute staff and kept on file at the institute. As is our policy, science advisors do not participate in any way in the evaluation of a project on which they serve as an investigator. Projects continuing from one biennium into the next are not subjected to external review unless the project is making insufficient progress toward its objectives or its focus has changed significantly from the original approved work plan. We require a detailed justification of any major shifts in project emphasis or significant budget changes. Continued funding for these projects also depends on sufficient funding of the overall Wisconsin Sea Grant program. Summaries of those reports are presented herein.

In addition to formal reports, project progress is also monitored and reported through periodic thematic area debriefings between project investigators and UW Sea Grant outreach and management staff. Outreach staff use the results presented at these meetings to develop or enhance their work plans. In addition, Communications staff regularly contact and meet with project investigators and students in connection with producing our bimonthly newsletter and other program reports, news releases, "Earthwatch" radio programs, Web sites and other means of communicating the progress and results of all UW Sea Grant research, outreach and education projects.

In-depth progress reports are also required each biennium for UW Sea Grant's ongoing core program projects in Advisory Services, Communications and Education, summaries of which are likewise included in this report. Detailed information on core program efforts in Advisory Services, Communications and Education subprograms is kept at the UW Sea Grant Institute's administrative offices at UW-Madison. In accordance with the program evaluation process outlined by the National Sea Grant Office (NSGO), these projects are subject to intense review every four years (next in connection with the NSGO Program Assessment Team visit in June 2001 and in connection with the 2002-04 omnibus proposal submission).

Lastly, a brief progress report is also required for completed or terminated projects, pending submission of a detailed project completion report within six months of the termination date of the project. Those reports also are included here.

The appendices to this report meet and surpass all of the required and suggested annual progress report content outlined in the NSGO's *Policy Document on the Implementation of Program Evaluation Procedures and Omnibus Proposal Submission in the National Sea Grant College Program, Section 4: Ongoing Program Assessment and Progress Reporting* (September 2000) to satisfy U.S. Department of Commerce Standard Terms and Conditions for Grants requirements.

PROJECT PROGRESS REPORT SUMMARIES

Research Program

Aquaculture & Seafood Technology Subprogram

Conversion of Fish Processing Waste and Underutilized Fish into Value-Added Protein Hydrogel (R/AQ-32)

Srinivasan Damodaran, Food Science, UW-Madison

A crude fish protein isolate (FPI) was prepared by extracting fish muscle with a dilute NaOH solution at pH 12. The extract was filtered through a 0.5 mm sieve to remove insoluble material. The filtrate was dialyzed against water using a 6000-8000 m.w. cut-off membrane to remove NaOH and lyophilized. To determine if the extraction procedure was drastic enough to unfold the fish proteins from an ordered state to a disordered state, its conformational characteristics were studied by circular dichroism spectroscopy. We found that the isolated protein contained 43% β -sheet, 15.5% α -helix, and the remainder aperiodic structure. Because a random coil-like structure is highly preferable for a hydrogel polymer, further investigations will be conducted to find extraction conditions that would completely denature fish proteins, particularly actin and myosin.

The FPI was chemically derivatized with ethylenediamine-tetraacetic dianhydride (EDTAD) to convert the protein into a polyanionic polymer. Preliminary experiments showed that about 76% of the lysine residues in FPI were modified to EDTA derivative when FPI was reacted with EDTAD at a EDTAD/protein (w/w) ratio of 0.4/1.0 at pH 12.0. The modified protein was dialyzed to remove salt and lyophilized. When the modified FPI was redissolved in water to a 15% solution, the solution spontaneously set into a gel. When the gel was cured over night and suspended in water, it did not dissolve into a solution. Instead, it swelled over a 24-hour period and took up to about 600 grams of water per gram of dry gel. The spontaneous gelation was found to be due to formation of a gel network via oxidation of endogenous sulfhydryl groups into disulfide linkages. The water uptake properties of this gel will be studied systematically.

Improvements in the method of making a protein-based hydrogel also have been made. Fish protein, extracted from fish muscle at pH 12.0, was modified with ethylenediamine tetraacetic dianhydride (EDTAD). The extent of modification of lysine residues was in the range of 70-80%. The modified protein was precipitated and pH 4.6 and recovered by centrifugation and lyophilized. A 10% solution of the lyophilized EDTAD-modified protein was reacted with glutaraldehyde at pH 9-10 to cross-link the protein. The gel was cured overnight. One portion of the cured gel was air dried at 35-40°C in an oven. Another portion of the cured gel treated with anhydrous ethanol for 3 hours, during which time water from the gel was extracted into the ethanol solvent. The dehydrated gel was then air-dried at room temperature. Examination of swelling properties of the fish protein hydrogel showed that ethanol treatment prior to drying of the gel markedly improved the rate and extent of water uptake compared to that of the control. For instance, an 80% modified sample treated with ethanol absorbed about 250 grams water per gram of dry gel within 5 hours, whereas the same gel without ethanol treatment absorbed only about 160 grams of water per gram of dry gel during the same time. Furthermore, whereas the ethanol-treated sample was odor free, the control sample had a strong fishy odor. The ethanol treatment has the following advantages:

- It dehydrates the gel and thereby eliminates the need, or drastically reduces the time needed, for drying. The ethanol can be recovered and reused in the process.
- It causes denaturation of proteins in the cross-linked gel and thereby improves the swelling properties of the gel.
- It extracts low molecular weight off-flavor compounds from the gel and thereby improves its acceptability.

A patent disclosure on the process was made to the Wisconsin Alumni Research Foundation.

In addition, the swelling properties of hydrogels made with mixtures of fish protein and soy protein were investigated. In this case, 61% modified soy protein and 80% modified fish protein were mixed at various weight ratios and a 10% protein solution of this mixture was cross-linked with glutaraldehyde. One portion of the cross-linked gel was dried in an oven at 40°C and the other portion was dehydrated using ethanol. The swelling properties of these samples in water were studied. Maximum rate and extent of swelling was observed at a soy protein to fish protein ratio of 1:1 in the gel. In absolute terms, the ethanol-treated gels exhibited higher rate and extent of swelling than the control gels at all soy protein-to-fish protein ratios. In contrast, interpenetrating mixed hydrogels prepared with binary combinations of fish protein (7.5% w/v) and carboxymethylcellulose (2.5% w/v), polyethylene glycol, guar gum or polyvinyl alcohol exhibited poor swelling properties compared to that of fish protein alone or that of fish protein + soy protein hydrogels.

Use of Fish Oil for the Production of Nutraceuticals Containing Omega-3 and Conjugated Linoleic Acid Residues (R/AQ-34)

Charles Hill, Chemical Engineering, UW-Madison

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 resulting modified 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.

We have been investigating 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. In the past year, we have focused on determination of the rate expressions for two of the (immobilized) enzyme-catalyzed reactions involved in the biotechnology to be employed in the process proposed for production of the indicated nutraceutical.

Work on the acidolysis of menhaden oil with CLA in a packed bed reactor is continuing to elucidate further the kinetics of this reaction and to characterize further the properties of the structured oils resulting from the enzyme-mediated acidolysis reaction. Response surface methodology is also being employed to optimize the reaction conditions.

Publications and Presentations

Manuscripts based on the experimental work of Prima Sehanputri on the kinetics of hydrolysis of corn oil have been published in *Biotechnology and Bioengineering* (64:568-579 [1999] and 69:450-456 [2000]). Another manuscript by H.S. Garcia, J.A. Arcos, D.J. Ward, and C.G. Hill, Jr., on the solvent-free acidolysis of menhaden oil with conjugated linoleic acid has been accepted for publication in *Biotechnology and Bioengineering*. A paper entitled "Synthesis of Acylglycerols Containing Both ω -3 Fatty Acids and Conjugated Linoleic Acid Residues: Enzyme Mediated Acidolysis of Fish Oils and Polyesterification of Glycerol," by H.S. Garcia, J.A. Arcos, C. Torres, and C.G. Hill, Jr., was presented at the June 2000 meeting of the Institute of Food Technologists.

Stress and Salmonid Fish: Role of Cortisol-Metabolizing Enzymes (R/AQ-35)

Terence Barry and Jeffrey Malison, Food Science, UW-Madison

We have measured 11-HSD activity in various tissues of rainbow trout including thymus, adipose tissue, gill, gonads, liver and kidney. Activity levels were lower than expected in all tissues; therefore, efforts were made to optimize the culture conditions. Experiments were conducted to evaluate the effects of various culture parameters (time, enzyme concentration, pH, and temperature) on 11-HSD activity in the liver (a primary source of 11-HSD activity in mammals). We determined that the optimal culture conditions were 15°C, pH = 7.5, and, most importantly, at least 5 mg (dry weight) of tissue per milliliter of culture medium. We consistently measured 11-HSD activity in the rainbow trout liver, a finding that contradicts published reports. Relative to the 11-HSD activity found in mammals, the 11-HSD activity in rainbow trout is very low (less than

5% conversion of cortisol to cortisone in 24 hrs.). Our studies have shifted to the kidney. Using our improved culture system, we recently obtained evidence that the kidney may be a primary source of 11-HSD activity in rainbow trout. Studies are now underway to characterize further this enzyme activity.

Students Supported

Two undergraduate students, Nicole Topp and Yuliana, have been conducting research on aspects of this project since August 2000.

Production of Stress-Resistant, Domesticated Yellow Perch for Commercial Aquaculture (R/AQ-36)

Jeffrey Malison, Food Science, UW-Madison

In the first seven months of this project, two experiments have been completed to document the ontogeny of the cortisol stress response in larval/juvenile yellow perch. In the first study we measured the concentration of cortisol in perch embryos at two-day intervals from fertilization to hatch. We found that cortisol concentrations declined steadily during this period. In the second study, we conducted histological evaluations and measured resting and post-stress cortisol concentrations in yellow perch fingerlings at weekly intervals beginning at hatch. We could not identify interrenal cells in newly-hatched perch fingerlings, and these fish did not respond to a stressor with an increase in cortisol concentration. In contrast, we did identify interrenal cells in yellow perch fingerlings one to two weeks old (~12 mm total length), and these fish responded to a stressor with a significant increase in cortisol level. These data show that the hypothalamic-pituitary-interrenal axis becomes functional in perch within the first two weeks after hatch. This time period is coincident with the onset of first exogenous feeding in perch, suggesting a functional linkage between these two physiological events.

Students Supported

This project provided an opportunity for Sissel Jentoft, a Ph.D. student at the Agricultural University of Norway, to study yellow perch physiology in our laboratory for a period of six months. Jentoft's travel was sponsored by a grant from the Norwegian government.

Biotechnology Subprogram

Developmental Toxicity of Dioxin in Zebrafish (R/BT-12)

Richard Peterson and Warren Heideman, School of Pharmacy, UW-Madison

The goal of this project is to gain an understanding of the molecular mechanisms by which agonists for the aryl hydrocarbon receptor (AhR) such as 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) cause early life stage toxicity in fish. Recognizing their utility as a vertebrate developmental model, we have established zebrafish (*Danio rerio*) as a model for studying AhR-mediated toxicity in early life stage fish. To apply the results obtained with zebrafish more widely, we have also been working with lake trout. During the first eight months we have:

- Used a zebrafish liver cell line to establish relative potencies (REPs) of polychlorinated dibenzo-*p*-dioxin, dibenzofuran, and biphenyl congeners for inducing CYP1A mRNA. The zebrafish liver cell line-derived REPs are similar to other *in vitro* REPs in that they are higher than those derived from *in vivo* models, and if used in ecological risk assessment they would over-estimate relative *in vivo* toxicity in fish. This work has been accepted for publication in *Environmental Toxicology and Chemistry* in 2000.
- Characterized a clone encoding a second zebrafish AhR (zfAhR1). A manuscript describing the sequence of this clone, as well as the transactivation, protein interaction, DNA binding and ligand binding properties of the encoded protein is being prepared for submission.

- Isolated three ARNT cDNAs from zebrafish encoding three different ARNT2 proteins. These cDNAs appear to arise by alternative splicing and encode ARNT proteins with striking differences in transactivation properties. This work has been accepted for publication in *Biochimica Biophysica Acta* in 2000.
- Identified a “developmental window” of time during which zebrafish are most sensitive to TCDD. This time extends from approximately 4 days post-fertilization to about day 10.
- Used transgenic zebrafish to investigate potential effects of TCDD on blood vessel development and maintenance. Transgenic zebrafish embryos expressing green fluorescent protein (GFP) under control of the mouse Tie2 promoter in vascular endothelial cells allowed us to visualize blood vessels in living embryos exposed to TCDD throughout development. We found that the vasculature was maintained in the zebrafish embryo when classic signs of TCDD developmental toxicity were fully manifested.
- Found in lake trout early life stages that TCDD-induced blue sac syndrome was not associated with morphologic lesions of the vascular endothelium, which is consistent with the lack of effect of TCDD on vascular endothelial development and maintenance during zebrafish development. Rather, there is an increase in vascular permeability associated with pericardial and yolk sac edema with the edema fluid being an ultrafiltrate of blood. This work was published in *Toxicology and Applied Pharmacology* in 2000.
- Tentatively identified anemia as a novel endpoint of TCDD developmental toxicity in zebrafish embryos of which we were previously unaware. Currently, we are determining if the anemia is due to a TCDD-induced block in differentiation to the adult form of the erythrocyte.
- Tested the hypothesis that TCDD binding to AhR in zebrafish produces dimerization between AhR and ARNT to such an extent that ARNT is not available for transcription of hypoxia-regulated genes controlled by the Hif1 α /ARNT heterodimer. While hypoxia appears to inhibit AhR/ARNT signaling, we find no evidence that TCDD inhibits the normal response to hypoxia.

Determining the Roles of Multiple Forms of AhR and ARNT in Dioxin Toxicity in Rainbow Trout (R/BT-14)

Warren Heideman and Richard Peterson, School of Pharmacy, UW-Madison

This project addresses two important gaps in our understanding of the AhR signaling pathway in rainbow trout. First, we do not know the functional significance of multiple AhRs and ARNTs in trout and other fish species. That is, we do not know how these different proteins interact, and we do not know the functional properties of the multiple possible combinations of AhR and ARNT proteins. Second, while rtAhR2 α and rtAhR2 β may regulate distinct sets of genes, we do not know their identity or role in producing early life stage toxicity in response to TCDD and related compounds. The overall goal of this research is to determine the functional significance of multiple forms of AhR and ARNT in rainbow trout and to identify important target genes for these two receptors and their respective roles in producing certain signs of TCDD early life stage toxicity in fish. In our first eight months of work, we have:

- Used *in vitro* transactivation assays to measure the activity of rtAhR2 α and rtAhR2 β at cyp1a enhancer regions. While rtAhR2 β can be shown to bind to these DNA sequences, it is almost completely inactive with these reporters. Surprisingly, rtAhR2 β does not appear to compete with rtAhR2 α in these transactivation assays.
- Identified a single residue at position 111 (lysine in rtAhR2 β and glutamate in rtAhR2 α) that is responsible for virtually all of the differences in activity between rtAhR2 α and rtAhR2 β . We have confirmed in a number of individual trout isolated from geographically and genetically distinct backgrounds that both forms of the rainbow trout AhR are present in all individuals and that the difference in amino acid sequence at position 111 is conserved. A manuscript describing this work is being prepared for publication.
- Constructed yeast expression systems for using a one-hybrid screen to identify trout genomic DNA sequences that interact with the two AhR isoforms.

Estuarine & Coastal Processes Subprogram

Net Heterotrophy/Autotrophy in Coastal and Offshore Lake Michigan (R/EC-6)

Russell Cuhel, J. Val Klump and Carmen Aguilar, Great Lakes WATER Institute, UW-Milwaukee

In conjunction with the NSF-NOAA Episodic Events-Great Lakes Experiment (EEGLE) program and the NOAA-EPA-NASA Coastal Intensive Site Network, coverage of coastal productivity processes was greatly enhanced during 2000. Especially important was a series of daily cruises (10 days on, 10 days off) during the early spring warming period in which small-scale temporal and spatial variability for primary and heterotrophic productivity was assessed.

During these cruises, two storm events left clear signatures on coastal processes. Particularly significant was repeated observation of harbor water influence on reef stations (perch spawning grounds) south of Milwaukee Harbor contrasting with similar stations just north of the harbor. Storm-driven circulation and nutrient injection patterns clearly influence productivity and phosphorus status of plankton in the coastal zone. Implications for the functionality of the Milwaukee Deep Tunnel Project and the fate of combined sewer overflows are apparent.

Presentations

This work is being presented at the 2001 American Society of Limnology and Oceanography annual meeting in Albuquerque, N.M., in February (Cuhel, Aguilar, Klump, and Waples: "High-Frequency Sampling of Productivity Parameters along a Coastal Depth Gradient during Early Spring Bloom Conditions in Lake Michigan"). A presentation was made to the UW-Milwaukee Biological Sciences Colloquium during late spring 2000: "Influences of the 1998 El Niño in Lake Michigan." Also, a UW Sea Grant Web site references educational activities associated with this research in cooperation with a NOAA-NURP 99NA&GL Aquanaut Program in the Great Lakes Project (www.seagrants.wisc.edu/madisonjason11/lake_michigan_research.html).

Material Transformations through a Series of Linked basins in a Great Lakes Land Margin Ecosystem (R/EC-7)

J. Val Klump and James Waples, Great Lakes WATER Institute, UW-Milwaukee

Our initial surveys of the Fox/Wolf River basin – from the headwaters of the upper Fox to the mouth of the Fox River at Green Bay – have been completed. An initial suite of samples characterizing the changes in water and material properties downstream has been collected (including stable isotope composition and U-238/U-234 ratios, as well as standard water quality measurements). Like other highly developed land margin systems, this watershed has been modified historically by the construction of a series of impoundments. We have begun to assess the impact of these impoundments on material fluxes in this system through the collection of a large number of cores in each impoundment for the determination of mass sedimentation and material accumulation rates.

To date, we have focused on coring in the upper Fox River (Park, Swan and Buffalo lakes are completed), and that activity is ongoing. We have established a contact in the Wisconsin DNR for accessing data in the state dam and impoundment GIS inventory. This database contains information on age and physical characteristics of more than 3,500 impoundments in Wisconsin.

We are supporting a student interested in GIS database management and modeling. Both of the principle investigators are members of the recently formed Strategic Data Acquisition Taskforce for the Fox/Wolf basin. This task force, made up of resource managers, scientists and representatives of local stakeholders, is developing guidelines for a basin-wide monitoring program and for the establishment of a Total Maximum Daily Load (TMDL) program for the Lower Fox River. Most of the major objectives in this project should be very pertinent to the TMDL and Fox/Wolf/Green Bay monitoring efforts, one example being the development of data and models of hydraulic retention, residence time and apparent river water "aging."

Living Resources Subprogram

Early Life History of Yellow Perch (R/LR-74-PD)

Fred Binkowski, Great Lakes WATER Institute, UW-Milwaukee

Most of the fieldwork on this project was completed as of August 1997. In 1999, we organized a public conference, held in Racine, Wis., and hosted by the S.C. Johnson Wax Fund, called "The Decline of Yellow Perch in Lake Michigan" at which results from this project and related yellow perch research funded by the Michigan and Illinois-Indiana Sea Grant programs were presented. Work since then has entailed caring for the captive Lake Michigan perch broodstock acquired for the project, which are now nearing sexual maturity. We will continue to nurture this stock through spring 2001, when we hope to induce spawning.

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

Fred Binkowski, Great Lakes WATER Institute, UW-Milwaukee

For a third season, the distributions of size, growth, condition and relative mortality of young-of-year yellow perch were tracked in southern Lake Michigan. Gill net surveys conducted off Milwaukee monitored perch spawning activity in 1998, 1999 and 2000. Egg basket observations from 17–24 June 2000 indicated an 18- to 20-day incubation period. The incubation period for this year was similar to, but less protracted than, that observed during the 1999 season.

Larval yellow perch continue to be scarce in the Wisconsin waters of Lake Michigan. This is consistent with multistate sampling results from around southern Lake Michigan. For year 2000 sampling, larval surveys were extended beyond the nearshore Green Can Reef sites to four sites 5-25 miles offshore in a southeasterly direction from the Milwaukee harbor. No larval yellow perch were collected at these offshore sites in 2000. The decline in catches of perch greater than 8 mm in total length suggests that larval perch most likely leave the nearshore surface waters shortly after they initiate feeding.

Through laboratory experiments, we have continued to quantify the causes and consequences of variability in larval perch condition and the effects of size and condition on predation vulnerability. In trials during 2000, periods of intermittent starvation were tested for the effect on newly hatched perch larvae. Preliminary results suggest that only the newly hatched larvae with yolk reserves were able to survive a starvation period of eight days. Initial trials examining the influence of rearing temperatures on DNA/RNA ratio as a measure of condition were conducted. Analysis of the results of these trials should be completed this winter.

Laboratory trials in both 1999 and 2000 examining the influence of condition on vulnerability to alewife and yearling yellow perch predators have been completed. Results of trials with 15- and 30-day-old perch as prey resulted in adequate feeding activity for both predators. Trials conducted with 0- to 5-day-old perch as prey resulted in no feeding activity for either predator species. To quantify diet selectivity in larval yellow perch as a function of larval size, an initial trial was conducted using zooplankton prey; samples from this trial are currently being analyzed. Subsequent diet selection trials will further examine alternative prey and possible differences between inshore and offshore plankton assemblages.

Application of Microsatellite and Mhc Markers to Stock Identification in Lake Superior Lake Trout (R/LR-76)

Ruth Phillips, Biological Sciences, UW-Milwaukee

We have successfully used microsatellite and Mhc markers to assess the stock structure of lake trout in Lake Superior. Our results indicate that the lean and siscowet morphotypes are reproductively isolated and that lake trout in Lake Superior are divided into separate assemblages or stocks that should be managed separately. Two papers have been submitted on this work, and one has been accepted pending submission of an acceptable revision. Presentations on the research were made at the Coastwide Salmonid Genetics Meeting in Missoula, Mont., in June and at UW Sea Grant's Lake Superior Thematic Area Workshop in Superior, Wis., in

September. A workshop on *Salvelinus* genetics – attended by principal investigators from the major trout genetics laboratories in Wisconsin, Michigan and Ontario – was held October 1-2, 1999, at UW-Milwaukee. Recommendations of the workshop included standardization of microsatellite loci for *Salvelinus* species, that funding be sought for mapping projects for *Salvelinus* species including production of crosses to examine quantitative trait loci (QTLs) for important traits, and that Canadian and U.S. scientists coordinate lake trout population genetics studies, including those using historical samples. Finally, it was proposed that the participants form a Great Lakes and East Coast Salmonid Genetics Group similar to the successful Coastwide Salmonid Genetics Group, which has been very important in fostering communication between U.S. and Canadian fisheries scientists on the West Coast. Tentatively, this group will hold meetings every two years, with the next meeting to be held in Michigan in 2001.

Causes and Impediments of Lake Trout Recovery in Lake Superior (RLR-77)

Michael Hansen, College of Natural Resources, UW-Stevens Point

After 35 years of intensive restoration efforts, fishery managers decided to cease stocking of lake trout in Lake Superior in 1996. Although restoration appeared to be a success, lake trout stocks must be monitored and regulated to avoid the possibility of another stock collapse. Wild lake trout density generally increased, whereas density of stocked lake trout generally decreased, during 1970-98 in all Michigan management areas of Lake Superior. Our modeling efforts indicate that recruitment of age-7 wild lake trout during 1978-98 was best described by density of age-8-and-older wild and stocked parents during 1970-90, with stocked parents represented as a constant fraction of wild parents. Recruitment rates were significantly greater for wild lake trout than stocked lake trout, and they changed with density of both wild and stocked parents. Recruitment rates of wild and stocked parents declined significantly with density in all Michigan management units, though density dependence of stocked lake trout recruitment was only half that of wild parents in all areas. Large-mesh gill-net fishing effort did not explain significant variation in recruitment, beyond that which was explained by wild and stocked parents. The results of this study will enable management agencies to develop strategies that will promote lake trout recovery.

Five students supported:

- Jessica M. Doemel, M.S. student. Primary funding support: UW Sea Grant. Degree in progress. Began employment with the U.S. Fish & Wildlife Service (off Sea Grant funding) May 31, 2000. Graduation expected December 2000.
- Brian Linton. M.S. student. Primary funding support: UW Sea Grant. Degree in progress. Began June 1, 2000.
- Michael Wilberg, M.S. student. Primary funding support: Great Lakes Fishery Commission. Degree awarded August 2000. Thesis title: "Historic and modern lake trout abundance, effects of fishing on lake trout, and dynamics of the commercial lake trout fishery in Michigan waters of Lake Superior."
- Jennifer Devine, M.S. student. Primary funding support: Great Lakes Fishery Commission. Began Sept. 1, 2000.
- Kevin Kapuscinski, M.S. student. Primary funding support: U.S. Fish & Wildlife Service. Began Jan. 1, 2000.

Six presentations at scientific meetings:

- Jessica M. Doemel, Michael J. Hansen, and Charles R. Bronte. *Modeling lake trout recruitment in Lake Superior*. 130th Annual Meeting of the American Fisheries Society, St. Louis, Mo., Aug. 20-24, 2000.
- Michael Wilberg, Michael J. Hansen, and Charles R. Bronte. *Spatial dynamics of the Lake Superior commercial lake trout fishery, 1929-1961*. 130th Annual Meeting of the American Fisheries Society, St. Louis, Mo., Aug. 20-24, 2000.
- Jessica M. Doemel, Michael J. Hansen, and Charles R. Bronte. *Modeling Lake Trout Recruitment in Lake Superior*. 29th Annual Meeting of the Wisconsin Chapter of the American Fisheries Society, Manitowoc, Wis., Jan. 4-6, 2000.
- Michael Wilberg, Michael J. Hansen, and Charles R. Bronte. *Overfishing and Lake Trout Collapse in Michigan Waters of Lake Superior*. 29th Annual Meeting of the Wisconsin Chapter of the American Fisheries Society, Manitowoc, Wis., Jan. 4-6, 2000.

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- Jessica M. Doemel, Michael J. Hansen, and Charles R. Bronte. *Causes and Impediments of Lake Trout Recovery in Lake Superior*. 61st Midwest Fish & Wildlife Conference, Chicago, Ill., Dec. 5-8, 1999.
- Michael Wilberg, Michael J. Hansen, and Charles R. Bronte. *Status of Lake Trout Restoration in Lake Superior*. 61st Midwest Fish & Wildlife Conference, Chicago, Ill., Dec. 5-8, 1999.

Three presentations at Lake Superior Technical Committee meetings:

- Jessica M. Doemel, Michael J. Hansen, and Charles R. Bronte. *Lake Trout Stock-Recruit Analysis*. Annual Summer Meeting of the Lake Superior Technical Committee, Brimley, Mich., Aug. 1-2, 2000.
- Michael Wilberg, Michael J. Hansen, and Charles R. Bronte. *Analysis of the Historic Lake Trout Fishery*. Annual Summer Meeting of the Lake Superior Technical Committee, Brimley, Mich., Aug. 1-2, 2000.
- Michael Wilberg, Michael J. Hansen, and Charles R. Bronte. *Historic lean and siscowet abundance in Michigan waters of Lake Superior*. Annual Winter Meeting of the Lake Superior Technical Committee, Ashland, Wis., Jan. 11-12, 2000.

Fisheries and Food Web Dynamics in Lake Superior (R/LR-78)

James Kitchell, Center for Limnology, UW-Madison

Originally scheduled to terminate Feb. 29, 2000, this project received a one-year no-cost extension to accommodate the hiring of a suitable post-doctoral appointee to contribute to satisfying project research goals and enhancing project accomplishments. An especially qualified appointee, Dr. Tom Hrabik, was hired, and he is now addressing the project goal of evaluating how the Lake Superior fish community will change in response to reductions in exotic species of fish, like the rainbow smelt, caused by management processes and food web interactions.

Dynamics of the Lake Superior Food Web (R/LR-82)

James Kitchell, Center for Limnology, UW-Madison

Launched March 1, this project continues the work begun in the preceding project (R/LR-78). Our work on Lake Superior food web dynamics has involved two general kinds of effort. One aspect of the research has focused on empirical studies of predator-prey interaction based on stable isotope concentrations in the tissues of components of the food web. That work forms the major portion of ongoing Ph.D. work by graduate student Chris Harvey. The first published result of that work recently appeared in the *Canadian Journal of Fisheries and Aquatic Sciences* (Harvey and Kitchell 2000).

The other major general effort involved collaboration with personnel from many of the agencies involved in fisheries management, coordinated through participation on the Lake Superior Technical Committee. This effort included research planning, participation in research cruises, and conducting a series of modeling workshops involving both UW personnel and representatives of concerned state and federal agencies. One result of that effort was a whole ecosystem model using the Ecopath/Ecosim approach, currently in press (Kitchell et al. 2000, *Ecosystems*), including as co-authors all 12 of the agency and academic personnel involved in the work. This program continues in related ventures under current sponsorship by UW Sea Grant and our agency collaborators.

Molecular Genetic Analysis of Lake Trout in Lake Superior and Richard's Reef, Lake Michigan (R/LR-83)

Ruth Phillips, Biological Sciences, UW-Milwaukee

This study will examine lake trout populations of different morphotypes spawning in different habitats to determine if genetic markers that might correlate with survival in different habitats can be identified. Previous work (*see project R/LR-76*) has shown that lean and siscowet morphotypes are genetically distinct. A third major morphotype, the "humpers," are found on shallow reefs (humps) surrounded by deep water. Because northern Lake Michigan contains numerous offshore reefs, humpers are being considered for introduction into Lake Michigan. Our analysis of allele frequencies at microsatellite loci in humpers suggests that they are genetically distinct. Currently, we are examining another marker, the Mhc locus, which is important in immune

function to determine if humpers have unique alleles at this locus. The study will also examine the genetic diversity of lake trout hatchery stocks currently used in Lake Michigan and lake trout currently spawning on Richard's Reef in northern Lake Michigan to determine if they have significant siscowet or "humper" parentage and whether certain genotypes survive better than others. This project is being done in collaboration with the U.S. Geological Survey laboratory at Ann Arbor Michigan. Arrangements have been made to collect the fish from Lake Michigan in November 2000.

Stock Discrimination of Rainbow Smelt in Western Lake Michigan (R/LR-85)

Diane Caporale and Christopher Harleb, Biology, UW-Stevens Point

Collection of spawning rainbow smelt from tributaries of western Lake Michigan was coordinated with fisheries managers in the Wisconsin Department of Natural Resources (DNR) at Milwaukee and Sturgeon Bay, Wis. Fisheries managers at the Michigan DNR Escanaba facility also assisted with the collection of spawning rainbow smelt from northern Lake Michigan and Lake Superior. Commercial fisherman from Two Rivers, Wis., contributed to the collection of rainbow smelt both during spring spawning and pooled populations of adults in the fall. Managers from the U.S. Fish & Wildlife Service are currently assisting in the collection of adult rainbow smelt from both the eastern and western offshore waters of Lake Michigan. So far, a total of 80 rainbow smelt have been collected. Their DNA has been isolated from both liver and muscle tissue. DNA concentrations were determined and averaged 20 ng/μl. Twenty samples were screened for possible genetic variation, using 10 different primers for the RAPD (random amplified polymorphic DNA) fingerprinting process.

Two different primers were informative in that they generated amplified DNA fragments. One of the primers (primer Z17, Operon Technologies) generated a multiple banding pattern when viewed on a horizontal agarose gel containing ethidium bromide. RAPD reactions were repeated using adjusted DNA amounts to produce uniform band intensities among the samples. The RAPD reaction using primer Z17 was repeated and samples were electrophoresed in a 6% polyacrylamide vertical gel and viewed under ultraviolet light using CYBRgold for better resolution. So far, we found four distinct DNA fingerprints among rainbow smelt collected near Two Rivers. Using the RAPD technique, we were able to discover genetic variation among rainbow smelt in Lake Michigan. We are continuing to screen all of the fish using our established protocol to determine the frequencies of those genotypes and to discover possibly more genetic variation among the rainbow smelt of Lake Michigan.

Preliminary Survey of Zebra Mussel Population Abundance and Distribution at Selected Sites in Green Bay (R/LR-86-PD)

Tara Reed-Anderson, Natural & Applied Sciences, UW-Green Bay

Zebra mussels were collected from 10 nearshore sites around mid- and lower Green Bay. We are currently processing these samples and expect to have zebra mussel density estimates at these sites by the end of the year. Benthic macroinvertebrates were also collected at these sites, which we are currently sorting, identifying and counting.

In collaboration with Dr. Bart DeStasio of Lawrence University, five historic sampling sites in lower and mid-Green Bay were visited four times during the summer of 2000. At these sites, limnological parameters such as temperature, dissolved oxygen, nutrients, pH, conductivity, chlorophyll *a*, light penetration and light extinction, as well as zooplankton abundance and diversity, were sampled. Initial analyses of these data indicate that the trophic gradient described by Sager and Richman in the 1980s is still evident. These initial data also indicate that there has been little or no apparent change in these parameters since zebra mussel introduction in the early 1990s.

We are also developing a collaborative relationship with Dave Rades of Integrated Paper Services (IPS), who has more than 30 years of experience sampling benthic macroinvertebrates in Green Bay. We are currently comparing the macroinvertebrates from our zebra mussel samples with his data, collected prior to zebra mussel invasion. Of note is that we are finding *Caenis* mayflies, a relatively pollution-tolerant species that has not been seen in IPS benthic samples since the 1970s

Students Supported

Students receiving some support from this project include two graduate students (Amy Fettes and Russell Japuntich) and five undergraduate student hourly workers. Amy Fettes is using the zebra mussel data collected during this project as the basis for her Master's thesis. One of the undergraduates, Sarah Wielgus, is using the other benthic invertebrates collected to develop a senior honors thesis.

Microcontaminants & Water Quality Subprogram

Impact of Contaminants on Sexual Development and Reproduction of Amphibians in Great Lakes Ecosystems (R/MW-76)

William Karasov, Wildlife Ecology, UW-Madison

To determine the sensitivity of leopard frog sexual development to putative endocrine disruptors, we exposed eggs and tadpoles from clutches to several doses of PCBs (congeners 54, 70 and 101 alone, not in combination) and to 17 β -estradiol (a positive control). Histological analysis of gonads indicated that 17 β -estradiol, but none of the PCBs, significantly shifted the sex ratio towards females, and exposure to PCB 70 may have increased the prevalence of "intersex" gonads (preliminary analysis). Intersex gonads were not observed in frogs raised in outdoor field enclosures at relatively contaminated or reference sites in the Green Bay ecosystem, though there was evidence for a male-biased sex ratio at the former site.

Blocking UV-B radiation had no significant effect on hatchability of eggs in the field enclosures. Induction of vitellogenin was not apparent in males raised in field enclosures. Fertilized eggs were collected at relatively contaminated sites and reference sites and raised to metamorphosis. Embryos from the former site exhibited a trend for lower hatchability ($P = 0.07$) and lower survivorship ($P = 0.021$), and among metamorphs there was no significant difference in sex ratio among the sites. However, the lower survivorship of hatchlings from the more contaminated site is consistent with the hypothesis that chronic exposure of wild females to contaminants results in eggs with lower viability.

To test this experimentally, we are developing a model system in the laboratory to study whether leopard frogs chronically exposed to contaminants produce normal progeny. Frogs collected in the fall were held at low temperature over winter. Following arousal in spring, frogs were given small intraperitoneal dosages of gonadotropic releasing hormone and pairs went into amplexus and females laid eggs. Males failed to fertilize them, and so in our final experiment with frogs exposed chronically to PCBs, males will be stripped of their sperm, embryos produced via artificial fertilization, and tadpoles will be raised until metamorphosis to test for effects on hatchability, survivorship, behavior, and sexual development.

Graduate students supported:

- Michele Rosenshield, M.S. granted in 1999
- John Allran, M.S. granted in 1999 (closely related project)
- Lisa Koch, M.S., current (presently the Great Lakes Commission-Sea Grant Fellow)
- Tara Edblom, M.S., current

Visiting graduate student supervised:

- Mariana Jofré, University of San Luis, Argentina

Post-doctoral scholar supported:

- Dr. Kate LeVering, September-December 1999

Undergraduate researcher supervised:

- Sarah Pabian

Resulting publications to date:

- Huang, Y.W., M.J. Melancon, R.E. Jung, and W.H. Karasov (1998) Induction of cytochrome P450-associated mono-oxygenases in northern leopard frogs, *Rana pipiens*, by 3,3',4,4',5-pentachlorobiphenyl (PCB 126). *Environmental Toxicology and Chemistry* 17:1564-1569.
- Jofre, M.B. and W.H. Karasov (1999) The direct effect of ammonia on three species of North American anuran amphibians. *Environmental Toxicology and Chemistry* 18:1806-1812.
- Huang, Y.W., W.H. Karasov, K.P. Patnode, and C.R. Jefcoate (1999) Exposure of northern leopard frogs in the Green Bay ecosystem to polychlorinated biphenyls, polychlorinated dibenzo-*p*-dioxins, and polychlorinated dibenzofurans is measured by direct chemistry but not hepatic ethoxyresorufin-*O*-deethylase activity. *Environmental Toxicology and Chemistry* 18:2123-2130.
- Rosenshield, M.L., M.B. Jofre, and W.H. Karasov (1999). Effects of PCB 126 on green frog (*Rana clamitans*) and leopard frog (*Rana pipiens*) hatching success, development and metamorphosis. *Environmental Toxicology and Chemistry* 18:2478-2486.
- Huang, Y.W. and W.H. Karasov (2000) Oral bioavailability and toxicokinetics of 3,3',4,4',5-pentachlorobiphenyl in northern leopard frogs, *Rana pipiens*. *Environmental Toxicology and Chemistry* 19(7):1788-1794.
- Huang, Y. W., J. J. Stegeman, B. R. Woodin, and W. H. Karasov (2000) Immunohistochemical localization of cytochrome P450-associated mono-oxygenases induced by 3,3',4,4',5-pentachlorobiphenyl in multiple organs of northern leopard frog, *Rana pipiens*. *Environmental Toxicology and Chemistry* (in press).
- Jofré, M.G., M.L. Rosenshield, and W.H. Karasov (2000) Effects of PCB 126 and ammonia, alone and in combination, on green frog (*Rana clamitans*) and leopard frog (*R. pipiens*) hatching success, development, and metamorphosis. *Jour. Iowa Acad. Sci.* 107(3) (in press).
- Allran, J.W. and W.H. Karasov (2000) Effects of atrazine and nitrate on northern leopard frog (*Rana pipiens*) larvae exposed in the laboratory from post-hatch through metamorphosis. *Environmental Toxicology and Chemistry* (in press).
- Allran, J.W. and W.H. Karasov (2001) Effects of atrazine on embryos, larvae, and adults of anuran amphibians. *Environmental Toxicology and Chemistry* (in press).

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

David Armstrong and Jon Manchester, Water Chemistry Program, UW-Madison
David Edgington, Great Lakes WATER Institute, UW-Milwaukee

We are investigating changes in PCB levels in Green Bay sediments by comparing levels in sediments accumulated over the past decade with levels found previously at the same sites. Our sampling focused on major sites of sediment accumulation in southern Green Bay. Sediment cores were obtained at nine sites and sectioned at one centimeter intervals for subsequent analysis. The sediments are analyzed for PCB congeners and also for the radionuclides ¹³⁷Cs and ²¹⁰Pb. The isotopes are used to model the influences of sedimentation rate, mixing, and horizontal transport on PCB profiles. The data will be used to assess the changes in PCB accumulation over the past decade and the input to the bay from the Fox River. Work on completing the analyses and data interpretation is continuing.

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

Marc Anderson, Water Chemistry Program, UW-Madison

The overall goal of this project was to investigate the use of two advanced oxidation technologies, subcritical water extraction/oxidation (wet air oxidation) and photocatalytic oxidation, in series for the remediation of sediments contaminated with PCBs. The two primary objectives of this project were to (1) investigate the use of subcritical water for the extraction and oxidation of PCBs adsorbed on sediments and (2) investigate the use of nanoparticulate titanium dioxide catalysts supported on silica particles for the photooxidation of organic contaminants in water. Experimental work towards meeting these objectives has been completed and preparation of final manuscripts is in progress.

The addition of hydrogen peroxide during wet air oxidation of PCBs adsorbed on sediments proved to be an extremely effective method of treatment. Fairly simple modifications of commercially available wet air oxidation systems would allow for the treatment of dredged sediments with minimal initial processing of the sediment. Further research directed toward determining the mechanisms, rate-limiting steps, and optimal conditions for this method of treatment is being pursued. Moreover, photocatalytic oxidation proved to be highly effective for the treatment of aqueous waste streams containing products of the wet air oxidation treatment process.

Students Supported

Several students were supported by this project. James Duffy has completed his Ph.D. in Water Chemistry at UW-Madison and is currently an Assistant Professor of Chemical Engineering at Montana State University. Dr. Duffy continued to assist with the completion of the project at Montana State University and while as a visiting scholar at UW-Madison during the summer of 2000. Michael Hardiman, supported on this project during the summer of 1999 as a visiting student at UW-Madison, is currently completing his Master's degree in Chemical Engineering at Montana State University.

The results of this project are discussed in the following thesis and journal articles:

- Duffy, J.E., 1999. "Remediation of Sediments and Waters Contaminated with Polychlorinated Biphenyls using Wet Peroxide Oxidation and Photocatalytic Oxidation." Ph.D. Thesis, University of Wisconsin-Madison.
- Duffy, J.E.; Anderson, M.A.; Hill, C.G., and Zeltner, W.A., 2000. Wet Peroxide Oxidation of Sediments Contaminated with PCBs. *Environ. Sci. & Technol.* 34:3199-3204.
- Duffy, J.E.; Anderson, M.A.; Hill, C.G., and Zeltner, W.A., 2000. Photocatalytic Oxidation as a Secondary Treatment Method Following Wet Air Oxidation. *Ind. & Eng. Chem. Res.* 39:3698-3706.
- Duffy, J.E.; Anderson, M.A.; Hill, C.G., and Zeltner, W.A. (MS). Wet Air Oxidation of Sediments Contaminated with PCBs. Submitted to *Ind. & Eng. Chem. Res.*

The following thesis and journal article are currently being written:

- Hardiman, M. "Photocatalytic Oxidation using Nanoparticulate Titanium Dioxide Supported on Silica Gel." Master's Thesis, Montana State University.
- Duffy, J.E.; Hardiman, M.; Anderson, M.A., and Zeltner, W.A. Photocatalytic Oxidation using Nanoparticulate Titanium Dioxide Supported on Silica Gel.

The results of this project have been presented at the following conferences:

- Marc A. Anderson, Photocatalytic Oxidation as a Secondary Treatment Method Following Wet Air Oxidation, *The Fourth International Conference on TiO₂ Photocatalytic Purification and Treatment of Water and Air*, May 23-28, 1999.
- James E. Duffy, Wet Peroxide Oxidation of Sediments Contaminated with PCBs, *The Sixth International Conference on Advanced Oxidation Technologies For Water and Air Remediation*, June 26-30, 2000.
- James E. Duffy, Enhanced Wet Air Oxidation of Sediments Contaminated with PCBs, *17th Annual Montana Water Conference*, October 5-6, 2000.

Speciation and Bioavailability of Metals in the Great Lakes Ecosystem (R/MW-80)

David Armstrong, Water Chemistry Program, UW-Madison

We are investigating speciation and bioavailability of trace metals in Great Lakes tributaries. One aspect of our work is determining the strength of binding of metals to the natural ligands that sequester metals and reduce their bioavailability to aquatic organisms. In determining the stability of natural metal-ligand complexes, we are providing key data from which we can build models relating chemical speciation to bioavailability.

Our early work has emphasized the use of adsorptive cathodic stripping and anodic stripping voltammetry to characterize the association of copper and zinc to strong and weak ligands, respectively. We plan to extend this approach to lead and to use complementary approaches such as kinetic-based separations on a metal-binding resin (Chelex) to explore similar associations for other metals. To provide information on the nature of these

metal-binding ligands, we are fractionating the ligands using ultrafiltration (3 kD, 10 kD, and 100 kD), high-performance liquid chromatography, and other methods.

Concurrently with the work on chemical measurements of metal availability, we are conducting laboratory experiments on direct metal uptake by phytoplankton and biochemical responses to metal exposures. We are optimizing a technique to determine cytoplasm levels of phytochelatin, a small group of proteins expressed by the organism in response to metal stress. These uptake measurements are made on the whole waters and on the ligands fractionated by ultrafiltration or other separation methods.

Our research is being conducted on tributaries from contrasting watersheds in the Great Lakes basin in order to determine the biogeochemical factors controlling ligand properties and metal bioavailability. We are also investigating metal levels and speciation in Lake Superior, the receiving water for many of the tributaries. We have completed a detailed GIS-based analysis of the complete Lake Michigan and Lake Superior (U.S. side) basins, which incorporates six major geospatial characteristics. This analysis, when combined with our metal-ligand database and chemical models of metal speciation, will provide a basis for landscape scale modeling of the forms, concentrations, and bioavailability of metals discharged to receiving waters.

Reproductive Toxicity of Methylmercury to Fish: Establishing the Relationship between Biomarkers and Reproductive Success (R/MW-81)

Mark Sandheinrich, Biology & Microbiology, UW-La Crosse
Ronald Rada, River Studies Center, UW-La Crosse

A graduate (Master of Science degree) student was recruited and started June 1, 2000. The student worked on development of a technique for analysis of mercury in fish tissue. A culture system was constructed for fathead minnows, and fathead minnow eggs were obtained from a U.S. Geological Survey laboratory and hatched in July 2000. Larvae were fed brine shrimp and dry trout chow until October 2000. The fathead minnows were then distributed to experimental aquaria and are being fed diets artificially contaminated with methylmercury. Currently, we are working on methods for analysis of estrogen and testosterone with enzyme-linked immunoassays (ELISA). Reproductive studies will commence in spring after the fish reach sexual maturity.

Atmospheric Deposition of Water-Soluble Compounds into Lake Michigan (R/MW-82)

James Schauer, Water Chemistry Program, UW-Madison

During the first eight months of the project methods have been developed to measure the acute toxicity of atmospheric aerosol samples to freshwater green algae (*Raphidocelis sucapitata*) and water fleas (*Ceriodaphnia dubia*) by adapting U.S. Environmental Protection Agency (EPA) methods for water discharge testing. Methods for measuring the toxicity of water-soluble and solvent-extractable fractions have been employed to quantify the toxicity of atmospheric particulate matter samples collected simultaneously at three nearshore locations in Milwaukee, the Indiana Dunes, and Southwest Michigan in late summer.

In addition, parallel tests have been conducted on a sample of motor vehicle exhaust. Currently, the results of these tests, along with the chemical characterization of the aerosol samples, are being compiled. A second phase of sampling is planned to be conducted in late fall that will be tested along with additional air pollution source emissions samples.

Students Supported and Resulting Publications

The project has provided partial support a graduate student in the Water Chemistry Program at UW-Madison. It is anticipated that at least two publications will be prepared for submissions to peer reviewed journals in the next few months that cover the activities that have been conducted under the subject project.

New Initiatives Subprogram

Prediction and Prevention of Stress Responses in Recreational Scuba Divers (R/NI-29-PD, R/NI-29)

William Morgan, School of Education, UW-Madison

The initial component of this project involved the preparation of a comprehensive review dealing with the influence of physical activity on panic attacks in patients with panic disorder in an effort to determine if such individuals might be at increased risk when engaged in physical activity (e.g., scuba diving). This review revealed that physical activity does not provoke panic attacks in patients with panic disorder (O'Connor, Smith & Morgan, *Anxiety, Stress, and Coping*, in press). A second paper has been prepared in collaboration with investigators from Indiana University (J.R. Raglin) and the University of Georgia (P.J. O'Connor) that describes an effort to predict panic behavior in beginning scuba students who score in the normal range on anxiety, and it was possible to predict panic episodes accurately in 83% of the cases (in review). A third paper was prepared titled "Utility of exertional perception with special reference to underwater exercise" (*International Journal of Sport Psychology*, in press), and this paper summarizes our Sea Grant research conducted over the past 10 years. This paper demonstrates that perception of effort is a crucial factor in the stress responses experienced by recreational scuba divers.

It has been possible to study the influence of manipulating perceived exertion with hypnosis in a collaborative project at the University of Texas Southwestern Medical Center at Dallas, and this research demonstrates that modification of perception can lead to cardiovascular changes, as well as alterations in regional cerebral blood flow (rCBF). This work has been accepted for publication in the *Journal of Applied Physiology* (in press). There is evidence that self-hypnosis and imagery designed to relax Navy divers (Mittleman, Doubt & Gravitz, 1992) immersed in cold water actually produced negative effects (e.g., hypothermia) in some divers. Therefore, an experiment was conducted in which hypnosis was compared with a non-hypnotic intervention (autogenic relaxation), and both conditions were evaluated in the seated and supine positions. It was found that the two procedures did not differ in terms of metabolic outcomes, but both treatments resulted in *reduced anxiety* irrespective of body position (Garvin, Trine, Morgan, *International Journal of Clinical & Experimental Hypnosis*, in press). This research establishes the foundation for our planned underwater research involving the study of interventions designed to produce a state of relaxation in recreational divers.

Students Supported

The co-authors on much of this research received Ph.D. degrees under the principal investigator's supervision, and these former graduate students were supported in part by project assistantships from the UW Sea Grant Institute: Ann Wertz Garvin, UW-Whitewater; Patrick J. O'Connor, University of Georgia; John S. Raglin, Indiana University; and Malani R. Trine, UW-Madison). Aaron J. Stegner completed the M.S. degree in summer 1999, and he is currently a Ph.D. student in my lab with support as a project assistant from UW Sea Grant Institute.

Non-Sea Grant Sources of Support

Additional support for this research has been provided by a generous gift from the Donald and Diane Masterson family, and grants from the American Heart Association-Texas Affiliate (BG98-085) and the National Institutes of Health (NIH RO1 HL 59145) to Dr. Jon W. Williamson (PI), and the National Institute of Mental Health (1 RO3 MH 54132-01) to Dr. Patrick J. O'Connor (PI).

Decompression Injury and Safety Recommendations in Scuba Diving (R/NI-30)

R. Tass Dueland, Veterinary Medicine, UW-Madison

Since March 1, 2000, our project has nearly completed trials with the UW sheep model to assess the scuba diver's risks of decompression sickness (DCS) and dysbaric osteonecrosis (DON) in repetitive, two-day "week-end" vs. four-day "vacation" scuba diving. Recent sheep findings point to a greater DON risk in repetitive, prolonged shallow dives (paired two-hour dives to 45-58 feet of sea water [fsw]) than in repetitive short deep dives (paired 25-minute dives to 101-112 fsw), which also provoke limb bends. Long-duration shallow dives

carry a greater risk of DON and disabling osteoarthritis than short-deep dives. With high-resolution MRI, we did not detect white-matter brain lesions in “shallow-diving” sheep; the brains of “deep-diving” sheep will be screened this winter. Our results support the theory that the pattern of pressure and duration in dive profiles controls the manifestation and severity of DCS in recreational scuba diving.

UW sheep findings and those from research of Puerto Rican seafood divers, from collaborative research with University of Puerto Rico Medical School (Drs. Lopez-Tristani and Dumois) and with Harvard’s Bingham and Women’s Hospital (Dr. Ferrigno), were reported to the Annual Meeting of the Undersea & Hyperbaric Medical Society (UHMS), Stockholm, June 2000. We demonstrated the public-health risk of DON and disabling osteoarthritis in divers experiencing limb bends.

In another study, we found a high risk of lethal DCS in personnel escaping from a disabled submarine after experiencing 24 hours at pressures ≥ 50 fsw (U.S. Navy-supported research, *Deep Submergence and Biomedical Development Program*, Capt. Henry Schwartz), and a lower but significant risk in emergency escape from NOAA’s *Aquarius* scientific habitat (46-47 fsw), Key Largo, Fla., also reported at Stockholm.

A project investigator (Charles Lehner) was an invited lecturer on DON pathophysiology to the Advanced Diving Course, a training course for diving medical officers from various countries, at the Canadian Defense and Civil Institute of Environmental Medicine (DCIEM), Toronto. He also lectured on provocative decompression and DCS at the 2000 Technical Diving Conference, National Association of Underwater Instructors (NAUI), held at the U.S. Army Special Forces Training Center, Key West, Fla.

Non-Sea Grant Support

In 2001, we will install an oxygen delivery system (Navy-funded) in our high-pressure chamber at the UW-Madison Biotron to test the usefulness of oxygen in accelerated decompression, applicable for both submarine and scientific habitat escape and for trials with mixed-gases used by Navy, recreational, and technical scuba divers. The ongoing synergism in our UW Sea Grant and Navy diving physiology research has been essential to the usefulness of our laboratory’s findings.

Policy Studies Subprogram

Sustainability, Uncertainty and the Management of the Lake Superior Fisheries

(R/PS-51)

Richard Bishop, Agricultural and Applied Economics, UW-Madison

Progress was made on our theoretical framework to address the radical uncertainty that afflicts natural resource decisions with long-term consequences. The framework suggests that attending to conservation of natural resources, as suggested by a safe minimum standard of conservation, may better promote intergenerational fairness than attending to conservation of value as more traditional economic approaches would suggest. Surprises can happen, and decision-makers know it. Surprise is more likely to matter if, in some crude sense, surprise occurrence is either “more likely” or may impose substantial losses. Both factors are operative when decisions are irreversible.

However, acknowledging the possibility of surprise strips economists of the usual decision-theoretic tools for making rational decisions; surprise means that we cannot enumerate all possible payoff relevant events, let alone ascribe probabilities to them. In such circumstances, we urge that preferences over acts are necessarily incomplete – that is, a complete ordering is not possible. This changes the decision problem from needing to make an optimal choice, to needing to make a choice from a maximal set. The safe minimum standard of conservation offers a compelling and intuitively appealing way to choose among elements of what decision theorists term the “maximal set” – one that focuses on conservation of resources as a way of respecting the rights of future generations. Progress was made on a paper on this topic that will eventually be sent to a peer-reviewed environmental economics journal.

Other accomplishments include:

- We programmed within MATLAB a working version of the ECOSIM ecosystems model. Parameters for a 19 species ECOSIM model of the Lake Superior ecosystem were provided by Prof. James Kitchell, UW-Madison, and colleagues. The ecosystem model has been coupled with an econometric model to describe how consumer surplus changes as a consequence of changes in harvest levels. These coupled systems have been further embedded within a dynamic programming framework to explore the economic, biological and ecological consequences of different decision-making strategies for proceeding under conditions of uncertainty.
- The project has completed lengthy, structured interviews with a score of Lake Superior fisheries managers and assessment biologists. The taped interviews have been transcribed and analyzed. Results from the modeling and structured interviews are forming the basis for a dissertation by Antony Scott and will eventually be incorporated in journal papers for disciplinary and interdisciplinary outlets, including those used by resource managers.

Interseasonal Comparisons of Static and Dynamic Economic Models of Recreational Salmonid Fishing on Lake Michigan (R/PS-52)

R. William Provencher and Richard Bishop, Agricultural and Applied Economics, UW-Madison

This project has developed a theoretical framework for examining the question of whether angler reactions to *intra*-seasonal variations in fish catch can be used to determine the economic value of long-run *inter*-seasonal changes in fish catch as might arise, for instance, from a policy to increase the stocking of salmonids in Lake Michigan. To examine this issue empirically, data concerning the fishing trips taken throughout the season by a random sample of 350 anglers were collected by the University of Wisconsin Survey Center. This data collection effort was successfully completed in mid-October 1999. Simultaneously, various economic models of angler behavior were developed and estimated using data collected in previous seasons with UW Sea Grant support. Forecasting simulations using these models indicate that angler responses to interseasonal variations in fish catch are quite similar to their responses to intraseasonal variations in fish catch, suggesting that the models are quite "portable" over time. Models estimated using the 1999 data will be used to forecast angler behavior in the summer 2001 to determine the robustness of this result.

Analysis of Persistence and Change in Apostle Island Boating 1975-1997 (R/PS-53)

Thomas Heberlein, Rural Sociology, UW-Madison

Coding and "cleaning" of the Apostle Islands survey data was completed in the summer of 1998, and we began data analysis that fall. For the second part of this project, "Society and Sailing in a Regional Context," we have compiled several strings of trend data. The database includes National Park Service visitation records, charter fleet sizes and numbers of marina slips, property values for 11 municipalities in Bayfield County, budget expenditures for the cities of Washburn and Bayfield, school enrollment statistics, demographic data, and other variables related to social and economic change in the communities around the Apostle Islands. This is being used to understand how sailing and tourism are related to the business structure, community vitality and social capital of the region.

Presentations and Papers

Aspects of this analysis have been presented at three conferences: the International Symposium for Society and Resource Management (ISSRM) in June 2000 in Bellingham, Wash., the Wilderness Horizons Conference in September 1999 in Ashland, Wis., and the Chequamegon Bay Natural Resources Conference in March 1999 in Ashland, Wis. The research team also has made two other presentations: "Changing Patterns of Recreation over Time: What Can Be Learned from Panel Studies?" International Symposium on Society and Resource Management, Brisbane, Australia, July 1999, and "Sea-Kayakers as an Invading Species in the Apostle Islands National Lakeshore," presented to National Park Service personnel at Apostle Islands National Lakeshore, Bayfield, Wis., June 1999. Finally, in the summer of 2000, we completed a paper, "Changing Visitor Composition and Perceived Crowding: A Longitudinal Analysis," that has been submitted to *Leisure Sciences* for publication.

Graduate Research Assistant Rebecca Grossberg completed her master's thesis in December 1999, using the cross-sectional and panel data from the Apostle Islands boater survey. Her thesis is titled "Changing Landscape Beliefs and the Meaning of Wilderness: Visitors' Beliefs about a National Park." We are currently editing this work to publishable length and will submit it for publication in December 2000.

Recreational Boating and Retirement on the Bayfield Peninsula of Lake Superior

(R/PS-54)

Thomas Heberlein, Rural Sociology, UW-Madison

We have surpassed our goals for data collection in the first phase of the retirement migration project. Starting in April, we made phone calls to Bayfield-area non-native property owners from a list provided by the county tax assessor's office. In total, we called 677 residents and located 90 retired in-migrants. In July and August, the principal investigator (Heberlein), Prof. Walter Kuentzel, University of Vermont-Burlington, and graduate research assistants Benjamin Vail and Rebecca Grossberg were stationed in Bayfield and, over the course of the two months (and another short trip in October), conducted 65 interviews. Our original goal was only 50 interviews, but we calculated that 72 would be necessary in order to have a representative sample of all 12 municipalities around the shores of the Bayfield peninsula.

We will conduct the remaining seven interviews in the spring of 2001. Most of the interviews have been transcribed, and we will begin data analysis within the next few weeks. To complement the in-depth interviews with more complete quantitative data, we developed a written questionnaire and sent it to all 90 migrant retirees. We sent a similar questionnaire to 89 retirees in Vilas County to provide a basis for comparison. Currently, we have a 66% response rate for the Bayfield sample and a 54% return for the Vilas County sample. We expect at least a 70% response rate from both groups after mailing a reminder letter next week.

Finally, we are preparing for the next phase of the project by identifying retired members of our Apostle Islands boater sample. We plan to send a mail questionnaire to this group in the spring of 2001.

Combining Stated and Revealed Preference Data to Estimate the Economic Value of Recreational Salmon Fishing

(R/PS-55)

R. William Provencher and Richard Bishop, Agricultural & Applied Economics, UW-Madison

Initiated last March, this project attempts to combine (1) anglers' statements of their behavior, given a *hypothetical* change in fishing conditions, and (2) the *actual* behavior of anglers under various fishing conditions to determine the economic value of recreational fishing. At this point, a substantial portion of the economic theory concerning how to combine such hypothetical (stated preference) and actual (revealed preference) data correctly has been developed and awaits application to angler data collected in 1999 (*see project R/PS-52*). The theory also will be applied to data to be collected during the 2001 fishing season.

Program Outreach, Education and Administration

Advisory Services Subprogram

Advisory Services: Program Coordination and Field Offices

(A/AS-1)
Allen H. Miller, Sea Grant Institute, UW-Madison

During the past year, UW Sea Grant Advisory Services staff members have begun to learn how to conduct workshops and courses on the World Wide Web. One graduate level seminar was taught on-line last spring using WebCT software. Two workshops are being prepared on boater safety using Blackboard® and on Global Environmental Change using WebCT. Additional Web-based workshops will be developed in the coming years. This report highlights only a very few of the many accomplishments of the five Advisory Services

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Specialists. See Appendix H for a complete listing of UW Sea Grant's Advisory Services partners during the 1998-2000 biennium and workshops sponsored or co-sponsored since last October.

- Victoria Harris (Water Quality/Habitat Specialist) assisted the Brown County Port, U.S. Army Corps of Engineers and Remedial Action Plan (RAP) partners in developing a \$5 million ecological restoration project to reconstruct a chain of habitat islands in southern Green Bay. The project will beneficially reuse dredged material to rebuild the Cat Islands, provide essential habitat for colonial nesting and shore birds and facilitate reestablishment of aquatic vegetation. Harris provided habitat designs, identified potential water quality impacts from island reconstruction, summarized PCB data and assisted the RAP committee in formulating recommendations for acceptable PCB levels in dredged material used to construct the islands.
- Working closely with the Milwaukee Lake Schooner Education Association (MLSEA), James Lubner (Education/Water Safety Specialist) provided instruction for MLSEA's 50 on-board educators and served as an onboard instructor for 27 teachers as part of MLSEA's summer weeklong *Field Learning on Lake Michigan*. Lunched in 2000, the MLSEA schooner *Denis Sullivan* should be fully operational in 2001.
- Philip Keillor (Coastal Engineering Specialist) outlined the scope of a new advisory booklet on shore protection for Great Lakes shore property owners at the request of the Detroit District U.S. Army Corps of Engineers. The last guidebook, *Help Yourself*, was printed in 1978. We anticipate that the Corps will continue their support through writing and printing the publication.
- Six prototype nonindigenous aquatic species "Attack Packs" were developed by Philip Moy (Fisheries/NIS Specialist) and presented to 36 high school students from four Waukesha-area high schools. The "Attack Pack" is a self-contained teaching aid including activities, overheads, a video, preserved specimens and a PowerPoint® presentation that allows high school students to teach elementary school students about aquatic nuisance species in Wisconsin.
- A Lake Superior Water Trail was established and dedicated in the spring of 2000 between Port Wing, Wis., and Ashland, Wis. Brochures were published, and a detailed map of the Lake Superior coastline was developed for use of recreational boaters and kayakers. An extension of the water trail is now planned for the nearshore waters from Port Wing, Wis., to Superior, Wis. Organizational and planning meetings are being held monthly to complete the necessary work to have the water trail open and useful by 2002. Harvey Hoven (Business Specialist) provided significant support in organizing and developing written materials for the trail.
- Continued partnership with the Wisconsin Department of Natural Resources, UW-Extension, Brown County Land Conservation Department units and Green Bay Area Public Schools allowed Harris to equip and train more than 50 adult volunteers and teachers from the Northeast Wisconsin region. New partnerships were initiated with Manitowoc and Kewaunee county land conservation departments, UW-Extension, and Peninsula State Park. In the past year, 2,528 students and 47 adults monitored water quality and stream habitat in 10 Green Bay and Lake Michigan tributaries and Lake Winnebago. The resulting data are being used to establish baseline conditions, identify watershed management needs and evaluate the effectiveness of nonpoint source abatement programs.
- James Lubner (Education/Water Safety Specialist), in conjunction with the Wisconsin Boating Law Administrator and several regional wardens (who are safety specialists) is developing an on-line version of the Wisconsin Boating Basics Course, targeted at persons with disabilities who are unable to attend standard site-based courses.

Transferring Sea Grant Zebra Mussel Research and Outreach Results to the Nation Using a World-Wide Web Server (A/AS-43)

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

The Sea Grant Non-Indigenous Species (SGNIS) Web site contains high-quality science and has been the Web presence for the National Sea Grant College Program on nonindigenous issues since 1996. All documents contained on the site, both research and outreach, have been subjected to peer review. People who use the site can be confident that the available materials are of the highest quality.

Content: To date, the SGNIS database contains over 1,100 research reports and educational items of more than 900 authors. Currently housed at the site are 428 completed research findings, 40 ongoing research abstracts, 312 research and outreach papers in six conference proceedings, 85 issues of newsletters, a 70-slide graphic library, 53 general publication, 14 training materials, and three distribution maps. Contributions to SGNIS have been made by more than 100 organizations (20 of which are Sea Grant Programs) and 23 peer-reviewed journals.

Usage: During the September 30, 1999-October 1, 2000, period, 831,727 files were transferred, up 27.4% from previous year (the average daily file transfer rate was 2,152). Foreign usage (83 countries) increased by 7.2% to 6,028 files per year, with an average of 20 files per month being translated to another language.

Web of Webs: Representatives from Sea Grant programs housing a national nonindigenous species site and a representative from the National Sea Grant Office served on a committee to develop a way to connect all of Sea Grant's national nonindigenous species sites into one seamless look. Based on the committee's work a "Web of Webs" (WOW) has been created. A separate address and front page for the WOW was designed and established. From this page, users can seamlessly access any of the national sites and can access any of the nonindigenous species pages on individual program web sites. Each participating program is required to place the WOW icon at the bottom of all of their pages so users can return to the WOW front page and navigate to other Sea Grant national or state sites.

Site Maintenance and Upkeep: Publications and scientific materials for purple loosestrife, sea lamprey, European green crab, and Eurasian milfoil have been added to the site. All materials added have been through the same peer-review process as other materials on the site. The site was completely redesigned during this project period. The front page was condensed and simplified by using Java applets to make navigation through the site easier for users. A full text search was added to the publications section in addition the existing customized search engines already used on the site. A new graphical web statistic program was added to the site that makes user statistics more accessible and understandable to users. A new address was established for the site (www.sgnis.org) with the aim of making the site's address easier for users to remember and easier to advertise. Stress balls containing the address for the site were developed to provide the site address to users at the 1999 International Aquatic Nuisance Species Conference in Toronto, Ont., Canada. Participants visiting the display filled out a user survey, and each respondent received a stress ball with the site address on it.

Kids Page: A committee of Sea Grant education specialists was assembled, and they have conducted two conference calls to date. The committee's charge is to guide the development of educational materials that should be offered on the SGNIS kids page. The materials placed on this page will be designed to take advantage of new web technologies, be interactive, complement classroom activities used by the teachers and assist students in self-directed learning from their classroom. A subsection of this site will contain teacher materials and resources for use in leading class activities. The committee will continue to meet throughout year three of the project, and new materials will be selected for Web use and placed on the site.

WATERS: The Wisconsin Aquaculture Technology, Education and Research Service (A/AS-44)

Fred Binkowski, Great Lakes WATER Institute, UW-Milwaukee

This project continues to provide aquaculture outreach services to both prospective and active regional aquaculturists. Previous UW Sea Grant aquaculture outreach programs have responded to more than 2,000 requests since 1989. Since March 1, 2000, we have made 32 mail and telephone responses providing specific technical information, resource guides, bibliographies, fact sheets, and technical bulletins. In cooperation with state government and commercial aquaculture, we were responsible for developing the technical program and assisting in organizing the 7th annual Wisconsin Aquaculture Conference held March 10-11, 2000, in Oshkosh. The conference attracted more than 350 attendees. Informational tours of the Great Lakes WATER Institute's Aquaculture Center facilities were provided to representatives of the St. Croix Chippewa Aquaculture Project, the Ashland Aquaculture Demonstration Project, and the tribal council of the Menominee Nation. The St. Croix Aquaculture Project, a \$23 million salmon and yellow perch production facility now under construction near Danbury, Wis., culminates 13 years of planning during which project representatives have been in repeated contact with members of the UW Sea Grant Aquaculture Advisory Services program. The project principal

investigator (PI) is currently chairman of the Program/Facilities Committee of the Ashland Aquaculture Demonstration Project, which was recently funded by the state at \$4.2 million and has been in planning for seven years. The PI also serves on the executive committee of the Wisconsin Aquaculture Industry Advisory Council.

Technical on-site activity continues to be an important component of this outreach project. It provides critical services to the industry regarding water quality, offering instruction on "best management practices" for pond aquaculture, demonstrating the application/operation of water quality testing, assisting in the set-up and providing technical advice on recirculating aquaculture systems, advising on aquaculture effluent issues, and working with the Wisconsin Department of Public Instruction in developing secondary education aquaculture curriculums. A half-day workshop was organized and presented on advanced aquaculture curriculum topics to 19 participants at the Wisconsin Association of Vocational Agriculture Instructors Conference at Madison, Wis., in June 2000.

Within the framework of this project, we will continue to emphasize the question/answer and problem-solving component as well as focus on developing the hands-on training, which provides the maximum benefit to aquaculture clients.

Applications of Geographic Information Systems to Coastal Zone Management: Enhancing Local Capacity (A/AS-45)

Stephen Ventura, Land & Information Computer Graphics, UW-Madison

The objectives of this project are to provide technical assistance and training in the application of geographic information systems (GIS) to assist the public agencies in better managing nearshore activities that affect Great Lakes shorelines and water quality. Several examples of GIS applications have been developed that utilize local government databases and serve as illustrative "teaching models" to demonstrate how GIS can be applied to specific coastal issues. The initial models applied GIS to shoreland management for an inland lake in northern Wisconsin, coastal erosion along Lake Michigan in Sheboygan and Ozaukee counties, and identification of agricultural riparian buffers to reduce nonpoint source pollution of the Pigeon River, a Lake Michigan tributary. More recently, models have been developed that address floodplain management in Ozaukee County, urban nonpoint source pollution in Marquette, Mich., and land use planning/growth management in Door County. This past year (11/1/99 to 10/31/00), a total of 14 customized coastal GIS training courses were conducted, reaching 180 people (*see Appendix H*). The courses cover the topics of shoreland management, urban nonpoint source pollution, water resource management, and land use planning. Four of these courses were conducted in coastal counties as part of a mobile GIS lab using laptop computers. Shoreland management and coastal erosion GIS training exercises have been placed on-line as part of the project's web site (coastal.lic.wisc.edu), providing GIS training to hundreds of people from around the world. One-on-one technical assistance was provided to officials from several coastal counties (Racine, Ozaukee, Manitowoc, Kewaunee and Door counties in particular), as well as to UW Sea Grant Advisory Services staff. A total of nine presentations on coastal GIS research were made at state and national workshops and conferences this year reaching 239 persons.

As part of a U.S. Army Corps of Engineers' project to assess potential damage along Lake Michigan arising from varying lake levels, digital parcel mapping, base maps and other data sets have been integrated for coastal counties and cities in Wisconsin. An important accomplishment of this project was the development of methods for inventory, acquisition and integration of existing local government spatial data for use in decision-making about regional-scale issues. These methods helped refine local data to address regional planning issues without the burden of enormous public expenditures for primary data collection. The integrated data can now be used to address other coastal issues facing the Lake Michigan coast of Wisconsin.

A Web site based on the MIT Orthophoto server (ortho.mit.edu) has been developed to provide access to digital orthophotos for the Lake Michigan coast of Wisconsin. The Lake Michigan orthophoto server can be accessed through the Coastal GIS Web site. Finally, a three-dimensional computer-based tool has been implemented to visualize development along coastal bluffs and how bluff erosion may impact coastal structures.

Communications Subprogram

Communications Office and Subprogram Coordination (C/C-1)

Stephen Wittman, Sea Grant Institute, UW-Madison

During the past year, we continued to build upon and enhance our four most popular and successful Web sites – “Fish of the Great Lakes” (www.seagrants.wisc.edu/greatlakesfish/), “Wisconsin’s Great Lakes Shipwrecks” (see project C/C-5), “Gifts of the Glaciers” (www.seagrants.wisc.edu/communications/greatlakes/glacialgift/) and “Earthwatch” (see project C/C-2). User visits to Communications’ Web sites have nearly doubled over the past year. As of October 2000, these and other Communications Web sites were totaling *more than a half-million hits per month* – an average of just over 19,000 hits per day. These hits resulted from a total of 45,000 visitor sessions per month (about 1,500 per day) by more than 15,000 unique visitors, each session averaging more than 15 minutes in duration.

The most significant enhancement to our “Fish of Great Lakes” Web site during the past year was the creation of an interactive on-line reproduction of the classic *Fishes of Wisconsin* book in cooperation with AT&T Labs and the University of Wisconsin Press. In a related development, we are collaborating with the UW-Madison Center for Limnology on a Teaching and Learning with Technology project, funded by the UW-Madison Department of Information Technology, to create an on-line fish identification database for use in an undergraduate-level course on fish ecology. We also created a page featuring more than 50 satellite images of the Great Lakes region that has proven to be very popular with Web surfers. We continue to host and maintain the Great Lakes Sea Grant Network Web site, and in cooperation with Michigan Sea Grant we organized and led a session on designing and developing a new regional Web site during the Great Lakes Sea Grant Network Outreach Workshop April 16-19, 2000, in Milwaukee.

In addition, we produced six institute newsletters (circulation ~1,000), three formal publications, four administrative documents, one fact sheet, a poster, several promotional printings, and 15 news releases (see Appendix D). The Communications Office also purchased reprints of a dozen science journal articles resulting from UW Sea Grant-supported projects and distributed a total of 6,441 copies of all publications, more than two-thirds of which were in response to requests. An evaluation survey of *Littoral Drift* subscribers was conducted last spring which revealed that our newsletter continues to be ranked as “very good” to “excellent” by a vast majority of the respondents. About 73,700 customized “Zebra Mussel Watch” cards were printed and sold to other Sea Grant programs and various state and federal agencies.

Communications staff also assisted in the scripting, recording and distribution of more than 240 “Earthwatch” radio programs in cooperation with the UW-Madison Institute for Environmental Studies (see project C/C-2 below). We also developed and hosted two exhibits, one on Lake Michigan bathymetry and another on aquatic nuisance species, respectively, for “UW-Madison on the Road” outreach events in Milwaukee and Chippewa Falls, Wis. (see Appendix H).

Non-Sea Grant Support

Individual and bulk sales of Sea Grant publications and other products during the year recovered \$14,263.

Earthwatch Public Service Radio Program (C/C-2)

Richard Hoops, Sea Grant Institute, UW-Madison

The Earthwatch Radio project produced 10 two-minute programs on science and the environment every two weeks during the reporting period and distributed them on cassette tape every two weeks to approximately 75 radio stations (see Appendix H). More than half of the programs deal with atmospheric or water-related subjects, such as global climate change, or marine and Great Lakes research. Many of the sources for the stories work with different offices of NOAA, Wisconsin Sea Grant, and other Sea Grant programs in the Great Lakes region and elsewhere.

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Stations were surveyed in fall 1999 as part of an annual progress evaluation. The survey resulted in removal of 34 stations from the mailing list: about half of them had stopped using the program because of changes in format; the rest were taken off the list because of their failure to respond to requests for information. Because the number of remaining stations was lower than in previous years, a market research project was initiated during spring 2000 to determine what, if any, market continues to exist for a public service program like Earthwatch Radio. The survey was conducted by MBA candidates in the UW-Madison School of Business, and of the 111 U.S. radio stations that responded, more than 40 percent reported the use of short programs that are similar to Earthwatch Radio in format if not in content. However, staff at very few of these stations were aware of Earthwatch Radio, and very few stations used programs on cassette audiotape, preferring instead the use of compact disk (CD). The results indicated that a market exists for the program, but successful marketing requires a switch to CD and an intense publicity campaign.

New audio production facilities on the UW-Madison campus have made the switch to CD production and distribution economically feasible for the Earthwatch Radio project, and programs will be distributed on CD for the first time in January 2001. The switch will be complemented by the design of new stationery, and a marketing and publicity campaign will follow.

Legal action to obtain trademark protection of the name "Earthwatch" continued during 1999 and 2000. It stalled during the year due to staff turnover at the Trademark Trial and Appeal Board and the complex nature of the process, which involved negotiations with another organization – Earthwatch Expeditions – that also is seeking trademark protection for the "Earthwatch" mark.

Students Supported

During the past year, the Earthwatch Radio project employed a total of six graduate and undergraduate students as half-time writers.

Non-Sea Grant Support

Earthwatch Radio is a joint production of the UW Sea Grant Institute and the UW-Madison Institute for Environmental Studies (IES). IES provides 50 percent of the programming and financial support for the project.

History beneath the Waves: Learning from Wisconsin's Shipwrecks (C/C-5)

Jefferson Gray, Underwater Archaeology, State Historical Society of Wisconsin

John Karl, Sea Grant Institute, UW-Madison

Since the project's start on March 1, three important shipwrecks, the *Louisiana*, the *Hetty Taylor*, and the Pilot Island site have been added to the "Shipwrecks of Wisconsin" Web site (www.seagrant.wisc.edu/shipwrecks). This material includes text about the ships' histories, final voyages, wreck histories, current condition, and preservation. It also includes historical and modern underwater images and a map of each wreck site. Drafts for two more sites, the *Fleetwing* and the *Francis Hinton*, are well under way.

A major public education project was also completed. "Notes from the Field 2000: Exploring Shipwrecks in Door County" was a Web-based chronicle of shipwreck exploration. From September 11 to October 5, divers from the State Historical Society and East Carolina University examined several shipwrecks and described their work in the photographs and journal entries posted on the Web at www.shsw.wisc.edu/shipwreck/notes.

Presentations and Publications

More than 20 presentations on Wisconsin's shipwrecks were given to archaeologists, schools, diving associations, and other groups. Several press releases resulted in newspaper articles and radio interviews about the project. These efforts have steadily increased visitor traffic at the project's Web site to nearly 10,500 visitor sessions per month.

Education Subprogram

Special Marine Education Projects (E/E-1)

Mary Lou Reeb, Sea Grant Institute, UW-Madison

During 2000, UW Sea Grant-sponsored students competed successfully in the national Dean A. Knauss Marine Policy Fellowship and Great Lakes Commission–Sea Grant Fellowship programs. The Education Subprogram pages on the institute's Web site were redesigned to be more user- and topic- oriented and to meet W3C accessibility requirements. Latest statistics (October 2000) indicate our education pages attracted 284,573 hits and had 60,511 page views (average length of visitor session over 9 ½ minutes). For a description of other activities supported by education program development funds, see Appendix A.

In-kind support was provided for the "Madison JASON Project" and its Web site. Praised as a national model by JASON Project organizers, "Madison JASON" last year involved 100 teachers and 3,000 students in 33 elementary and middle schools in 14 Madison-area communities. We hosted two teacher development workshops (attendance 100 teachers in November 1999 and 68 teachers in September 2000) a five-week teacher professional development series in winter 1999 and a distance learning conference for 2,300 students in March 2000. Visitors (including 1,181 teachers) to our Madison JASON Web sites requested 43,723 bookmarks during this period. We also participated in the National Science Teachers Association meeting in Tulsa, Okla., in November 1999 by providing 1,000 Madison JASON bookmarks to NOAA (at the request of NSGCP) for distribution. Awards and recognition for the Madison JASON Web sites include the 2000 Silver Award by the University and College Designers Association and a feature as "HyperSite of the Week" (January 8, 2000) on the national Yahoo! Yahoo!igans site for children.

Madison JASON Project was also invited to be a participant in the UW-Madison Future Fair, held in Madison, Wis., on December 4-5, 1999. Nearly 7,000 visitors attended the two-day event. Thirty percent of the fair attendees visited the Madison JASON exhibit (based upon distribution of Madison JASON material). More than 4,500 copies of general Sea Grant educational material were distributed at the event. Program publicity included six days of Madison JASON ads in daily papers (circulation 116,000) and a full-page insert in a Sunday edition (circulation 175,000).

Non-Sea Grant Support

We solicited and received funding from a private corporation (Alliant Energy Foundation) for 400 scholarships for students to participate in Madison JASON. Other than staff time, \$11,363 of in-kind contributions/outside funding completely paid for our participation in the UW-Madison Future Fair.

"Recent Advances in Oceanography and Limnology" Seminar Series (E/E-35-SE)

Arthur Brooks, Great Lakes WATER Institute, UW-Milwaukee

The following UW Sea Grant-supported lectures were held Thursday evenings at the UW-Milwaukee Great Lakes WATER Institute in Milwaukee. Open to the public, attendance at each seminar averaged 30 people. Nine advanced undergraduate students and two graduate/special students were enrolled in the course in 2000.

Clifford H. Mortimer, Biological Sciences/Center for Great Lakes Studies, UW-Milwaukee
David Schwab, NOAA Great Lakes Environmental Research Lab, Ann Arbor, Mich.

Topic: "Advances in Physical Limnology: Measurements and Modeling of the Great Lakes"

Date: February 10, 2000

David Allan, University of Michigan, Ann Arbor

Topic: "Stream Restoration: Thoughts on the State of the Science"

Date: February 24, 2000

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David A. Stahl, Northwestern University, Evanston, Ill.

Topic: "Molecular Approaches in Limnology and Oceanography"

Date: March 17, 2000

David Bolgrien, Mid-Continent Ecology Division, U.S. Environmental Protection Agency, Duluth, Minn.

Topic: "The Application of Remote Sensing to Lakes and Watersheds"

Date: March 30, 2000

David Edgington, Department of Geosciences/Center for Great Lakes Studies, UW-Milwaukee

Topic: "Advances and Challenges in Geochemistry: A Curmudgeon's View of Great Lakes Research"

Date: April 13, 2000

Mikhail Grachev and **Yelena Likhoshway**, Institute of Limnology, Irkutsk, Russia

Harvey Bootsma, Great Lakes WATER Institute, UW-Milwaukee

Ray Weiss, Scripps Institute of Oceanography, La Jolla, Calif.

David Edgington, Center for Great Lakes Studies, UW-Milwaukee

Topic: "Recent Discoveries in Ancient Lakes Baikal and Malawi"

Date: April 15, 2000 (Saturday)

Gene Likens, Institute of Ecosystem Studies, Millbrook, N.Y.

Topic: "Limnology and Freshwater Ecosystems in the Twenty-First Century"

Date: May 4, 2000

Water Chemistry Program "Special Seminar Series" (E/E-37-SE)

James Schauer, Water Chemistry Program, UW-Madison

The following UW Sea Grant-supported lectures were held Fridays in Room 102 at the Water Science and Engineering Laboratory on the UW-Madison campus. Fourteen graduate students were enrolled in the course in 2000.

Jonathan Kahl, Atmospheric Science Group, Mathematical Sciences, UW-Milwaukee

Topic: "Long-Range Transport of Atmospheric Contaminants to the Greenland Ice Sheet"

Date: October 13, 2000

Graduate Students: 20

Faculty and Staff: 15

David Sedlack, Civil and Environmental Engineering, University of California-Berkeley

Topic: "Effluent-Derived Chemical Contaminants in Recycled Water"

Date: October 27, 2000

Graduate Students: 30

Faculty and Staff: 20

Sea Grant Fellowships

Sea Grant Industrial Fellowship: ATR-Based Photocatalytic Drinking Water Systems (E/E-32)

Paul Check and Marc Anderson, Water Chemistry Program, UW-Madison

Introduction: Titanium dioxide (TiO₂) photocatalytic oxidation can totally destroy organic contaminants at room temperature. This destruction can be carried out in a liquid or gas-phase waste stream, producing only CO₂ and H₂O as byproducts. For this photocatalytic oxidation to occur, ultraviolet (UV) light (wavelength of ca. 380 nm or less) and an electron acceptor such as oxygen must be present. The mechanisms of photocatalytic oxidation have been studied extensively. The generally accepted mechanism of photocatalysis is that UV light (<380 nm) induces electron and hole formation in the conduction and valence bands of TiO₂. These electrons and holes can recombine, releasing the adsorbed energy as heat, or undergo interfacial charge transfer at the surface. At the surface, these holes and electrons can be trapped by Ti⁴⁺-O²⁻-Ti⁴⁺ traps. The trapped holes and electrons react directly with organics or indirectly by first reacting with water to form hydroxyl radicals that then react with organics.

Background: Many studies have attempted to increase the efficiency of TiO₂ photocatalytic reactors. Attempts have been focused on maximizing the reactive surface area and the area of light exposed catalyst per reactor volume. Reactor designs studied have included stirred tank reactors, rotating disks, and flow-through reactors. The catalysts used have been both fixed and unfixed. A fixed catalyst is preferred because a non-fixed catalyst is difficult to remove from the product water and requires an additional step to be effectively recycled. Fixing TiO₂ catalysts has been primarily accomplished by coating glass with TiO₂. Other studies have used silicone rubber and epoxy adhesives to fix the catalyst. Previous reactor designs have had limited success due to low organic removal efficiencies. As a result of these low efficiencies, water treatment devices utilizing TiO₂ photocatalysis have not been feasible for use in commercial or public applications. The purpose of this study is to increase the efficiency of a TiO₂ photocatalytic reactor by utilizing waveguide technology. In the reactor design used in this study, TiO₂ is coated on the outside of the waveguide surface. Light enters the waveguide and is distributed to the catalyst by successive internal reflections at the waveguide surface. Multiple waveguides are coated with TiO₂ and placed in a reactor. Light travels down the waveguide, illuminating the TiO₂ and producing electron and hole formation for organic destruction. The major advantage over non-waveguide reactors is the large area of lighted catalyst per reactor volume available. This study investigates the use of acrylic as a waveguide. Acrylic was chosen for the waveguides because it has high optical clarity and is machineable.

Summary of 1999 Results: In our 1999 report, different acrylics were tested for light transmittance, and one was chosen based on its high UV light transmittance. A procedure for polishing the waveguide inlet was developed using commercially available polishing aids. A range of surface tests was explored as part of a quality control program for coating the waveguides. These procedures were written and designed for use in long-term endurance testing of the waveguide TiO₂ coatings.

Methods (year 2000): A prototype design of a reactor was developed, and three reactors were constructed. Some of the design features incorporated into the prototype are:

- All reactor components are removable for diagnostic purposes.
- Individual waveguides may be added to or removed from the reactor to facilitate performance testing.
- The waveguides are perpendicular to the light source to maximize the transmittance UV light to the TiO₂ catalyst.
- The design incorporates methods to maximize mixing of the test solution with air and maximize exposure of the aerated solution to the catalyst.
- The test solution flow is equally distributed across the width of the reactor to expose it uniformly to the catalyst.
- Polished sections of the reactor allow measurement of UV light intensity.

The prototype reactor removal performance was tested utilizing an organic tannic acid. Tannic acid was chosen because it has high solubility in water and a negligible vapor pressure. The negligible vapor pressure allowed

for simple aeration in the reactor since no appreciable tannic acid is transferred to the vapor phase. The presence of tannic acid is easily measured and can also be found in natural groundwater, making field testing of the reactor possible. To test the reactor performance, tap water was dosed with tannic acid at various concentrations and pumped through the reactor at a wide range of flow rates. During these test runs major parameters such as the temperature of the solution, electrical current and voltage powering the UV light source, the light intensity transmitted by the UV light, dissolved oxygen levels, flow rate of the solution through the reactor, the tannic acid concentrations at the inlet and outlet of the reactor were measured. During these experiments, sets of waveguides with four, six and eight of TiO_2 will be studied to evaluate coating thickness on reactor performance.

Conclusions: At 20°C and operating with five waveguides (78 sq. in. of coated waveguide), the reactor removed 5 to 20 percent of the influent tannic acid concentrations ranging from 1 to 7.5 mg/L at flow rates of 10 mL/min to 275 mL/min. This data was accumulated from 280 hours of reactor run time. From preliminary analysis of the data, the following observations were made:

- Without aeration of the solution in the reactor, the removal performance approaches zero.
- The percentage of tannin removal remained constant over a tannic acid concentration range of 1 to 7.5 mg/L.
- The removal percentage ranged from 5 to 20 percent. Higher removal occurred at lower flow rate.

The apparent need for the presence of oxygen (supplied during aeration) was not a surprising result. Oxygen reacts with the electrons on the TiO_2 surface that are produced by UV light exposure. The oxygen consumes these electrons that would have otherwise recombined with the "holes" produced on the TiO_2 surface by UV light exposure. These "holes" oxidize the tannic acid. Usually, the concentration of the organic being oxidized would have an affect on the rate of oxidation. This indicates that rate of tannic acid degradation is 0 order with respect to tannic acid concentration. This small reactor is fairly efficient at reducing tannic acid over the range of 0.5 to 7.5 mg/L. Additional work will be performed to determine the affect of temperature, the addition of waveguides to the reactor, and changing light intensity.

Non-Sea Grant Funding

Additional support for this project has been provided by the Clack Corporation of Winsdor, Wis. (see Appendix B).

Dean John A. Knauss Marine Policy Fellowship (E/E-36)

Christian Lenhart, Water Resources Management/Landscape Architecture, UW-Madison

This one-year internship began in February at the National Marine Fisheries Service's Office of Habitat Conservation in Silver Spring, Md. The intern, a Master's degree candidate in water resources management and landscape architecture, has mostly worked on projects involving the Community-Based Restoration Program and the Coastal Wetland Planning, Protection and Restoration Act (CWPPRA) program, which supports projects to combat the loss of 25 square miles of coastal Louisiana wetlands annually. This has provided him with exposure to CWPPRA budget and project management, grant proposal reviews, partnerships development and congressional budget hearings.

He has assisted in collecting information needed for preparing an environmental assessment for the Four-Mile Canal Terracing and Sediment Trapping Project, worked on an assessment of the CWPPRA monitoring program, and attended a CWPPRA Task Force meeting. He is also working on a project involving the analysis of 21 fish passage projects, which has resulted in manuscripts for a NOAA document ("Development of Guidelines for NOAA Small Dam Removal") and a paper ("Assessment of Community-Based Fish Passage and Dam Removal Projects) that will be submitted to a peer-reviewed journal (*Coastal Management*). In addition, he has been working with The Nature Conservancy (TNC) to develop a Memorandum of Understanding that will form the basis of a partnership where NOAA and TNC will work together to restore and protect coastal areas, with candidate projects identified in Florida, Connecticut, New York and Oregon.

Other activities have included attending two federal training conferences, the Northeast Stream Restoration Workshop in Fairlee, Vt., and a U.S. Fish & Wildlife Service Fish Passageways and Bypass Facilities workshop in Amherst, Mass., and attending an American Association for the Advancement of Science-sponsored debate featuring the science policy advisors for U.S. presidential candidates Al Gore and George Bush.

Administration Subprogram

Program Development (M/SGA-1)

Anders W. Andren, Sea Grant Institute, UW-Madison

For activities supported with program development funds, see Appendix A.

Program Management (M/SGA-2)

Anders W. Andren, Sea Grant Institute, UW-Madison

During 2000, we (1) continued to refine program administrative processes according to the National Sea Grant Office's new procedures; (2) continued our matrix approach of integrating thematic areas with traditional subprograms to manage information flow for research, outreach and education more effectively; (3) drafted an updated strategic plan in connection with developing UW Sea Grant's 2002-2004 omnibus proposal; (4) formed an advisory panel for our Communications Subprogram; (5) held strategic planning meetings with various constituent groups; (6) redesigned our Web site to be more user- and topic-oriented in addition to meeting W3C accessibility requirements; (7) developed a secure Web-based project accounting application system; (8) started the development of a Web-based project management reporting system; (9) used State of Wisconsin matching funds to begin an upgrade of our conference room to include video conferencing and to enhance computer presentations; (10) participated, via presentations by program personnel, in three separate UW-Madison "On the Road" outreach events in Milwaukee and Chippewa Falls, Wis.

Ship Time (M/SGA-3)

Anders W. Andren, Sea Grant Institute, UW-Madison

This project provided ship support to the following continuing and terminating projects: R/LR-75 and R/EC-6.

APPENDIX A

Activities Supported from Program Development Funds

November 1, 1999, through October 31, 2000

- Travel support was provided for principal investigators and project researchers to attend scientific conferences and/or to present papers based on Sea Grant-supported research and outreach (R/MW-80, R/PS-52, R/NI-29, R/NI-30, C/C-3).
- Additional support was provided for two outreach projects – one to further refine the site characterization module of the RemSim contaminated sediments remediation simulation model (A/AS-1), and the other to fund additional field support to allow a “Notes from the Field” Web component by which audiences could follow on-line a team of underwater archaeologists as they documented shipwrecks (C/C-3).
- Funding was provided for a preliminary survey of zebra mussel population abundance and distribution at selected sites in Green Bay (R/LR-86-PD).
- Education program development funds were used to provide partial support for the “Recent Advances in Limnology and Oceanography Seminar Series” (E/E-35-SE) at UW-Milwaukee and the Water Chemistry Program “Special Seminar Series” (E/E-37-SE) at UW-Madison (*see Appendix H*). Travel support for an orientation session was provided for UW Sea Grant graduate student Christian Lenhart, who began his Dean John A. Knauss Marine Policy Fellowship on February 1, 2000 (E/E-36) (*see Appendix E*). A modest amount of support was provided for a student to begin data collection for a survey of former Sea Grant-supported graduate students. In-kind support was provided for the “Madison JASON Project” and its Web site.

APPENDIX B

Collaborating Institutions

November 1, 1999, through October 31, 2000

- University of Wisconsin System**
Great Lakes Wisconsin Aquatic Technology &
Environmental Research Institute
- University of Wisconsin-Madison**
Agricultural and Applied Economics
Aquaculture Research Center
Biotechnology Center
Biotron
Center for Limnology
Chemical Engineering
Civil & Environmental Engineering
College of Agricultural & Life Sciences
College of Engineering
College of Letters & Science
Environmental Remote Sensing
Environmental Toxicology Center
Food Science
Graduate School
Institute for Environmental Studies
Kinesiology
Land Information & Computer Graphics
Facility
Medical School
Oceanography & Limnology Graduate Program
Radiology
Research Animal Resources Center
Rural Sociology
Sea Grant Institute
School of Education
School of Natural Resources
School of Pharmacy
Soil Science
State Laboratory of Hygiene
Statistics
Surgical Sciences
Urban & Regional Planning
Water Chemistry Program
Water Resources Institute
Water Resources Management Program
Water Science and Engineering Laboratory
Wildlife Ecology
Zoology
- University of Wisconsin-Green Bay**
Natural & Applied Sciences
Sea Grant Advisory Services
- University of Wisconsin-La Crosse**
Biology
College of Science and Applied Health
- University of Wisconsin-Manitowoc**
Sea Grant Advisory Services
- University of Wisconsin-Milwaukee**
Aquaculture Institute
Biological Sciences
Geosciences
Graduate School
Sea Grant Advisory Services
- University of Wisconsin-Stevens Point**
College of Natural Resources
Department of Biology
- University of Wisconsin-Superior**
Sea Grant Advisory Services
- Madison, City of**
Madison Metropolitan School District
- National Oceanic & Atmospheric
Administration**
Coastal Services Center
- North Carolina State University**
Zoology
- Purdue University**
Illinois-Indiana Sea Grant College Program
- State Historical Society of Wisconsin**
Underwater Archeology
- University of Maryland**
Chesapeake Biological Laboratory
- University of Vermont**
School of Natural Resources
Sea Grant Project
- Woods Hole Oceanographic Institution**
Biology

APPENDIX C

Non-Federal and Federal Sources of Program Funding

November 1, 1999, through October 31, 2000

<i>Sources of Significant Non-Federal Funding</i>				
Agency/Donor	Date of Award Acceptance	Purpose	Amount	Period of Support
State of Wisconsin	1-Jul-00	FY 2000-01 Sea Grant Support	\$1,548,694	7/1/00-6/30/01
Clack Corporation, Windsor, Wis.	11-Jun-99	Industry Fellowship Industrial Match	\$30,000	9/1/99-12/31/00
<i>Non-Federal Subtotal:</i>			\$1,578,694	
<i>Federal Funding</i>				
NOAA-Sea Grant	7-Apr-00	Dean John A. Knauss Marine Policy Fellowship	\$38,000	2/1/00-1/31/01
NOAA-Sea Grant	14-Jul-00	FY 2000 Omnibus	\$1,832,000	3/1/00-8/31/01
U.S. Army Corps of Engineers	14-Jul-00	Update of <i>Help Yourself</i> coastal processes booklet (Phase 1)	\$24,342	5/19/00-9/30/00
NOAA-Sea Grant	8-Sep-00	FY 2000 Omnibus Supplement	\$100,987	3/1/00-9/30/01
<i>Federal Subtotal:</i>			\$1,995,329	
<i>Combined Federal and Non-Federal Funding Total:</i>			\$3,574,023	

APPENDIX D

List of Publications and News Releases

Including Distribution Figures and Recovery of Funds through Sales
November 1, 1999, through October 31, 2000

Publications (November 1, 1999–October 31, 2000)

Quantity	Publication No. and Title
4,000	WISCU-B-00-001 <i>Wisconsin Fishes 2000: Status and Distribution</i> by John Lyons, Philip Cochran and Don Fago
1,050	WISCU-G-00-001 "PCBs in Green Bay: Locations, Amounts, and Clean-up Scenarios" by John R. Karl
5,000	WISCU-G-00-002 "Great Lakes Fishes Poster" by Elizabeth White, editor; Amy Kittleson, designer; Joseph Tomelleri, illustrator
4,360	WISCU-G-00-003 "Research for the Real World" UW Sea Grant program brochure by Stephen Wittman; Tina Yao, designer
500 Sets of 7	WISCU-H-00-001 "Guides to Historic Shipwrecks: Wisconsin Waters of Lake Michigan" by Jeff. Gray and John Karl; Tina Yao, designer
1,000	WISCU-Q-00-002 "UW Sea Grant Institute 2000-02 Program Directory" by Stephen Wittman, Coordinator; Elizabeth White, Editor; John Karl, Writer; Tina Yao, Designer
200	WISCU-R-99-015 "Effects of Polychlorinated Biphenyl 126 on Green Frog (<i>Rana clamitans</i>) and Leopard Frog (<i>Rana pipiens</i>) Hatching Success, Development, and Metamorphosis" by Michele Laura Rosenshield, Mariana Beatriz Jofre and William Henry Karasov
250	WISCU-R-99-016 "Sources of Variability in Microcontaminant Data for Lake Michigan Salmonids: Statistical Models and Implications for Trend Detection" by E. Conrad Lamon III and Craig A. Stow
250	WISCU-R-99-017 "Space, Time, and Scale: New Perspectives in Fish Ecology and Management" by Doran M. Mason and Stephen B. Brandt
200	WISCU-R-99-018 "Optimal-Sustainable Management of Multi-Species Fisheries: Lesons from a Predator-Prey Model" by Richard T. Woodward and Richard C. Bishop
300	WISCU-R-00-001 "Effects of Lighting Spectrum and Disturbance Level on the Growth and Stress Responses of Yellow Perch, <i>Perca flavescens</i> " by Alex B. Head and Jeffrey A. Malison
200	WISCU-R-00-002 "Oral Bioavailability and Toxicokinetics of 3,3', 4,4',5-Pentachlorobiphenyl in Northern Leopard Frogs, <i>Rana pipiens</i> " by Yue-Wern Huang and William H. Karasov
200	WISCU-R-00-003 "Regional Differences in Rates and Patterns of North American Inland Lake Invasions by Zebra Mussels (<i>Dreissena polymorpha</i>)" by Clifford E. Kraft and Ladd E. Johnson
200	WISCU-R-00-004 "Wet Peroxide Oxidation of Sediments Contaminated with PCBs" by James E. Duffy, Marc A. Anderson, Charles G. Hill, Jr., and Walter A. Zeltner

2000 Wisconsin Sea Grant Progress Report

- 200 WISCU-R-00-005 "High Levels of MHC Class II Allelic Diversity in Lake Trout from Lake Superior" by M.O. Dorschner, T. Duris, C.R. Bronte, M.K. Burnham Curtis and Ruth B. Phillips
- 200 WISCU-R-00-006 "Spatial Pattern of Localized Disturbance Along a Southeastern Salt Marsh Tidal Creek" by Janet M. Fischer, Tara Reed-Andersen, Jennifer L. Klug and Alice G. Chalmers
- 200 WISCU-R-00-007 "Photocatalytic Oxidation as a Secondary Treatment Method Following Wet Air Oxidation" by James E. Duffy, Marc A. Anderson, Charles G. Hill, Jr., and Walter A. Zeltner
- 200 WISCU-R-00-008 "A Stable Isotope Evaluation of the Structure and Spatial Heterogeneity of a Lake Superior Food Web" by Chris J. Harvey and James F. Kitchell

18,510 TOTAL Wisconsin Sea Grant-generated publications – 18 new titles

"Zebra Mussel Watch" Cards

- 2,900 Illinois-Indiana version (reprinted)
- 15,900 New York version (reprinted)
- 36,700 U.S. Coast Guard version (reprinted)
- 7,700 Vermont version (reprinted)
- 10,500 Wisconsin version (reprinted)
- 73,700 TOTAL – 5 versions**

UW Sea Grant Administrative Documents

UW-Madison FY2001 Federal Initiatives: UW Sea Grant College Program

1999 Annual Report

UW Sea Grant College Program Strategic Plan, 2000-05 (draft)

2000 Annual Report to the National Sea Grant Office

Miscellaneous

Gifts of the Glaciers: Lake Michigan fact sheet

3-D Lake Michigan Bathymetry mini-poster

Great Lakes Fishes promotional bookmark

Wisconsin Fishes 2000 promotional postcard

UW Sea Grant Program pocket folders (2 versions)

Publications Distribution (October 1999-September 2000)

- 2,112 Journal Reprints
- 1,921 Public Information
- 1,320 Non-UWSG
- 1,041 Advisory
- 47 Technical
- 6,441 TOTAL**

Sales Credits (October 1999 – September 2000)

\$14,262.76 Total Funds Recovered from the Sale
of Publications and Other Products

News Releases (November 1999-October 2000)

Date Issued	Release Headline
11/17/99	UW Student Addresses International Gathering of Ocean Scientists
1/25/00	Wisconsin Student Selected for First Great Lakes Commission Fellowship
1/27/00	UW-Madison Student Wins Knauss Fellowship
3/3/00	Local Students Embark on Under Sea, Outer Space Virtual Expedition
4/28/00	Spring Ritual of Netting Smelt Fading
4/26/00	UW Sea Grant Received \$1.8 Million Federal Grant
5/22/00	Falling Water Levels Raise Boating Hazards
6/15/00	Beware of Dangerous Currents (sent only to Wisconsin coastal parks)
6/16/00	Another Big Alewife Die-Off Likely This Year
6/29/00	Dangerous Breaking Waves Threaten Great Lakes Boaters
7/18/00	Moorings Placed at Historic Shipwrecks off Sheboygan
8/16/00	Lake Michigan Shipwrecks Preserve Rich Wisconsin History
9/1/00	Shipwreck Divers Invite Cyber Visitors on Exploration
10/26/00	Wisconsin Trout Vulnerable to Whirling Disease, Researcher Says
10/26/00	Web Site Tells All You Ever Wanted to Know about Wisconsin Fishes
TOTAL:	15

Littoral Drift Bimonthly Newsletter Cover Stories (circ. ~1,000 each issue)

GIS Is Where It's At: Smart Maps Advance Coastal Decision-Making (Nov.-Dec. 1999)

It Pays to Keep Yellow Perch Relaxed: Study Shows Calm Perch More Profitable for Aquaculture (Jan.-Feb. 2000)

New Material Made from Fish Protein: Hydrogel May Boost Value of By-Catch (March-April 2000)

Double Trouble for Trout: Researchers Explore Dioxin's Effects on Cellular Processes (May-June 2000)

Panel Finds Fox River Dredging Effective: Technology for Removing PCBs Called 'Very Clean, Precise' (July-Aug. 2000)

Wisconsin Trout Vulnerable to Whirling Disease: Public Education Needed, Researcher Says (Sept.-Oct. 2000)

APPENDIX E

Students and Fellows Supported

November 1, 1999, through October 31, 2000

Students Supported

During the past year support was provided via research and project assistantships and part-time employment to:

17 Graduate students
24 Undergraduate students

Degrees Awarded

Ten UW Sea Grant project-related theses were completed during 1999-2000, resulting in the awarding of three Master's degrees and seven Ph.D.'s:

Master's Degrees

Isabel Galdo-Miguez, Water Chemistry, UW-Madison, 1999
Profs. David Armstrong/William Sonzogni, project R/MW-77

Aaron Stegner, Kinesiology, UW-Madison, 1999
Prof. William Morgan, project R/NI-26

Marcus Renner, Institute for Environmental Studies, UW-Madison, 2000
Mr. Richard Hoops, project A/AS-3

Doctorate Degrees

Zhengjin Cao, Animal Health and Biological Sciences, UW-Madison, 1999
Prof. Richard Peterson, project R/BT-1

James Duffy, Water Chemistry, UW-Madison, 1999
Profs. Marc Anderson/Charles Hill, project R/MW-56

Chris Babiarz, Water Chemistry, UW-Madison, 2000
Profs. David Armstrong/William Sonzogni, projects R/MW-71 & R/MW-77

Habibollah Faraji, Food Science, UW-Madison, 2000
Prof. Robert Lindsay, project R/SF-3

George Lauster, Oceanography and Limnology, UW-Madison, 2000
Prof. D.E. Armstrong, project R/MW-50

Peter Rankin, Chemical Engineering, UW-Madison, 2000
Profs. Daniel Klingenberg/Kenneth Nealson/Sangtae Kim, project R/BT-4

David Markwardt, School of Pharmacy, UW-Madison, 2000
Profs. Richard Peterson/Warren Heideman, project R/MW-58

Fellows Supported

Dean John A. Knauss Marine Policy Fellowship

Jeffrey J. Ripp, M.S. graduate, Water Resources Management Program, UW-Madison
Committee on Resources, U.S. House of Representatives, Washington D.C., 1999

Christian Lenhart, M.S. graduate, Water Resources Management/Landscape Architecture, UW-Madison
Office of Habitat Conservation, National Marine Fisheries Service, Silver Spring, Md., 2000

Sea Grant Industrial Fellowship

Paul Check, Ph.D. candidate, Department of Civil & Environmental Engineering, UW-Madison
Clack Corporation, Windsor, Wis., 1999-2000

Great Lakes Commission-Sea Grant Fellowship

Lisa Koch, M.S. candidate, Department of Wildlife Ecology, UW-Madison
Great Lakes Commission, Ann Arbor, Mi., 2000

APPENDIX F

Program Awards and Honors

Award Title: "Apex 2000 Award of Excellence"
Recipient: *Littoral Drift* Newsletter
Staff Recognized: John Karl, writer; Elizabeth White, editor, and Stephen Wittman, assistant director for communications
Presented by: Communications Concepts, Inc.

Purpose of Award: The Apex Awards for Publication Excellence is an annual nationwide awards competition (4,932 entries this year) designed to "help writers, editors and managers improve their publications by providing recognition for outstanding publications from newsletters and magazines to annual reports and Web sites." Award selections are "based on excellence in graphic design, editorial content and the success of the entry – in the opinion of the judges – in achieving overall communications effectiveness and excellence."

Award Title: "2000 Silver Award"
Recipient: Underwater Exploration Web site
Staff Recognized: James Grandt, information technology specialist; Daniel Marklein, information technology coordinator; Mary Lou Reeb, education coordinator, and Tina Yao, art director
Presented by: University and College Designers Association

Purpose of Award: The University & College Designers Association Competition is an annual nationwide competition (1,400 entries this year) recognizing the best of exceptional design work. According to competition organizers, electronic media winning entries "reflect not only the creativity and originality of the designers but also their understanding of the unique challenges of designing for the Web. The Web sites were judged for design, technology, flexibility, interactivity, and suitability for their intended audiences." In addition to receiving an award, winning entries were also displayed at the 30th Annual Design Competition and Show, held Sept. 23-26, in Miami Beach, Fla.

Award Title: "Aquaculture Education Award"
Recipient: Underwater Exploration Web site
Staff Recognized: Allen H. Miller, assistant director for advisory services
Presented by: Wisconsin Aquaculture Association

Purpose of Award: This award recognizes leadership in aquaculture education. "The recipient...is best described as a tireless worker who is committed to the completion of any task. [His] tenure on the Wisconsin Aquaculture Industry Advisory Council and as chair of the Education Committee are clear measures of his commitment and dedication to educational excellence within aquaculture."

APPENDIX G

List of All Active Projects

November 1, 1999, through October 31, 2000

Research Projects

AQUACULTURE & SEAFOOD TECHNOLOGY

R/AQ-31 — Steroid Regulation of the Stress Response and Immune Function in Salmonid Fishes (Terence Barry and Jeffrey Malison, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/AQ-32 — Conversion of Fish Processing Waste and Underutilized Fish into Value-Added Protein Hydrogel (Srinivasan Damodaran, UW-Madison)

R/AQ-33-PD — Mitigation of the Consequences of Stress in Yellow Perch Aquaculture (Jeffrey Malison, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/AQ-34 — Use of Fish Oil for the Production of Nutraceuticals Containing Omega-3 and Conjugated Linoleic Acid Residues (Charles Hill, UW-Madison)

R/AQ-35 — Stress and Salmonid Fish: Role of Cortisol-Metabolizing Enzymes (Terence Barry and Jeffrey Malison, UW-Madison)

R/AQ-36 — Production of Stress-Resistant, Domesticated Yellow Perch for Commercial Aquaculture (Jeffrey Malison, UW-Madison)

BIOTECHNOLOGY

R/BT-10 — The Production of Fast-Growing, Sterile Walleye Hybrids Through Genetic & Endocrine Technologies (Jeffrey Malison, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/BT-11 — Identification of the Endogenous Ligand for the Aryl Hydrocarbon Receptor (Richard Peterson and Margaret Clagett-Dame, UW-Madison) *NOTE: This project ended June 30, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/BT-12 — Developmental Toxicity of Dioxin in Zebrafish (Richard Peterson and Warren Heideman, UW-Madison)

R/BT-14 — Determining the Roles of Multiple Forms of AhR and ARNT in Dioxin Toxicity in Rainbow Trout (Warren Heideman and Richard Peterson, UW-Madison)

ESTUARINE & COASTAL PROCESSES

R/EC-5 — Recruitment Decline of Yellow Perch in Green Bay, Lake Michigan: Evaluation of Environmental Influences and Predation (Fred Binkowski, UW-Milwaukee) *NOTE: This project ended August 31, 2000, and a project completion report is being forwarded to the National Sea Grant Office.*

2000 Wisconsin Sea Grant Progress Report

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

R/EC-7 — Material Transformations through a Series of Linked Basins in a Great Lakes Land Margin Ecosystem (J. Val Klump and James Waples, UW-Milwaukee)

LIVING RESOURCES

R/LR-74-PD — Early Life History of Perch (Fred Binkowski, UW-Milwaukee)

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

R/LR-76 — Application of Microsatellite and Mhc Markers to Stock Identification in Lake Superior Lake Trout (Ruth Phillips, UW-Milwaukee)

R/LR-77 — Causes and Impediments of Lake Trout Recovery in Lake Superior (Michael Hansen, UW-Stevens Point)

R/LR-78 — Fisheries and Food Web Dynamics in Lake Superior (James Kitchell, UW-Madison)

R/LR-82 — Dynamics of the Lake Superior Food Web (James Kitchell, UW-Madison)

R/LR-83 — Molecular Genetic Analysis of Lake Trout in Lake Superior and Richard's Reef, Lake Michigan (Ruth Phillips, UW-Milwaukee)

R/LR-85 — Stock Discrimination of Rainbow Smelt in Western Lake Michigan (Diane Caporale and Christopher Hartleb, UW-Stevens Point)

R/LR-86-PD — Preliminary Survey of Zebra Mussel Population Abundance and Distribution at Selected Sites in Green Bay (Tara Reed-Anderson, UW-Green Bay)

MICROCONTAMINANTS & WATER QUALITY

R/MW-76 — Impact of Contaminants on Sexual Development and Reproduction of Amphibians in Great Lakes Ecosystems (William Karasov, UW-Madison)

R/MW-77 — Watershed Export and Speciation of Trace Metals in the Lake Superior Basin (David Armstrong and William Sonzogni, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/MW-78 — Changes in Patterns of PCB Contamination in Surficial Green Bay Sediments over the Past Decade: Applications to Sediment Remediation (David Armstrong, UW-Madison, and David Edgington, UW-Milwaukee)

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

R/MW-80 — Speciation and Bioavailability of Metals in the Great Lakes Ecosystem (David Armstrong, UW-Madison)

R/MW-81 — Reproductive Toxicity of Methylmercury in Fish: Establishing the Relationship between Biomarkers and Reproductive Success (Mark Sandheinrich and Ronald Rada, UW-La Crosse)

R/MW-82 — Atmospheric Deposition of Water-Soluble Compounds into Lake Michigan (James Schauer, UW-La Crosse)

NEW INITIATIVES

R/NI-27 — Diver Health and Safety: Minimizing Decompression Risk (R. Tass Dueland, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/NI-28 — Erosion Information System in Support of Coastal Zone Management and Science (Frank Scarpace and Alan Vonderohe, UW-Madison) *NOTE: This project ended August 31, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/NI-29-PD — Prediction and Prevention of Stress Responses in Recreational Scuba Divers (William Morgan, UW-Madison)

R/NI-29 — Prediction and Prevention of Stress Responses in Recreational Scuba Divers (William Morgan, UW-Madison)

R/NI-30 — Decompression Injury and Safety Recommendations in Scuba Diving (R. Tass Dueland, UW-Madison)

POLICY STUDIES

R/PS-51 — Sustainability, Uncertainty and the Management of the Lake Superior Fisheries (Richard Bishop, UW-Madison)

R/PS-52 — Interseasonal Comparisons of Static and Dynamic Economic Models of Recreational Salmonid Fishing on Lake Michigan (R. William Provencher and Richard Bishop, UW-Madison)

R/PS-53 — Analysis of Persistence and Change in Apostle Island Boating 1975-1997 (Thomas Heberlein, UW-Madison)

R/PS-54 — Recreational Boating and Retirement on the Bayfield Peninsula of Lake Superior (Thomas Heberlein, UW-Madison)

R/PS-55 — Combining Stated and Revealed Preference Data to Estimate the Economic Value of Recreational Salmon Fishing (R. William Provencher and Richard Bishop, UW-Madison)

Outreach, Education and Administration Projects

ADVISORY SERVICES

A/AS-1 — Advisory Services: Program Coordination and Field Offices — Madison Office (Allen Miller, UW-Madison – *core program*)

A/AS-39 — WATERS: Wisconsin's Aquaculture Technology, Education and Research Services (Fred Binkowski, UW-Milwaukee) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

A/AS-40 — Applications of Geographic Information Systems to Coastal Zone Management: Building Local Capacity (Stephen Ventura, UW-Madison) *NOTE: This project ended August 31, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

A/AS-43 — Transferring Sea Grant Zebra Mussel Research and Outreach Results to the Nation Using a World-Wide Web Server (Allen Miller, UW-Madison)

A/AS-44 — WATERS: The Wisconsin Aquaculture Technology, Education and Research Service (Fred Binkowski, UW-Milwaukee)

A/AS-45 — Applications of Geographic Information Systems to Coastal Zone Management: Enhancing Local Capacity (Stephen Ventura, UW-Madison)

COMMUNICATIONS

C/C-1 — Communications Office and Subprogram Coordination (Stephen Wittman, UW-Madison – *core program*)

C/C-2 — Earthwatch Public Service Radio Program (Richard Hoops, UW-Madison – *core program*)

C/C-3 — Sailing through Death's Door: Multi-Media Site Guides to Wisconsin's Lake Michigan Shipwrecks (Jefferson Gray, State Historical Society of Wisconsin, and John Karl, UW-Madison) *NOTE: This project ended July 31, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

C/C-5 — History beneath the Waves: Learning from Wisconsin's Shipwrecks (Jefferson Gray, State Historical Society of Wisconsin, and John Karl, UW-Madison)

EDUCATION

E/E-1 — Special Marine Education Programs (Mary Lou Reeb, UW-Madison – *core program*)

E/E-31-SE — Recent Advances in Limnology and Oceanography Seminar Series (Arthur Brooks, UW-Milwaukee) *NOTE: This project ended May 31, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

E/E-35-SE — Recent Advances in Limnology and Oceanography Seminar Series (Arthur Brooks, UW-Milwaukee)

E/E-37-SE — Water Chemistry Program "Special Seminar Series" (James Schauer, UW-Madison)

PROGRAM MANAGEMENT

M/SGA-1 — Program Development (Anders Andren, UW-Madison – *core program*)

M/SGA-2 — Program Management (Anders Andren, UW-Madison – *core program*)

M/SGA-3 — Ship Time in Support of Sea Grant Research Projects (Anders Andren, UW-Madison – *core program*)

Sea Grant Fellowship Projects

E/E-32 — Sea Grant Industrial Fellowship: ATR-Based Photocatalytic Drinking Water Systems (Marc Anderson, UW-Madison)

E/E-36 — Dean John A. Knauss Marine Policy Fellowship (Christian Lenhart, UW-Madison)

National Sea Grant Strategic Investments and Enhancement Projects

MARINE BIOTECHNOLOGY

R/MW-58 — Ah Receptor-Mediated Developmental Toxicity in Zebrafish (Richard Peterson and Warren Heideman, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

R/BT-10 — The Production of Fast-Growing, Sterile Walleye Hybrids Through Genetic and Endocrine Technologies (Jeffrey Malison, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

NONINDIGENOUS SPECIES – ZEBRA MUSSELS

R/LR-63 — The Effect of Zebra Mussel Infestation in Inland Lakes on Pelagic Benthic Coupling (David Edgington, Russel Cuhel and Jerry Kaster, UW-Milwaukee) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

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, UW-La Crosse) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

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, UW-Madison) *NOTE: This project ended Feb. 29, 2000, and a project completion report has been forwarded to the National Sea Grant Office.*

A/AS-43 — Transferring Sea Grant Zebra Mussel Research and Outreach Results to the Nation Using a World-Wide Web Server (Allen Miller, UW-Madison)

APPENDIX H

Relevance of Wisconsin Sea Grant Projects to National Sea Grant Strategic Plan Key Action Areas

ECONOMIC LEADERSHIP — Key Action Areas

Coastal Business Development

A/AS-1 — Advisory Services: Business Outreach Specialist

R/PS-53 — Analysis of Persistence and Change in Apostle Island Boating 1975-1997

Coastal Community Development

R/PS-54 — Recreational Boating and Retirement on the Bayfield Peninsula of Lake Superior

Commercial Biotechnology

R/AQ-31 — Steroid Regulation of the Stress Response and Immune Function in Salmonid Fishes

R/AQ-32 — Conversion of Fish Processing Waste and Underutilized Fish into Value-Added Protein Hydrogel
(also *Seafood Technology*)

R/AQ-34 — Use of Fish Oil for the Production of Nutraceuticals Containing Omega-3 and Conjugated Linoleic Acid Residues (also *Seafood Technology*)

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

Commercial Fisheries

A/AS-1 — Advisory Services: Fisheries Outreach Specialist

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

R/LR-74-PD — Early Life History of Perch

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

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

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

R/LR-82 — Dynamics of the Lake Superior Food Web

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R/LR-85 — Stock Discrimination of Rainbow Smelt in Western Lake Michigan

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

Environmental Technology

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

A/AS-43 — Transferring Sea Grant Zebra Mussel Research and Outreach Results to the Nation Using a World-Wide Web Server

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

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

R/LR-83 — Molecular Genetic Analysis of Lake Trout in Lake Superior and Richard's Reef, Lake Michigan

R/LR-85 — Stock Discrimination of Rainbow Smelt in Western Lake Michigan (*also Commercial Fisheries*)

R/MW-81 — Reproductive Toxicity of Methylmercury in Fish: Establishing the Relationship between Biomarkers and Reproductive Success

R/PS-51 — Sustainability, Uncertainty and the Management of the Lake Superior Fisheries (*also Commercial Fisheries*)

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

Revitalizing Marine Infrastructure

(no project)

Seafood Technology

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

R/AQ-34 — Use of Fish Oil for the Production of Nutraceuticals Containing Omega-3 and Conjugated Linoleic Acid Residues

Sustainable Aquaculture

R/AQ-35 — Stress and Salmonid Fish: Role of Cortisol Metabolizing Enzymes

R/AQ-36 — Production of Stress-Resistant, Domesticated Yellow Perch for Commercial Aquaculture

R/AQ-33-PD — Mitigation of the Consequences of Stress in Yellow Perch Aquaculture

A/AS-44 — WATERS 2000: The Wisconsin Aquaculture Technology, Education and Research Service

COASTAL ECOSYSTEM HEALTH AND PUBLIC SAFETY — Key Action Areas

Coastal and Great Lakes Habitats

A/AS-1 — Advisory Services: Nonindigenous Species Outreach Specialist

R/EC-6 — Net Heterotrophy/Autotrophy in Coastal and Offshore Lake Michigan

R/EC-7 — Material Transformations through a Series of Linked Basins in a Great Lakes Land Margin Ecosystem

R/LR-63 — The Effect of Zebra Mussel Infestation in Inland Lakes on Pelagic Benthic Coupling

R/LR-86-PD — Preliminary Survey of Zebra Mussel Population Abundance and Distribution at Selected Sites in Green Bay

Coastal Hazards

A/AS-1 — Advisory Services: Coastal Engineering Outreach Specialist

Healthy Coastal Ecosystems

A/AS-1 — Advisory Services: Water Quality Outreach Specialist

R/BT-11 — Identification of the Endogenous Ligand for the Aryl Hydrocarbon Receptor

R/BT-12 — Developmental Toxicity of Dioxin in Zebrafish

R/BT-14 — Determining the Roles of Multiple Forms of AhR and ARNT in Dioxin Toxicity in Rainbow Trout

R/MW-58 — Ah Receptor-Mediated Developmental Toxicity in Zebrafish

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

R/MW-77 — Watershed Export and Speciation of Trace Metals in the Lake Superior Basin

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

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

R/MW-80 — Speciation and Bioavailability of Metals in the Great Lakes Ecosystem

R/MW-82 — Atmospheric Deposition of Water Soluble Compounds into Lake Michigan

Safety at Sea

A/AS-1 — Advisory Services: Marine Safety Outreach Specialist

R/NI-27 — Diver Health and Safety: Minimizing Decompression Risk

R/NI-29 — Prediction and Prevention of Stress Responses in Recreational Scuba Divers

R/NI-30 — Decompression Injury and Safety Recommendations in Scuba Diving

Sustainable Development

R/NI-28 — Erosion Information System in Support of Coastal Zone Management and Science

R/PS-55 — Combining Stated and Revealed Preference Data to Estimate the Economic Value of Recreational Salmon Fishing

EDUCATION AND HUMAN RESOURCES — Key Action Areas

Scientists and Engineers

E/E-1 — Special Marine Education Programs

E/E-32 — Industrial Fellowship: ATR-Based Photocatalytic Drinking Water Systems

E/E-31-SE — Recent Advances in Limnology and Oceanography Seminar Series

E/E-35 — Recent Advances in Limnology and Oceanography Seminar

E/E-37-SE — Water Chemistry Program “Special Seminar Series”

Resource Managers

A/AS-40 — Applications of Geographic Information Systems to Coastal Zone Management: Building Local Capacity

A/AS-45 — Applications of GIS to Coastal Zone Management: Enhancing Local Capacity

E/E-36 — Dean John A. Knauss Marine Policy Fellowship

Technical Training

A/AS-39 — WATERS: Wisconsin’s Aquaculture Technology, Education and Research Services

A/AS-44 – WATERS 2000: The Wisconsin Aquaculture Technology, Education and Research Service

Precollege Education

A/AS-1 — Advisory Services: Education Outreach Specialist

C/C-5 — History beneath the Waves: Learning from Wisconsin's Shipwrecks

E/E-1 — Special Marine Education Programs

Informal Education

C/C-1 — Communications Office

C/C-2 — Earthwatch Public Service Radio Program

C/C-3 — Sailing through Death's Door: Multi-Media Site Guides to Wisconsin's Lake Michigan Shipwrecks

APPENDIX I

Outreach Activities

November 1, 1999, through October 31, 2000

Advisory Services Workshops

Sponsored or Cosponsored, November 1, 1999-September 30, 2000

Land Use Planning Using ArcView (Hart)

Date: November 4, 1999

Attendance: 15 people

Location: Sturgeon Bay

GIS Day Event (Hart)

Date: November 19, 1999

Attendance: 35 third-graders

Location: Blessed Sacrament School, Madison

Madison JASON Training on Water Quality Sampling (Lubner)

Date: November 6, 1999

Attendance: 40 teachers

Location: Madison

Urban Nonpoint Source Pollution Modeling Using ArcView (Hart)

Date: December 16, 1999

Attendance: 8 people

Location: UW-Madison/LICGF

Sustainable Development for Coastal Communities (Harris)

Date: November 6, 1999

Attendance: 75 people

Location: Sustainable Green Bay Conference, Green Bay

REMSIM Demonstration (Keillor)

Date: January 21, 2000

Attendance: 40 engineers and contractors

Location: Annual meeting, Midwest Chapter, Western Dredging Association, Chicago

Great Lakes Biodiversity and Nonindigenous Species (Lubner)

Date: November 10, 1999

Attendance: 100 people

Location: UW-Milwaukee High School Environmental Conference, Milwaukee

GIS for DNR Water Management Specialists (Hart)

Date: January 25-27, 2000

Attendance: 17 people

Location: UW-Madison/LICGF

ArcExplorer Training (Hart)

Date: November 17, 1999

Attendance: 12 people

Location: Racine

Great Lakes Water Levels (Lubner)

Date: January 28, 2000

Attendance: 10 people

Location: Marine Dealers Boat Show, Milwaukee

State of the Great Lakes (Lubner)

Date: November 18, 1999

Attendance: 90 people

Location: West Shore Water Producers, Racine

Great Lakes Water Levels (Lubner)

Date: January 31, 2000

Attendance: 50 people

Location: Rotary Club, Oconomowoc

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GIS for DNR Water Management Specialists (Hart)

Date: February 15-17, 2000

Attendance: 18 people

Location: UW-Madison/LICGF

Great Lakes Water Levels (Lubner)

Date: February 15, 2000

Attendance: 55 people

Location: Sheboygan Area Great Lakes Sport Fishermen, Sheboygan

GIS in the Classroom (Miller/Hart)

Date: February 19, 2000

Attendance: 10 middle school teachers

Location: UW-Madison/LICGF

GIS for DNR Water Management Specialists (Hart)

Date: February 22-24, 2000

Attendance: 19 people

Location: UW-Madison/LICGF

Great Lakes Water Levels (Lubner)

Date: February 23, 2000

Attendance: 45 people

Location: Rotary Club, Wauwatosa

Great Lakes Water Levels (Lubner)

Date: February 23, 2000

Attendance: 35 people

Location: South Shore Yacht Club, Milwaukee

RAP Objectives and Recommendations for Restoring the Green Bay and Fox River Ecosystem (Harris)

Date: February 28, 2000

Attendance: 35 people

Location: Fox River Basin Plan Update Workshop for Fox Basin Partners Group, Green Bay

Great Lakes Biodiversity and Nonindigenous Species (Lubner)

Date: March 1, 2000

Attendance: 65 people

Location: Kiwanis Club, Milwaukee

GIS in the Classroom (Miller)

Date: March 3, 2000

Attendance: 36 middle and high school ag teachers

Location: Appleton

GIS in the Classroom (Miller)

Date: March 7, 2000

Attendance: middle and high school agriculture teachers

Location: New Glarus

State of the Great Lakes (Lubner)

Date: March 8, 2000

Attendance: 85 people

Location: UW-Milwaukee Natural Resources Management course, Milwaukee

Great Lakes Water Levels (Lubner)

Date: March 8, 2000

Attendance: 45 people

Location: Salmon Unlimited, Racine

Overview of ArcView (Hart)

Date: March 20, 2000

Attendance: 11 people from Kewaunee County

Location: UW-Madison/LICGF

GIS for DNR Water Management Specialists (Hart)

Date: March 21-23, 2000

Attendance: 17 people

Location: UW-Madison/LICGF

Boating Safety (Hoven)

Date: April 12-26, 2000

Attendance: 18 people

Location: Superior

Great Lakes Water Levels (Lubner)

Date: April 17, 2000

Attendance: 60 people

Location: Lake Ridge Boat Club, South Milwaukee

Wisconsin Boating Basics (Lubner)

Date: April 25-May 23, 2000

Attendance: 50 students

Location: Greenfield

Wisconsin Boating Basics (Lubner)

Date: April 26-May 24, 2000

Attendance: 44 students

Location: Wauwatosa

Urban Nonpoint Source Using ArcView (Hart)

Date: April 27, 2000

Attendance: 11 people

Location: UW-Madison/LICGF

**Great Lakes Water Resource Management Issues,
Restoring the Green Bay Ecosystem and PCB
Remediation in the Fox River (Harris)**

Date: April 29-May 5, 2000

Attendance: 40 people

Location: Normal University, Beijing, China

Boating Safety (Hoven)

Date: May 7-21, 2000

Attendance: 26 people

Location: Superior

**Wisconsin Lake Schooner On-Board Educator
Training (Lubner)**

Date: May 4, 6, 11, 2000

Attendance: 50 people

Location: Milwaukee

**Training on Vessel Safety Check Program for U.S.
Coast Guard Auxiliary and U.S. Power Squadron
(Lubner)**

Date: May 8, 12, 15, 2000

Attendance: 21 people

Location: Milwaukee

Boating Safety (Hoven)

Date: June 4-5, 2000

Attendance: 46 people

Location: Lake Nebagamon

**Hands-on computer class in use of REMSIM
(Keillor)**

Date: June 7, 2000

Attendance: 15 people

Location: UW Engineering Professional
Development short course on remediation of
contaminated sediments, Madison

GIS in the Classroom (Miller)

Date: June 14, 2000

Attendance: 14 middle and high school teachers
from around the state

Location: Part of a 4-day workshop on using
technology, Stevens Point

GIS for DNR Water Management Specialists (Hart)

Date: June 20-22, 2000

Attendance: 20 people

Location: UW-Madison/LICGF

**A Big Fish Story: All the Science You Can Eat,
Water Quality, Water Sampling and
Macroinvertebrates (Lubner)**

Date: June 27, 2000

Attendance: 14 teachers

Location: Madison

GIS in the Classroom (Miller/Hart)

Date: June 28-29, 2000

Attendance: 33 middle and high school and
Technical College instructors

Location: Annual conference for Wisconsin
Association of Vocational Agriculture Instructors,
Madison

**A Big Fish Story: All the Science You Can Eat,
Water Quality, Water Sampling and
Macroinvertebrates (Lubner)**

Date: July 11, 2000

Attendance: 15 teachers

Location: Rice Lake

**Field Learning on Lake Michigan, Wisconsin
(Lubner)**

Date: July 24-28, 2000

Attendance: 27 teachers

Location: Lake Schooner Education Association,
Milwaukee

ArcView GIS (Hart)

Date: July 26, 2000

Attendance: 4 people from the Town of Caledonia

Location: Racine

Communications Outreach

“Three-Dimensional Lake Michigan Bathymetry” (Wittman)

Date: February 21, 2000

Attendance: 1,200 area elementary and high school students, general public

Location: “UW-Madison on the Road” outreach event, Milwaukee Public Museum, Milwaukee, Wis.

“Building a Better Regional Mousetrap” (Wittman)

Date: April 18, 2000

Attendance: 25 Great Lakes Sea Grant Network Extension and Communications staff

Location: Regional Web Design session, Great Lakes Sea Grant Outreach Workshop, Milwaukee

“Aliens among Us: Aquatic Nuisance Species” (Wittman)

Date: May 4, 2000

Attendance: 200 area elementary and high school students, general public

Location: “UW-Madison on the Road” outreach event, Chippewa Falls, Wis.

Education Workshops

In addition to the educational outreach conducted through Advisory Services and Communications, the following workshops were coordinated directly through the UW Sea Grant Education Subprogram:

Madison JASON

Educator Professional Development Session (Reeb)

Dates: Five-week session (November 9, 16 and 30, and December 7 and 14, 1999)

Attendance: 16 teachers

Location: MSCR Building, Madison, Wis.

Telepresence Global Conference (Reeb)

Date: March 7-10, 2000

Attendance: Almost 2,300 students and their teachers

Location: BioPharmaceutical Technology Center Institute, Fitchburg, Wis.

Educator Professional Development Conference (Reeb)

Date: September 1, 2000

Attendance: 68 teachers

Location: The Pyle Center, UW-Madison campus

Advisory Services Partnerships, 1998-2000

The following organizations contributed to one or more specific Advisory Services projects during the 1998-2000 biennium. We also look for opportunities to work with other Sea Grant programs, regionally and nationally. In recent years we have worked cooperatively on issues of aquaculture, nonindigenous species and teacher education. These partnerships are listed below with nine other Sea Grant Programs.

- Aldo Leopold Center, Madison (teacher education)
- Alpine Farms, Sheboygan Falls (aquaculture)
- American Planning Association (GIS)
 - Land Based Classification Standards Project
- Ashland Area Development Corporation, Ashland (aquaculture, business)
- Barker's Island Marina, Superior (business)
- Bay Area Community Council, Green Bay (water quality)
- Bay Port Aquaculture Systems, Inc., West Olive, MI (aquaculture)
- Bayfield County (business, GIS)
- Bay-Lake Regional Planning Commission, Green Bay (GIS, coastal hazards, water quality)
- Bennett Academy of Ski and Scuba, Milwaukee (water safety)
- Boudin's Fisheries Inc., Ashland (business, fisheries)
- Boutin Fishing Company, Bayfield (business, fisheries)
- Brown County (dredging, hazards, GIS, water quality)
 - Conservation Alliance
 - Harbor Commission
 - Homebuilders Association
 - Land Conservation Department
 - Planning Department
 - Port and Solid Waste Department
- Case Western Reserve University (GIS)
 - Department of Geological Sciences
- City of Appleton (Nonindigenous species)
 - Department of Utilities, Wastewater Division
- City of Ashland (business, nonindigenous species)
 - Marina
- City of Bayfield (business)
- City of Green Bay (GIS, nonindigenous species, teacher education, water quality)
 - Chamber of Commerce
 - Mayor's Office
 - Metropolitan Sewerage District
 - Planning Department
 - Public Schools Einstein Project for Northeast Wisconsin
- City of Manitowoc (GIS, nonindigenous species)
 - Public Works Department
- City of Milwaukee (teacher education, water safety)
 - Police
 - Public Schools
- City of Superior (business, nonindigenous species)
- City of Washburn (business)
 - Marina
- City of Wauwatosa
- Coastal Planning and Design, Inc., Green Bay (hazards)
- Coastal Services Center, NOAA, Charleston, SC (GIS)
- Dean Vegetable Company, Green Bay (water quality)
- Door County (coastal engineering, GIS, nonindigenous species)
- East Central Wisconsin Regional Planning, Oshkosh (nonindigenous species)
- Everett Fisheries, Inc., Port Wing (business)
- Federal Geographic Data Council (GIS)
 - National Shoreline Data Standard Working Group, Bathymetric Subcommittee
- Fish Creek Aquaculture Development Center, Ashland (aquaculture)
- Fishing Charters of Racine, Racine (fisheries)
- Fort James Corporation, Green Bay (water quality)
- Fox-Wolf Basin 2000, Appleton (water quality)
- Freedom High School, Freedom (aquaculture)
- Friends of the Branch River, Manitowoc (water quality)
- Great Black Creek Fish Company, Black Creek (aquaculture)
- Great Lakes Commission (water quality)
 - Great Lakes Information Network
 - Lake Michigan Tributary Monitoring Assessment
- Great Lakes Fish Distributors (business, fisheries)
- Great Lakes Fishery Commission (business, fisheries)
- Great Lakes Indian Fish and Wildlife Commission, Odanah (business, fisheries)
- Great Lakes Panel on Aquatic Nuisance Species (nonindigenous species)
- Great Lakes Sea Grant Network (aquaculture, nonindigenous species, teacher education)
- Great Lakes Sport Fishermen (fisheries)
- Green Bay Duck Hunters Association, Green Bay (water quality, habitat restoration)
- Halvorson & Son Fisheries, Bayfield (business)
- Hamline University, St Paul, MN (teacher education)
 - Center for Environmental Education

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- Havenwoods Environmental Awareness Center, Milwaukee (teacher education)
- Heart-of-Valley Metropolitan Sewerage District, Kaukauna (water quality)
- Illinois-Indiana Sea Grant Program (nonindigenous species, teacher training)
- Inland Sea Society, Washburn (business)
- International Association for Great Lakes Research, Ann Arbor, MI (water quality)
- International Joint Commission, Great Lakes Regional Office, Windsor, Ontario (water quality)
- John G. Shedd Aquarium, Chicago, IL (teacher education)
- Kenosha Charter Boat Association, Kenosha (fisheries)
- Kewaunee County
 - Land and Water Conservation Department (water quality)
- Lake District - Lake Pewaukee, Pewaukee (nonindigenous species)
- Lake Largo Lake Association (habitat restoration)
- Lake Michigan Federation, Chicago, IL (teacher education)
- Lake Michigan Lakewide Management Plan Forum (water quality)
- Lake Michigan Monitoring Coordination Council (water quality)
- Lake Superior businesses in Wisconsin (business)
 - 110 businesses, Superior to Hurley
- Lake Superior herring fishermen (business)
 - 10 licensed commercial fishermen
- Leech Lake Band of Chippewa, Leech Lake, MN (aquaculture)
- Local Emergency Planning Committee, Green Bay (hazards)
- Lower Fox River Dischargers Association, Green Bay (water quality)
- Lower Green Bay and Fox River Remedial Action Plan, Green Bay (water quality)
- Madeline Island Ferry, Bayfield (business)
- Madison School District, Madison (GIS)
- Manitowoc County (nonindigenous species)
 - Land and Water Conservation (water quality)
- Maywood Environmental Center, Sheboygan (teacher education)
- McDonald Lumber and Warehousing Companies, Green Bay (habitat restoration)
- Medford School District, Medford (teacher education)
- Metropolitan Interstate Commission, Duluth, MN (water quality)
- Michigan Sea Grant Program (nonindigenous species)
- Michigan State University (fisheries)
 - Department of Fisheries and Wildlife
- Milwaukee County (aquaculture, nonindigenous species)
 - Community Right-to-Know Subcommittee
 - Emergency Planning Committee
- Minnesota Sea Grant Program, Duluth (nonindigenous species)
- Mississippi-Alabama Sea Grant Program (teacher education)
- Morey's Fish Company, Motley, MN (aquaculture)
- Neville Public Museum, Green Bay (teacher education, water quality)
- Northern Great Lakes Visitors Center, Ashland (teacher education)
- Northland College, Ashland (GIS)
 - Siquerd Olson Environmental Institute
- Northwest Wisconsin Regional Planning Commission, Spooner (GIS)
- Thousand Islands Environmental Center, Kaukauna (water quality)
- Oneida Environmental Services Program, Oneida Tribe (water quality)
- Outagamie County (nonindigenous species, water quality)
 - Land Conservation
 - Planning and Zoning
- Ozaukee County (GIS, hazards)
 - Land Information Office
- Paragon Aquaculture, Oshkosh (aquaculture)
- Pewaukee School District, Pewaukee (nonindigenous species)
- Pigeon River Priority Watershed Water Action Volunteers (WAV), Sheboygan (water quality)
- Purdue University (nonindigenous species)
- Racine County (hazards, nonindigenous species)
 - Planning and Zoning
- Red Lake Band of Chippewa, Red Lake, MN (aquaculture)
- Rufus King High School, Milwaukee (teacher education)
- Sailboats, Inc., Superior (business)
- Saint Louis River Remedial Action Plan, Duluth, MN (water quality)
- Salmon Unlimited, Racine (fisheries)
- Sheboygan County (GIS, water quality)
 - Land and Water Conservation
- Slinger Middle School, Slinger (teacher education)
- SODA Farms, Princeton (aquaculture)
- South Shore Yacht Club, Milwaukee (water safety)
- Southeast Michigan Coalition for Occupational Safety and Health (water safety)
- St. Norbert College, DePere
 - Benchmarks Project (water quality)
 - Project COAST (teacher education)
 - Ocean Voyagers Program (teacher education)

- SUNY Buffalo (teacher education)
 - Great Lakes Program
- Sustainable Green Bay Action Team (water quality)
- Town of Hobart (water quality)
- United States Army Corps of Engineers (GIS, habitat restoration, hazards, nonindigenous species)
 - Chicago District
 - Detroit District
 - San-Ship Canal Barrier Project
- United States Coast Guard Marine Safety Office, Milwaukee (water safety)
 - Eastern Wisconsin Area Committee
- United States Department of Agriculture (aquaculture, GIS)
 - Natural Resources Conservation Service
 - Natural Resources Damage Assessment
 - North Central Regional Aquaculture Center (NCRAC)
- United States Department of Commerce, NOAA (hazards, teacher education)
 - GEWEX Continental-Scale International Project (GCIP)
 - Great Lakes Environmental Research Laboratory
 - National Weather Service
 - Office of Global Programs
 - Ohio River Forecast Center
 - National Undersea Research Program
- United States Department of the Interior (aquaculture, fisheries, GIS, water quality, habitat restoration)
 - Bureau of Indian Affairs
 - Federal Geographic Data Committee
 - Fish and Wildlife Service, Ashland and Green Bay
 - Geological Survey
 - National Park Service, Apostle Islands National Lakeshore, Bayfield
- United States Environmental Protection Agency, Chicago, IL (water quality)
 - Great Lakes Region National Program Office
- United States Navy (teacher education)
 - Naval Oceanographic and Meteorological Command
- University of Michigan (hazards)
 - Center for Great Lakes and Aquatic Sciences
 - Department of Ocean Engineering
- University of Wisconsin Colleges (teacher education)
 - Fox Valley
 - Manitowoc
 - Marinette
 - Waukesha
- University of Wisconsin System (aquaculture, nonindigenous species, teacher education)
 - WATER Institute
 - Aquaculture Institute (aquaculture)
- University of Wisconsin-Extension (aquaculture, business, habitat restoration, water quality)
 - Area Water Quality Education Specialists
 - Solid & Hazardous Waste Education Center
 - Water Action Volunteer Program
- University of Wisconsin-Green Bay (nonindigenous species, water quality, habitat restoration)
 - Department of Public & Environmental Affairs
 - Department of Natural and Applied Sciences
 - Outreach and Extension
 - Center for Biodiversity
- University of Wisconsin-Madison (aquaculture, GIS, hazards, water quality)
 - Department of Civil and Environmental Engineering
 - Environmental Remote Sensing Center
 - Department of Geology and Geophysics
 - Institute for Environmental Studies
 - Land Information and Computer Graphics Facility
 - State Cartographer's Office
- University of Wisconsin-Milwaukee (teacher education)
 - Aquanaut Program
 - Center for Great Lakes Studies
 - Project JASON
- University of Wisconsin-Stevens Point (teacher education)
- University of Wisconsin-Superior (business)
 - Center for Economic Development
- Washington Sea Grant Program (teacher education)
- Winnebago County (nonindigenous species)
 - Land Conservation Department
- Wisconsin Center for Environmental Education (teacher education)
- Wisconsin Commercial Fisheries Association (fisheries)
- Wisconsin Conservation Congress (fisheries)
- Wisconsin Department of Administration (dredging, GIS, hazards, nonindigenous species, water quality, habitat restoration)
 - Coastal Management Program
 - Natural Hazards Advisory Committee
 - Office of Land Information Services, Wisconsin Land Council Technical Working Group
 - Small Business Clean Air Assistance
- Wisconsin Department of Agriculture, Trade and Consumer Protection (aquaculture, business)
 - Governor's Blue Ribbon Task Force on Aquaculture
 - Wisconsin Aquaculture Industry Advisory Council (WAIAC)
- Wisconsin Department of Commerce (aquaculture)

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- **Wisconsin Department of Natural Resources**
(aquaculture, dredging, fisheries, GIS, hazards, nonindigenous species, teacher education, water quality, habitat restoration)
 - Big Bay State Park
 - Boating Safety Program
 - Fishery Management Office
 - Fox River Remediation Advisory Team
 - Geographic Management Units
 - Lower Fox Partnership
 - Door County Stewardship Council
 - Milwaukee River Partnership
 - Lake Superior Partnership
 - Fox-Wolf Basin Advisory Council
 - Water Body Use Designation Advisory Committee
 - Lake Superior Basin Advisory Committee
 - Lake Superior Management
 - Nonindigenous Species Task Force
 - Northeast Region Water Division
 - Park Naturalists
 - Shoreland Zoning Unit
- **Wisconsin Department of Public Instruction**
(aquaculture, GIS)
 - Harbor Assistance Program
- **Wisconsin Division of Emergency Government (GIS)**
- **Wisconsin Environmental Education Board (teacher education)**
- **Wisconsin Governor's Northern Office, Hayward**
(aquaculture)
- **Wisconsin Land and Water Conservation Board (GIS)**
- **Wisconsin Maritime Museum, Manitowoc (teacher education)**
- **Wisconsin Society of Science Teachers (teacher education)**
- **Wisconsin State Historical Society (committee)**
 - Marine Archeology Committee
- **Wisconsin State Laboratory of Hygiene (water quality)**
- **Wisconsin State Legislature (business, nonindigenous species)**
- **Sen. Margaret Farrow/Rep. Dan Vrakas**

Communications Partnerships, 2000

Alaska Sea Grant

Water Wise boating safety book

American Fisheries Society

Fish Bioenergetics Model marketing agreement

AT&T Labs

On-line version of *Fishes of Wisconsin* book

Center for Limnology, UW-Madison

Teaching & Learning with Technology project
Fish Bioenergetics Model production & marketing

Chancellor's Office, UW-Madison

"UW-Madison on the Road" program

Chippewa Falls Museum of Industry & Technology

"UW-Madison on the Road" presentation

College of Agricultural & Life Sciences, UW-Madison

"Earthwatch Radio" project

Eastman Kodak Co.

Argentum VI conference proceedings
Argentum Web site

Great Lakes Commission

Great Lakes Information Network Partner
GLIN Advisory Board
Web design session, regional outreach workshop

Great Lakes Sea Grant Network

Regional Web site
Communications chair/representative
Outreach workshop planning

Illinois-Indiana Sea Grant

Zebra Mussel Watch cards
Great Lakes Fishes poster

Institute for Environmental Studies, UW-Madison

"Earthwatch Radio" project

Instructional Communications Systems, UW-Madison

"Earthwatch Radio" project

International Joint Commission

Projects data for regional research database

Maine-New Hampshire Sea Grant

Marine Science Careers publication

Michigan Sea Grant

Web design session, regional outreach workshop
Great Lakes Basins brochure series
Great Lakes Fishes poster

Milwaukee Public Museum

"UW-Madison on the Road" presentation

Minnesota Sea Grant

Great Lakes Fishes poster
Ruffe Watch cards
Round Goby Watch cards

New York Sea Grant

Zebra Mussel Watch cards
Great Lakes Fishes poster

Great Lakes Environmental Research Laboratory (NOAA)

"Earthwatch Radio" programs

Marine Geology & Geophysics Branch, National Geophysical Data Center (NOAA)

3-D Lake Michigan Bathymetric Map and other
Milwaukee Museum exhibit materials

National Sea Grant Library

Publications distribution

National Sea Grant Office

NOAA-Sea Grant outreach conference

North Carolina Sea Grant

Rip Currents brochure & poster distribution

South Dakota State University

Fish Bioenergetics Model as instructional software

Ohio Sea Grant

Sea Grant NIS Research & Outreach report
Great Lakes Fishes poster

Pennsylvania Sea Grant

Great Lakes Fishes poster

Sea Grant Association

Coastal Ecosystems and Habitats Theme Team

Sea Grant Communicators Steering Committee

Great Lakes Network representative
Radio Task Force
National Strategic Planning Session

2000 Wisconsin Sea Grant Progress Report

Sea Grant National Media Relations Office

National Sea Grant Experts Guide
News releases, clippings; media queries

School of Business, UW-Madison

“Earthwatch Radio” project

School of Journalism & Mass Communications

“Earthwatch Radio” project

Speakers Bureau, UW-Madison

UW Sea Grant speakers for service clubs

Tomelleri, Joseph; Leawood, Kan.

Great Lakes Fishes poster illustrations

Trent University, Peterborough, Ont.

Fish Bioenergetics Model as instructional software

**Underwater Archeology Program,
State Historical Society of Wisconsin**

Wisconsin’s Great Lakes shipwrecks project
Shipwreck dive guides marketing

U.S. Coast Guard

Zebra Mussel Watch cards

University of Idaho

Fish Bioenergetics Model as instructional software

University of Wisconsin Press

On-line version of *Fishes of Wisconsin*

Vermont, State of

Zebra Mussel Watch cards

Wisconsin Alumni Association

“UW-Madison on the Road” program

Wisconsin Department of Natural Resources

Wisconsin Fishes 2000 book
Zebra Mussel Watch cards
Teaching & Learning with Technology project
Annual fish consumption advisory distribution

Wisconsin Public Radio

“Earthwatch Radio” project

York University, Toronto, Ont.

Fish Bioenergetics Model as instructional software

“Earthwatch Radio” Stations, 1999-2000

(260 two-minute science & environmental news programs per year)

CALIFORNIA

Armed Forces Radio, March AFB
KOFX-FM, Oakland

COLORADO

KGNU-FM, Boulder
KDUR-FM, Durango

FLORIDA

WKLN-FM, St. Augustine

IDAHO

Environmental News Network, Sun
Valley

IOWA

KCCK-FM, Cedar Rapids
KROS-AM, Clinton
KALA-FM, Davenport
KDPS-FM, Des Moines
KCMR-FM, Mason City

ILLINOIS

WESN-FM, Bloomington
Illinois Radio Reader, Champaign
WPCD-FM, Champaign
WEPS-FM, Elgin
WDCB-FM, Glen Ellyn
WGEL-FM, Greenville
West Central Illinois Radio Info Service,
Macomb
Radio Information Service, Mount Carmel
WVJC-FM, Mount Carmel
WPNA-AM, Oak Park
WCCI-FM, Savanna

INDIANA

WJHS-FM, Columbia City
WPSR-FM, Evansville
Northeast Indiana Radio Reading Service,
Fort Wayne
WEEM-FM, Pendleton

MICHIGAN

WATZ-AM, Alpena
WLEW-AM, Bad Axe
WAUS-FM, Berrien Springs
WKAR Radio Talking Book, East
Lansing
WJMS-AM, Ironwood
WKJC-FM, Tawas City
WTCM-AM, Traverse City

MINNESOTA

KASM-AM, Albany
WTIP-FM, Grand Marais
KVSC-FM, St. Cloud
KSRQ-FM, Thief River Falls
KWOA-AM, Worthington

NEW MEXICO

KENW-FM, Portales

NEW YORK

WBSU-FM, Brockport
WEOS-FM, Geneva
WLVL-AM, Lockport
WPOB-FM, Plainview

OHIO

WCRS Reading Service, Akron
WZIP-FM, Akron
WATH-AM, Athens
WKHR-FM, Chagrin Falls
WDPS-FM, Dayton
WHSS-FM, Hamilton
WXTS-FM, Toledo

PENNSYLVANIA

WESA-AM, Charleroi
WPGA-FM, Philadelphia
WNAE-AM, Warren
WCLH-FM, Wilkes-Barre

TEXAS

KEOS-FM, College Station

WASHINGTON

World Exploration Society, Vancouver

WISCONSIN

WBSD-FM, Burlington
WCFW-FM, Chippewa Falls
WIPZ-FM, Kenosha
WORT-FM, Madison
WMSE-FM, Milwaukee
WOCO-AM/WOCO-FM, Oconto
WSUP-FM, Platteville
WDDC-FM, Portage
WQPC-FM, Prairie Du Chien
WSHS-FM, Sheboygan
WCSW-AM, Shell Lake

WDOR-AM/WDOR-FM, Sturgeon Bay

KUWS-FM, Superior

WTRW-AM, Two Rivers

CANADA

CHMR-FM, St. John's, Newfoundland

CAPR, Sydney, Nova Scotia

CKMS-FM, Waterloo, Ontario

TAIWAN

International Community Radio Taipei,
Taipei

SHORTWAVE

Radio for Peace International, Miami

Education Partnerships

Besides the education partnerships listed under Advisory Services and Communications, the following partnership activities were coordinated directly through the Education subprogram.

UW-Madison

Chancellor's Office – Madison JASON Project was invited to be a participant in the UW-Madison Future Fair held Dec. 4-5, 1999, at the Monona Terrace, Madison, Wis. Modeled after the World's Fair of 1904, the purpose of the Future Fair was to provide an entertaining and educational family event with a mix of displays and interactive exhibits focusing on life in the next century. The event was attended by nearly 7,000 people and some 4,525 Sea Grant educational program materials were distributed. Outside funding/in-kind contributions totaled \$11,363.03.

Madison JASON Partners & Schools

The Madison JASON Project is designed to excite and engage middle school students and their teachers in science and technology and to provide professional development for their teachers. More than 100 teachers and 3,000 students in 33 schools in the communities of Baraboo, Columbus, Cross Plains, De Forest, Madison, Middleton, Monona, Montello, Mount Horeb, Oregon, Stoughton, Sun Prairie, Verona and Windsor participated in this project in the last year.

Schools

Abundant Life Christian School
Baraboo Middle School
Cherokee Heights Middle School
Columbus Middle School
Country View Elementary School
Crestwood Elementary School
DeForest Middle School
Elvehjem Elementary School
Glacier Creek Middle School
Hamilton Middle School
Lincoln Elementary School
Mendota School
Montello Jr. High School
Mr. Horeb Intermediate Center
Netherwood Knoll Elementary School
O'Keeffe Middle School
Patrick Marsh Middle School
Randall Elementary School
Sacred Hearts School
Sandhill School
Savanna Oaks Elementary School
Sennett Middle School
Shorewood Hills Elementary School
St. James School
St. Peters School
Stephens Elementary School
Sugar Creek Elementary School
Toki Middle School
Verona Area Middle School
Whitehorse Middle School
Windsor Elementary School

Wingra School
Winnequah Middle School

Community Partners

Aldo Leopold Nature Center
Alliant Energy Foundation
Bethel Horizons Nature Center
BioPharmaceutical Technology Center
Institute
Henry Vilas Zoo
International Crane Foundation
Madison Art Center
Madison Children's Museum
Madison Metropolitan School District
Olbrich Botanical Gardens
Promega Corporation
Wisconsin Department of Natural Resources
MacKenzie Environmental Center

University Partners

Lawrence University
University of Wisconsin-Madison
Arboretum
Center for Biology Education
Elvehjem Museum of Art
Geology Museum
Space Place
University of Wisconsin-Milwaukee
Center for Continuing Education

National Partners

JASON Foundation for Education

APPENDIX J

External Advisory Groups

UW Sea Grant Institute Advisory Council, 2000-2001

Anders W. Andren (*ex-officio*)

Director, Sea Grant Institute
Director, Water Resources Institute
Professor, Water Chemistry
UW-Madison

Richard R. Burgess

Professor, Oncology
UW-Madison

Arnold L. Clement

Planning & Development Director
Racine County Planning & Development
Sturtevant, Wis.

George Evenson

Wisconsin Coastal Management Council
Citizen Representative
Sturgeon Bay, Wis.

Jeffery A. Foran

Director, Great Lakes WATER Institute
UW-Milwaukee

Frances C. Garb

Senior Academic Planner
Office of Academic Affairs
University of Wisconsin System
Madison, Wis.

Hallett (Bud) J. Harris (*Chair*)

Professor Emeritus, Natural & Applied Sciences
UW-Green Bay

Lee Kernen

Citizen Representative
Madison, Wis.

Dea Larsen Converse

Chief, Wisconsin Coastal Management Program
Madison, Wis.

Reuben H. Lorenz

Citizen Representative
Madison, Wis.

John J. Magnuson

Professor Emeritus, Zoology
Center for Limnology
UW-Madison

Kevin McSweeney

Professor, Soil Science & Environmental Studies
Director, School of Natural Resources
UW-Madison

David T. Michaud

Senior Environmental Scientist
Business Planning
Wisconsin Electric Power Co.
Milwaukee, Wis.

Nathaniel E. Robinson

Member, National Sea Grant Review Panel
Executive Assistant to the State Director
Wisconsin Technical College System
Madison, Wis.

Daniel O. Trainer

Professor Emeritus, Wildlife
Dean Emeritus, College of Natural Resources
Stevens Point, Wis.

Committee on Advisory Services, 1999-2000

Carmen Aguilar (*Scientist*)
Great Lakes WATER Institute
Milwaukee, Wis.

Steve Skavroneck (*Water Quality*)
Milwaukee, Wis.

Jack Culley (*Business*)
Sailboats, Inc.
Superior, Wis.

Angie Tornes (*Recreation*)
Rivers, Trails and Conservation Assistance
National Park Service
Milwaukee, Wis.

John Lacenski (*Water Safety*)
Boating Law Administrator
Wisconsin Department of Natural Resources
Madison, Wis.

Dave Wentland (*Coastal Engineering*)
Coastal Planning and Design
Green Bay, Wis.

David Lee (*Coastal GIS*)
Bayfield County Land Information Office
Washburn, Wis.

John Wolf (*Aquaculture*)
Alpine Farms
Sheboygan Falls, Wis.

Terry Lychwick (*Fisheries/NIS*)
Northeast Region (Lower Fox) District Office
Wisconsin Department of Natural Resources
Green Bay, Wis.

Pat Zigelbauer (*Education*)
Slinger Middle School
Slinger, Wis.

Communications Advisory Panel, 2000-01

Marc Anderson (*Faculty*)

Professor, Civil & Environmental Engineering
Professor, Aquatic Sciences Center
UW-Madison

Philip Keillor (*Outreach*)

Coastal Engineering Specialist
Sea Grant Advisory Services
UW-Madison

Maxine Appleby (*Recreational Fishing*)

Adgrafix-Webmariner
Former Lake Michigan Charter Fishing Captain
Milwaukee, Wis.

Peyton Smith (*Chair*)

Assistant Vice Chancellor
General Educational Administration
UW-Madison

Albert Friedman (*Publishing*)

Director, University Publications Office
UW-Madison

Patrick Strickler (*Media Relations*)

Director, University Communications Office
UW-Madison

David Gollon (*Aquaculture*)

Gollon Bait & Fish Farm, Dodgeville, Wis.
Wisconsin Aquaculture Association

Stephen Wittman (*ex officio*)

Assistant Director For Communications
UW Sea Grant Institute

Subprogram Science Advisors

LIVING RESOURCES

James F. Kitchell
Center for Limnology
University of Wisconsin-Madison

ESTUARINE & COASTAL PROCESSES

J. Val Klump
Great Lakes WATER Institute
University of Wisconsin-Milwaukee

MICROCONTAMINANTS & WATER QUALITY

David E. Armstrong
Water Chemistry Program
University of Wisconsin-Madison

POLICY STUDIES

Richard C. Bishop
Agricultural Economics
University of Wisconsin-Madison

AQUACULTURE & SEAFOOD TECHNOLOGY

Jeffrey A. Malison
Food Science Department
University of Wisconsin-Madison

Fred P. Binkowski
Great Lakes WATER Institute
University of Wisconsin-Milwaukee

BIOTECHNOLOGY

Richard E. Peterson
School of Pharmacy
University of Wisconsin-Madison

NEW INITIATIVES

Anders W. Andren
Sea Grant Institute
University of Wisconsin-Madison

Received
National Sea Grant Library

MAY 31 2006

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