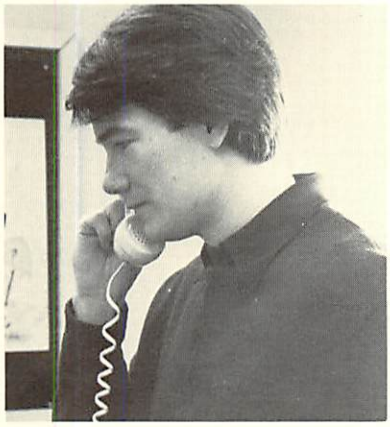
Minnesota Sea Grant Institute

Annual Report

1981-82

Robert Holt
Dean, Graduate School



Tom Mack
Marine Recreation and Economics Agent

Nancy Berini
Public Relations Representative

1981-82 was a period of moderate growth for Minnesota Sea Grant. Research areas established in 1980-81 were not altered and one new project was introduced. Fisheries, coastal engineering, marine applied economics and water safety (hypothermia) all need more research and extension activity before we feel the job is thoroughly completed. The public benefits from our activities as soon as it is realistically possible. We are most proud of our graduate students. Four have now been honored for their Sea Grant supported research.

Sea Grant is people working together. Recently we welcomed a new member to our Minnesota family—Dean Robert Holt of the Graduate School, who follows Dean Warren Ibele as the Dean responsible for the Sea Grant Institute. Bob Holt's background is in political science, where he is known for his publications on the political bases of economic development. Formerly he was Professor and Head, Department of Political Science (UM).

The Sea Grant family is also losing two members who are moving upward to more responsible positions. Tom Mack came to Minnesota Sea Grant in the winter of 1979 from a one-year internship with New York Sea Grant Extension. Previously he did his Master's work in Madison, examining recreational boating safety. Tom has focused on the recreational industry of the Superior coastline, working with family resort owners on tourist marketing plans, with the town of Two Harbors on recreational waterfront development, and with principal investigators of Sea Grant research in designing studies on tourism development. He has produced a newsletter *North Shore Correspondence* since 1980, maintained a "Duluth Visitor Statistics Abstract," and worked with boating groups to understand and benefit from Sea Grant research on hypothermia. Tom's talents with residents and tourists on the Superior coast will be missed—we wish him good luck in the computer business.

Nancy Berini has been Sea Grant Extension's communicator since 1980. She wrote and produced *The Seiche*, and produced important Extension publications like *Fixin' Fish* and *Lacustrine Lessons*, a curriculum guide designed to introduce science teachers and their students to marine topics, and numerous other publications. Nancy is starting her own free lance publications business in Duluth.

If you, our readers, have problems the University faculty can solve, let me know. Communication is the key to our success and our future.

Donald C. McNaught
Director
Minnesota Sea Grant Institute

The Minnesota Sea Grant Program 1981-82

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Published by the Minnesota Sea Grant Institute, University of Minnesota, St. Paul, Minnesota, 1983. Copies are available by writing the Institute at 116 Classroom Office Building, 1994 Buford Avenue, St. Paul, Minnesota 55108.

This work is the result of research supported by the NOAA, Department of Commerce, Office of Sea Grant, under Grant #NA81AA-D-00114. The U.S. Government is authorized to produce and distribute reprints for governmental purposes.

We would also like to thank the Minnesota Legislature, the University of Minnesota Agricultural Extension Service, Agricultural Experiment Station and Continuing Education and Extension.

The Laurentine leaving Duluth-Superior Port. Background: Aerial Lift Bridge.

THE MINNESOTA SEA GRANT INSTITUTE PROGRAM

This is a report of the University of Minnesota's sixth year of participation in the National Sea Grant College Program. The Sea Grant program, funded by the National Oceanic and Atmospheric Administration, is a three-part program of marine research, education, and advisory services at the Twin Cities and Duluth campuses, as well as 29 other programs throughout the nation's coastal states.

Benefiting the Nation and the Great Lakes Region

Sea Grant's applied research emphasis necessitates commitment to working with representatives from industry and the public to solve marine and coastal problems. On a regional level, the Minnesota Sea Grant Program in cooperation with Sea Grant Programs in Wisconsin, Michigan, New York, Ohio, and Indiana/Illinois is working to develop, use, and conserve the vast resources of the Great Lakes—our nation's third ocean.

Lake Superior is the largest freshwater body in the Northern Hemisphere, providing an underdeveloped resource that must be properly developed and maintained. The Great Lakes region represents over one-fourth of the Gross National Product, and it operates under a unique set of constraints which are not found on the tidewater seacoasts. Lake Superior has primary importance for transporting iron ore, grain, peat, and coal, all primarily domestic products.

Nationally the Minnesota Sea Grant Program has:

- increased the knowledge of hypothermia and hypothermic reactions throughout cold-water regions through research in Minnesota's cold-water Hypothermia Laboratory in Duluth.
- developed and increased the use of the cryobiological method of preserving fish gametes for up to three years.
- provided scientific and technical training to 23 students since 1979; most are now sharing their knowledge and skills with government, industry, and universities throughout the nation.
- successfully developed bait leech culture in laboratory and pond settings.
- planned a national conference on Maritime User Fee perspectives on the Upper Great Lakes.

During the University's six years of association with Sea Grant, the Institute Program has contributed research and education stemming from interest and expertise in coastal and environmental engineering, processes management, sedimentation contamination, hypothermia, fisheries and aquaculture, marine natural products and marine applied economics.

This annual report covers our program's activities from October 1, 1981, to September 30, 1982.

Sea Grant Directors Donald McNaught and Dale R. Baker (Extension) talk with Rep. James L. Oberstar (DFL 8th District, Merchant Marine and Fisheries Committee).

Director McNaught and Eugene Fritz, Office of Sea Grant Monitor and Fisheries Program Leader.

Dr. Fay Biles, site team member responsible for the Water Safety/Hypothermia subprogram review.

SEA GRANT EXTENSION AND ADVISORY SERVICES

Disseminating Important Research Results

October 1982 marked the beginning of the ninth year for the Sea Grant Extension Program in Duluth. Each of the agents, Jeff Gunderson in Fisheries, Tom Mack in Marine Recreation, Douglas Tave in Aquaculture, and Nancy Berini in Communications, produced exceptional programming under Bruce Munson's acting directorship. Director Dale Baker was on leave of absence working toward his Ph.D. in Environmental Engineering at the University of Minnesota, Twin Cities campus.

In review, Extension demonstrated a mature posture. With the addition of Douglas Tave, marine educational staff development at the departmental level matured. The summer of 1982 marked Sea Camp's final year and its accomplishments in education and marine science did not go unnoticed. Over the past years 12,046 students, many of them minority and low income, have attended. Marine Education Agent Bruce Munson continued with his much in demand in-service for teachers and education students. The educator fish "Lawrence the Lake Trout" spoke with well over 100,000 people in 1981-82.

In 1982, hypothermia and other research areas provided "Sea Grant Radio" programming for 24 National Public Radio shows and numerous workshops, educating the City of Duluth's workers, hospital personnel, and emergency medical technicians, further disseminating this important information.

The City of Two Harbors requested agent Tom Mack's assistance in developing ideas for their community. As a result, a waterfront development project in Two Harbor's Burlington Bay was developed for representatives of 15 to 20 public agencies and private industries.

Planning for the National Maritime User Fee Conference on the Upper Great Lakes sessions had begun. Sea Grant researcher Wilbur Maki began work on the development and dissemination of a recreational computer model with Marine Recreation Agent Tom Mack.

Fisheries Agent Jeff Gunderson worked out the implementation of NOAA's satellite map of Lake Superior's surface and subsurface temperatures for fishermen.

Bruce Munson teaching young marine enthusiasts at Sea Camp.

Pulling in the trap net.
Jeff Gunderson and commercial fisherman Doug Chambers.

Lawrence in action.

GREATER DEMAND FOR PUBLICATIONS

As of March 1982 the Sea Grant Extension office had 1,150 requests for *Bait Leech: Its Nature and Nuture*, and Jeff Gunderson's fisheries publications were routinely used in ichthyology classes at University of Minnesota-Duluth and the University of Wisconsin at Superior.
Fixin' Fish became a very successful publication with reprints spanning the globe. Use of underutilized fish in canning, cooking, and preserving became important especially in the depressed Iron Range area. Requests for other publications and research information increased markedly. In 1982, 19 research articles were published.

Clearly, marine agents are the people in the field who educate the public and function as sounding boards for problem-solving in marine science.

1981-82 Research and Extension publications.

Marine Advisory Staff

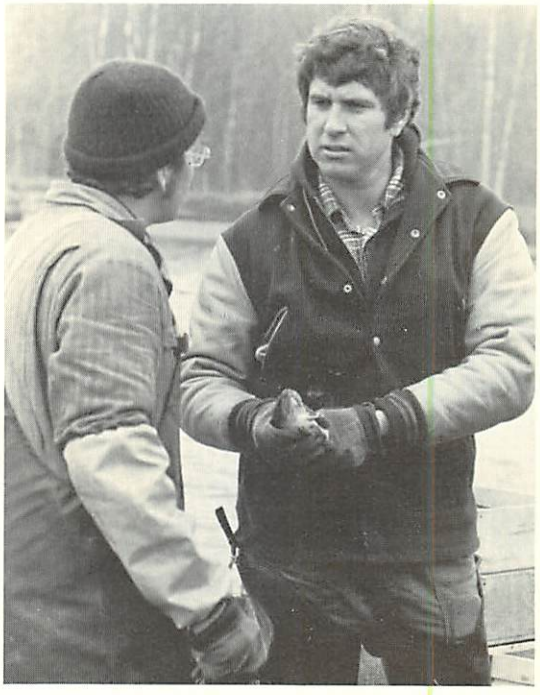
Marine Fisheries
Jeff Gunderson—Fisheries Agent
Sea Grant Extension Program
208 Washburn Hall
University of Minnesota-Duluth
Duluth, Minnesota 55812
(218) 726-8106

Aquaculture
Douglas Tave—Aquaculture Specialist
130 Hodson Hall
1980 Folwell Avenue
University of Minnesota
St. Paul, Minnesota 55108
(612) 376-9921

Marine Recreation
Tom Mack—Marine Recreation Agent
Sea Grant Extension Program
208 Washburn Hall
University of Minnesota-Duluth
Duluth, Minnesota 55812
(218) 726-8106

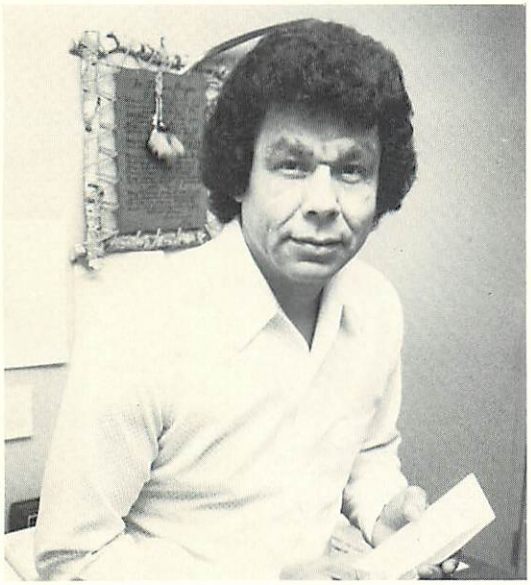
Marine Education
Bruce Munson—Marine Education Agent
Sea Grant Extension Program
208 Washburn Hall
University of Minnesota-Duluth
Duluth, Minnesota 55812
(218) 726-8106

Communications
Nancy Berini—Public Relations Representative
Sea Grant Extension Program
208 Washburn Hall
University of Minnesota-Duluth
Duluth, Minnesota 55812
(218) 726-8106

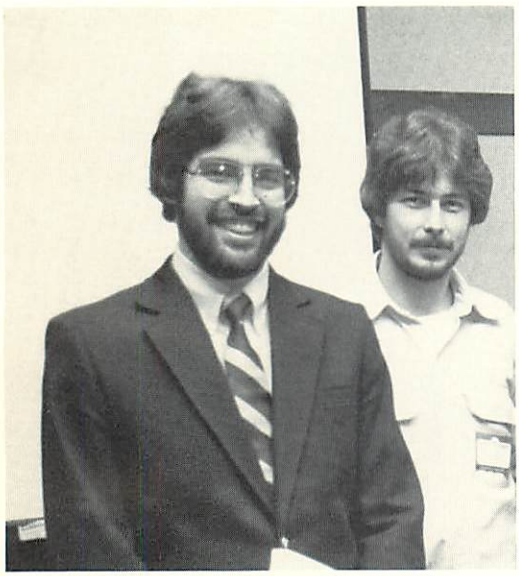

Dale R. Baker and fisherman discuss inland herring.

Coastal Engineering
Dale R. Baker—Extension Director
Sea Grant Extension Program
208 Washburn Hall
University of Minnesota-Duluth
Duluth, Minnesota 55812
(218) 726-8106

The Marine Advisory Program is coordinated by Dale R. Baker at the program's office at the University of Minnesota in Duluth, 208 Washburn Hall, Duluth, Minnesota 55812, (218) 726-8106



Robert Diver
Director of American Indians in Marine Sciences.



Research Assistant Dave Lee (Economics), Jeff Denny (Sea Grant Award Winner and Research Assistant, Biology).

MARINE EDUCATION AND TRAINING

Sea Grant sponsored 15 scholarships in the 1981-1982 funding year, 12 were Graduate Traineeships, and 3 were for American Indians in Marine Sciences. Graduate training is at the core of our marine research education program in Minnesota, and one reason for the close relationship between the Sea Grant Institute and the Graduate School. Providing a communications link between University researchers' laboratories and private industry is crucial to the Sea Grant mandate and part of our ongoing dissemination effort; good students characterized by careful preparation are our best emissaries.

Our American Indian training program is the first of its kind in the nation. Now in its second year, the program works with an established Indian program already in place at UMD and with its coordinator Robert Diver. It is anticipated that in training these dedicated students we will help prepare marine scientists for businesses not normally entered by American Indians.

Our graduate students have distinguished themselves in the process of completing research. In 1982 Jeffery Denny (Dept. of Biology, UMD) won honorable mention in the Master's category of the Sea Grant Association student competition for his project on bait leech culture while working under Dr. Hollie Collins. Training students for careers in marine sciences is a farsighted commitment to the field.

MARINE CURRICULUM

An in-service curriculum project focusing on acid rain and an interdisciplinary approach to marine research problem solving has been developed by Sea Grant researcher Eugene Gennaro, Associate Professor of Curriculum and Instruction, and Sea Grant trainees Harriet Stubbs and Steven Rakow. They have compiled Great Lakes curriculum for the elementary and secondary levels from Michigan and Ohio Sea Grant and adapted these materials for Minnesota use.

A series of statewide, in-service, teachers workshops were held to pass this information along. The model generated increased literacy in the marine sciences and infused new techniques into existing curriculum. Tested materials are sent to the national clearinghouse Marine Educational Materials System and the National Sea Grant Depository.

Bruce Munson, Sea Grant's Marine Education Agent in Duluth, and Nancy Berini, Extension Communicator, continued to produce *Lacustrine Lessons* in 1981-1982. This is a carefully chosen collection of aquatic-related projects sent to teachers in the form of a bimonthly newsletter.

Minnesota Sea Grant Traineeships

Project Number	Title and Principal Investigator	Trainees
R/F-6	The Relationship of Growth Rate Changes to Smoltification of Chinook Salmon—I.R. Adelman	Donald Pereira
R/C-4	A Market Segmentation Study of North Shore Tourism—Uel Blank	Sally Stanbrough
R/A-1	Bait Leech, *Nephelopsis obscura,* Culture and Economic Feasibility—H.L. Collins, L.L. Holmstrand, and W.A. Jesswein	Jeffrey Denny
R/CL-1	Microcontaminant—Air, Water Sediment, Biota Interactions in Lake Superior—S.J. Eisenreich	Brian Looney
R/F-5	Estimation of Yield Potential of Suckers (Catostomidae) from Minnesota Tributaries to Lake Superior—G.R. Spangler	Sheryl Middlemis
R/F-9	Nutrients, Productivity, and Water Quality in Lake Superior: A Mechanistic Approach to an Oligotrophic Food Web—G.D. Tilman	Richard Kiesling
R/S-2	Diving Reflex: Cardiovascular Adjustments to Cold and Water Stress—L.E. Wittmers	David Howard
R/F-12	Application of Gamete Preservation Techniques to Enhance Minnesota Aquaculture—E.F. Graham	Alan Erdahl
R/CL-6	Sediment Mass Movement on the Tailings Fan in Lake Superior at Silver Bay, Minnesota—W.H. Busch and T.C. Johnson	Dora Barlaz
R/C-8	Recreation Industry—Activity Cluster Assessments for Recreation Resource Management—W.R. Maki	Kathleen Novak
E/T-5	Inservice Training in Marine Education for Elementary and Secondary Teachers—A Dissemination Model—E.D. Gennaro	Harriet Stubbs Steven Rakow
E/T-4	American Indian Scholarship Students—Undergraduate Education for American Indians in the Marine Sciences—R. J. Diver	Monique Luzius Michele Luzius Michael Swan

COASTAL PROCESSES

SEDIMENTATION MASS MOVEMENT ON SILVER BAY DELTA

A new study in the Coastal Processes subprogram during the 1981-1982 year was the investigation of sediment movement on the taconite delta, or what has come to be known as Reserve Delta at Silver Bay.

Sea Grant geologists William Busch and Tom Johnson and Sea Grant trainee Dora Barlaz have been investigating whether movement on the slope has caused resuspension of asbestos-like fibers found in taconite tailings. Concern by the industry and ancillary regulatory agencies over the entrance of these particles into Lake Superior, Duluth's source of drinking water, prompted the study.

The researchers are particularly interested in the interaction between the tailings and the natural clay bottom of the lake. The delta is composed of tailings on top of fine-grain clay, appearing similar to an alluvial fan.

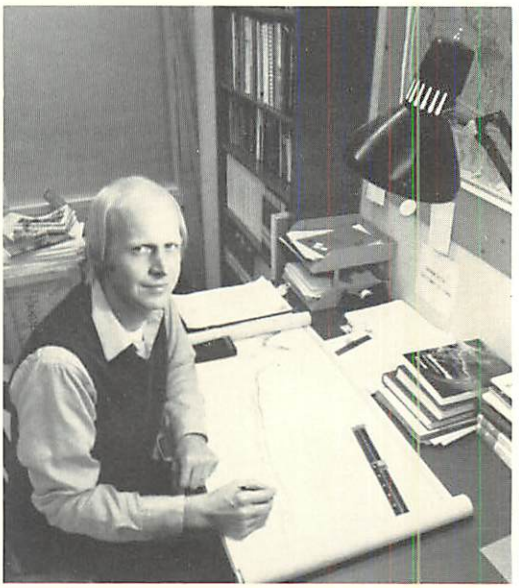
To determine if sediment movement is present, they have been comparing profiles of the shoreline throughout recent years and then comparing the sediment makeup of inshore and offshore samples.

To make this comparison the geologists go shipboard. Using a gravity corer and box corer to take sediment samples and a seismic reflection profiler to map the delta, they amass needed data.

Another concern is the composition of the delta as the water gets deeper. According to Johnson, in Western Lake Superior there is an increase in clay sediment as the water depth increases. Clay is finer grained and more reactive to pollutants. Fortunately there appears to be less movement of sediment in the deeper water and therefore less potential problem.

Back in the laboratory, samples are x-rayed and examined for sedimentary structure data; engineering properties, porosity, sheer strength, and compressability are tested. This gives baseline information on how the sediments are behaving at present and an indication of how they will behave in the future, information important in identifying the relative stability of the man-made delta. Potential users will include industrial waste disposal programs and environmental regulatory agencies.

Dr. Tom Johnson, Geologist.



Dr. William Busch examining the seismic profile of Silver Bay Delta.

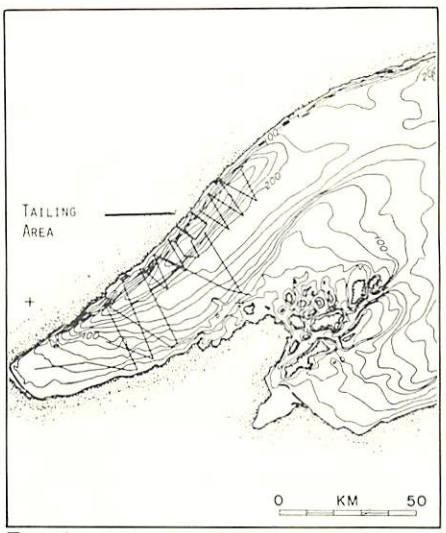
TURBIDITY CURRENTS AND INDUSTRIAL WASTE—A MODEL

A companion study to the Busch/Johnson project is Gary Parker and Heinz Stefan's investigation of the redistribution of tailings deposits in Lake Superior by turbidity currents. Turbidity currents are water currents laden with suspended sediments that move down sloping beds of otherwise still bodies of water. The driving force behind the movement is the sediment.

Reserve Bay delta affords an excellent opportunity to study this process in action, observing redistribution of taconite/clay sediment from shallow to deeper water.

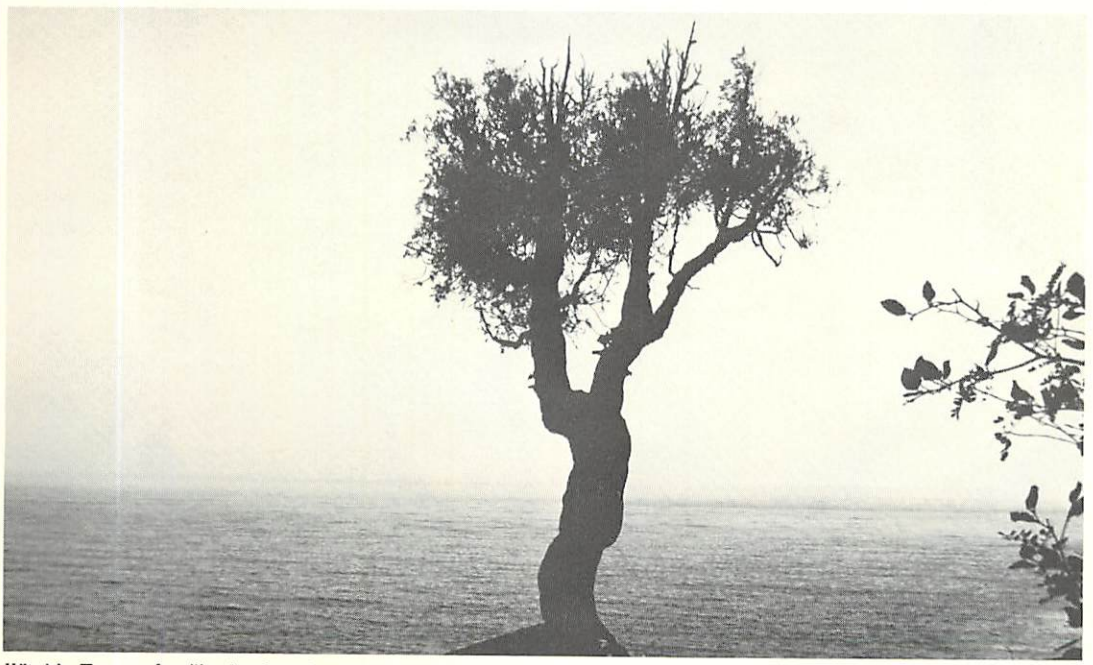
During the period of disposal (from 1955 to 1980), turbidity currents were predicted and observed to provide a direct route for moving the tailings into the lake. In 1972 an industry-generated study by geologists Normark and Dickson estimated that 45 percent of the discharged tailings had been moved into deeper water by turbidity currents.

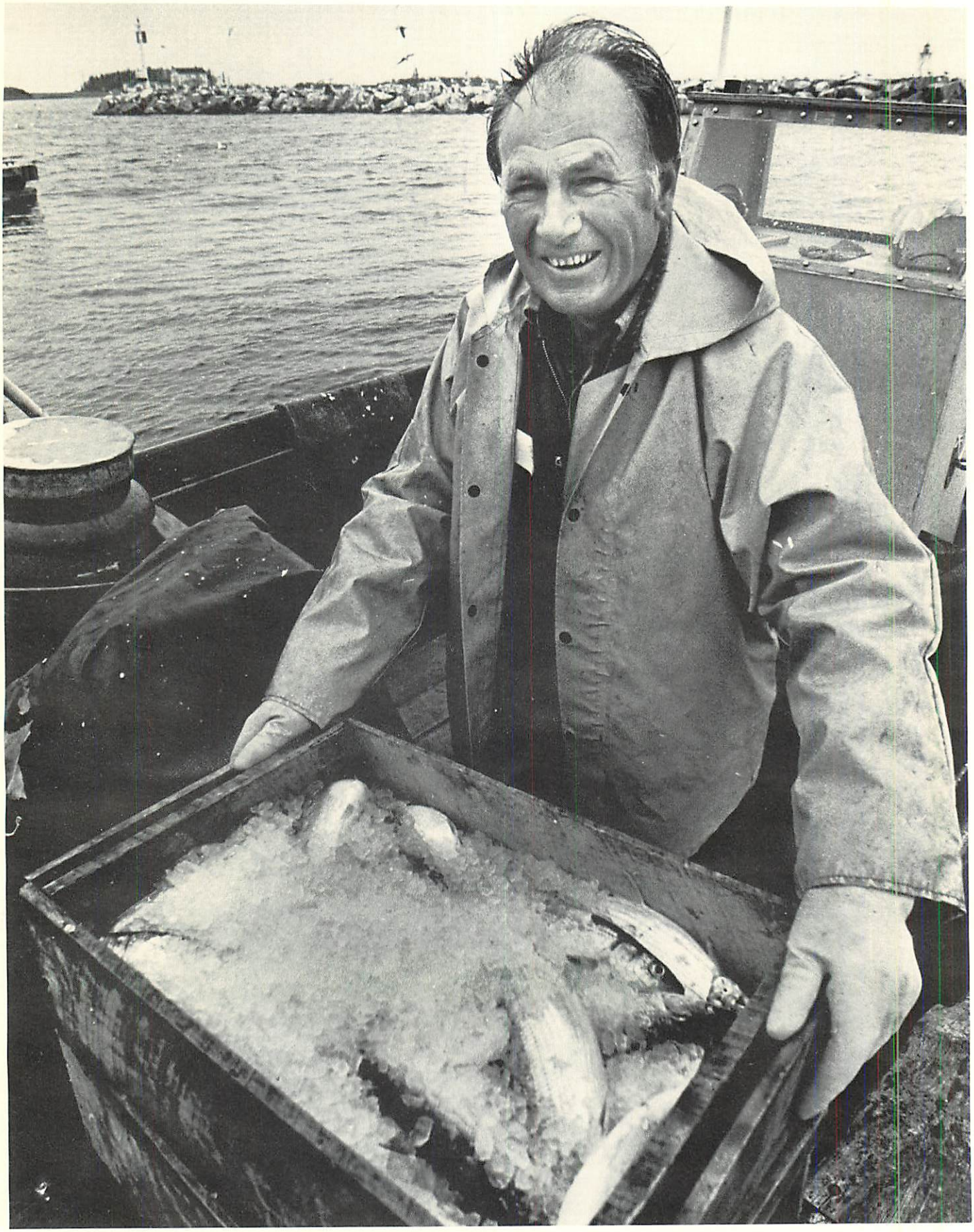
What was not known at the time were two additonal factors: findings of trace amounts of asbestos-like fibers in the tailings, and the possibility of their migrating by drift from the delta deposit to the circulating longshore water used for drinking. Study of the eroding and depositing currents at the setting is therefore very important since the delta is being reworked by wave action and by movement of the sediments themselves. An examination of these resuspending currents is basic to the development of a computational model that can be tested and applied to other sites of disposal involving mined materials.



Taconite delta on the Western arm of Lake Superior. Outlined here, the route of Dr. Busch's research vessel.

Other sedimentologists, oceanographers, limnologists, and reservoir engineers are particularly interested in the findings of Parker and Stefan. The prediction of future industrial disposal sites will undoubtably take into account the processes of eroding drift and depositing turbidity currents.


Witch's Tree, a familiar landmark on the Northshore.



Tom Eckel, one of Lake Superior's 46 commercial fisherman, displays herring catch.

FISHERIES AND AQUACULTURE

Feeding the Nation

One of the most successful and ongoing efforts funded for the past five years has been Dr. Edmund Graham's gamete preservation research. Rising out of the hatcheries' need to maintain an extended period of time to bring male and female gametes together, early research by Graham and Assistant Scientist Marcia Schmehl led to the development of two methods for storing sperm. The liquid method keeps sperm viable for days; the frozen method keeps sperm viable for years.

The scientists have worked successfully with brown trout, rainbow trout, chinook salmon, walleye, northern, muskellunge, yellow perch, and bluegill sunfish gametes.

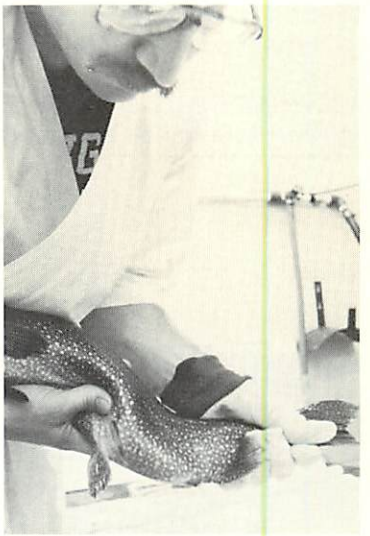
Recent efforts have been concentrating upon the preservation of various species of fertilized ova. Dr. Graham states, "There is a need now to understand the female's role in spawning and on fertilization mechanisms such as the length of time gametes are viable." Sea Grant trainees David and Alan Erdahl have become involved in testing the fertilization and hatchabililty of eggs subjected to different treatments.

Requests from individuals and institutions throughout the world have demonstrated the importance and usefulness of the study. Federal, State, and private fish hatcheries and marine biologists throughout the nation have been interested in applying the cryobiological technique.

Among the important applications of their work are these: unlimited interstate shipping of spermatozoa and ova, allowance for gamete union when the parent fish do not ripen at the same time, maintenance of a bank of viable fish gametes, year-round use of hatchery personnel, and an increase in the number and quality of useable gametes.

This emerging industrial technique has a potential large-scale impact, with fisheries management personnel particularly interested.

Dr. Edmund Graham



Research Associate David Erdahl milking Lake Trout semen.

Research Associate David Erdahl explains cryobiological techniques.

MICROCONTAMINANTS IN LAKE SUPERIOR'S ECOSYSTEM ASSESSED

Microcontaminant pollution has been of concern in the Great Lakes since its relative notoriety in the 1970's. While microcontaminants are largely undetectable to the unaided senses, they do enter the ecosystem and can increase the risk of health hazards in indigenous species and humans who may unknowingly injest them.

A recent study by University of Wisconsin Sea Grant

researchers has concluded that exposure to PCBs in the womb results in an increase in the number of infectous illnesses for the baby's first four months of life. Clearly this is important research since five parts per trillion of PCB (polychlorinated biphenol) in the environment may concentrate in fish species at 15 parts per million, increasing concentration 3,000,000 times.

Minnesota Sea Grant researcher Steven J. Eisenreich has been studying microcontaminants in the Great Lakes for the past several years. Working with Sea Grant, the International Joint Commission and the Environmental Protection Agency, Professor Eisenreich has taken samples of environmental water from Minnesota to New York.

With their recent completion of a three-year study of Lake Superior microcontaminants, Eisenreich and graduate students Paul Capel and Brian Looney have begun to generate a model of the movement of organic pollutants as they enter and leave the system.

Microcontaminants like PCB, DDT, PAH, and dioxin enter Lake Superior from the air transferred by a midcontinental air mass. Once the polluted particulates reach water they cling to particles within the lake. Since pristine Lake Superior has few particles, the pollutants do not dissolve but settle into the sediments. As a consequence they enter into the biota and then into the food chain.

Previous to this research, industrial contaminants like PCB and other organic contaminants had yet to be thoroughly traced through their cyclical transformations in marine settings. The dynamic physicochemical model can be used for other lakes in the Great Lakes system and the oceans. Now that the investigators have determined in detail the precise methods of contaminant departure, whether through tributary outflow, biodegradation, or vaporization, they are able to help propose effective methods for controlling contamination.

Eisenreich and colleagues have published a number of articles on the topic. The contribution this information will make to society, industry, and those who depend on fish for food is important.

Lake Superior's wilderness shoreline below Split Rock Lighthouse.

SALMON COMING OF AGE

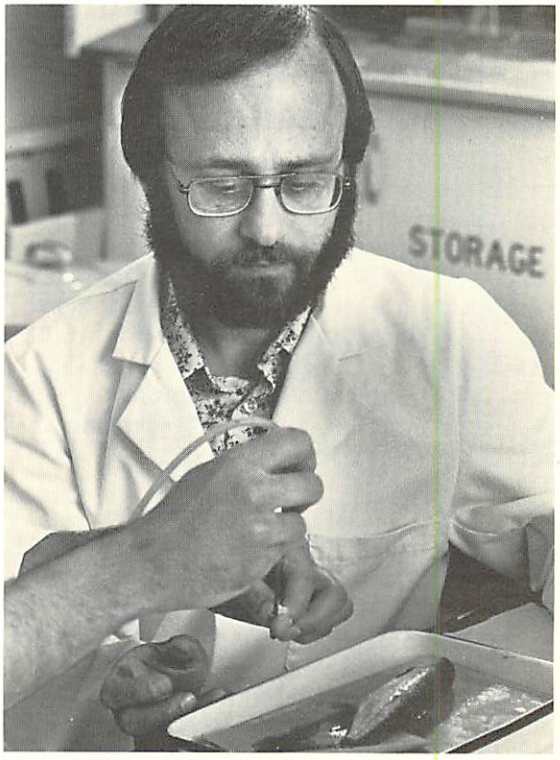
Dr. Ira Adelman, Sea Grant researcher and Associate Professor of Fisheries and Wildlife, and Sea Grant trainee Don Pereira have been observing the relationship of growth rate changes and characteristics associated with smoltification in Chinook salmon.

Smoltification is the process in a salmon's life cycle when it becomes morphologically, physiologically, and behaviorally ready to more from its home stream to a large body of water. In Minnesota the salmon migrate to Lake Superior, imprint upon the stream they leave, and return to that stream to spawn.

Adelman and Pereira have been closely monitoring smoltification for a number of reasons. By releasing the salmon from the hatchery during smoltification, the fish will move downstream rapidly and competition with native fish in the streams will be minimized. Overall returns to the home stream are greatly increased in part because imprinting seems to occur during smoltification.

Also by manipulating in the laboratory the environmental factors that trigger smoltification, the researchers have been able to alter the time of smoltification. Fish spend less time in the hatchery and can be released earlier.

In their second year of funding, the biologists have been concerned with the effects of both temperature and light on the smoltification process. By manipulating reproduction factors appropriately, effective management can be insured and the Great Lakes may soon be able to adequately support salmon stock.



Dr. Ira Adelman in his laboratory.

BALANCING COMMERCIAL AND RECREATIONAL USE OF THE DULUTH BAY

Creating a Model

The Duluth Bay, North Shore region is one of the most commercially productive and frequently used recreational areas of Lake Superior. Uses of the estuary for commercial and sport fisheries compete with use of the area for recreational purposes: swimming, sailing, boating, and sunning.

Water quality in this area is greatly influenced by the influx of general human activity according to Dr. David Tilman, Associate Professor of Ecology and Behavioral Biology, and Sea Grant trainee Richard Kiesling. They have been involved in monitoring the changes and patterns of seven major algal species in the St. Louis River Estuary.

During field sampling the researchers determined that two nutrients besides commonly abundant phosphate are involved in controlling the growth rates of algae and zooplankton; they are nitrate and silicate. Subsequent laboratory experiments indicated that species composition and quality of algal production depend upon the relative availability of these three nutrients. Too many nutrients and the wrong ratios of N:P and Si:P in the water greatly reduce both the recreational and the fisheries value for human use and produce algal bloom, an often unpleasant environment. Control of blue-green algae is also desirable from a commercial vantage point. Enriched waters become dominated by a few species of algae which are inedible for plankton and often toxic, further limiting the production of desirable fish species.

Fishery aquaculture can be hindered by the detrimental effects of fertilization on the quality of algal production, and changes in fish populations have been directly attributed to changes caused by increased nutrient influx. Primary examples include walleye decline in Inner Saganaw Bay and a decrease in whitefish, walleye, and lake herring in the Bay of Quinte. Drastic changes in species populations have been attributed to a general decline in environmental water quality; less oxygen, more algal enrichment, and waters enriched from more silt generated by agricultural techniques have all contributed to the general decline.

Now in their third and last year of study, Tilman and Kiesling are refining their mechanistic model of algal and zooplankton production so that it may be better used for management decisions concerning water quality and fish production in Lake Superior.

Potential users include fisheries managers who can use this information to predict fishery yields, as well as environmental agencies that determine nutrient loadings to the lake.

YIELD POTENTIAL OF SUCKER DETERMINED

A Fisheries Population Model is Built

Fisheries resource managers have for some time been interested in the development of strategies to estimate the size and age of populations of particular species. In Lake Superior's tributaries, the underutilized sucker (Catostomidae) has been of considerable interest. Two species of sucker, the longnose and the white, have been examined by Dr. George Spangler, Associate Professor of Fisheries and Wildlife, and Sea Grant trainee Sherry Middlemis.

What they have discovered is that sucker has very little potential for commercial harvest. By estimating the size, sex ratio, and age composition of spawning runs and then estimating potential yields, the researchers have shown that there is virtually no relationship between parental abundance and production of young.

Field efforts began in the spring, when adult suckers come to Lake Superior's tributaries to spawn. The biologists trapped sucker adults, some as old as 20 years. About ten days later they trapped their fry as they moved downstream.

Once the species were brought back to the laboratory, they were separated by their biological characteristics to determine the population structure of the spawning stock. Middlemis used a single ray from a fin, sliced

Dr. George Spangler
Fisheries and Aquaculture.

Collecting bait leech samples in UMD test pond.

it, mounted it on a slide, and then examined the bone growth to determine growth rate and age.

The researchers entered their data into a computer which simulated a variety of growth and mortality conditions to estimate the yield potential. This also helped determine which streams were currently most abundant.

Spangler has been able to determine the small yield potential for commercial harvest of sucker, thereby discouraging the development of an intensive fishery for these species. Spangler was able to warn potential investors that this resource did not deserve and could not withstand development.

LABORATORY CULTURE OF THE LUCRATIVE BAIT LEECH: *Nephelopsis obscura*

In recent years live bait leeches have become the "preferred" bait of Minnesota walleye fishermen. As a result, approximately 60 tons of leeches are harvested annually from Minnesota lakes and ponds with little resource management. This demand results in a yearly industry revenue of almost 3.5 million dollars.

Concern for their depletion prompted Sea Grant researchers Hollie Collins, Linda Holmstrand, and Wayne Jesswein and graduate trainee Jeff Denny to determine the economic feasibility of culturing the ribbon leech under controlled settings.

During their three-year study they successfully kept leeches alive in laboratory conditions, stimulated reproduction out of phase, raised leeches to larger and jumbo sizes, and developed a system that analyzed the survival, nutrition, growth, and reproductive needs of the leech.

Optimal conditions for the propagation and production of leeches in laboratory culture and pond settings were ascertained. These included proper lighting, ambience, controlled temperature, and adequate nutritional diet.

Cost estimates were developed for laboratory leech culture, pond rearing, and wild harvesting. Costs per pound in Minnesota's six Department of Natural Resources regions were estimated by a breakdown of expenses. Average costs and volumes for each region were used.

The researchers found the price per pound of wild harvesting varied regionally; but the average cost per pound of cultured bait was indeed feasible, on the average one cent more per pound.

Commercial bait culture production is particularly feasible during the summer months of July through September when there are few wild leeches to be found and high demand for their recreational use.

The researchers have published an informative synopsis entitled *Bait Leech: It's Nature and Nurture* available through Sea Grant Extension. It provides timely tips for fishermen and potential leech breeders.

SOME ASPECTS OF THE EARLY LIFE HISTORY OF LAKE HERRING IN WESTERN LAKE SUPERIOR

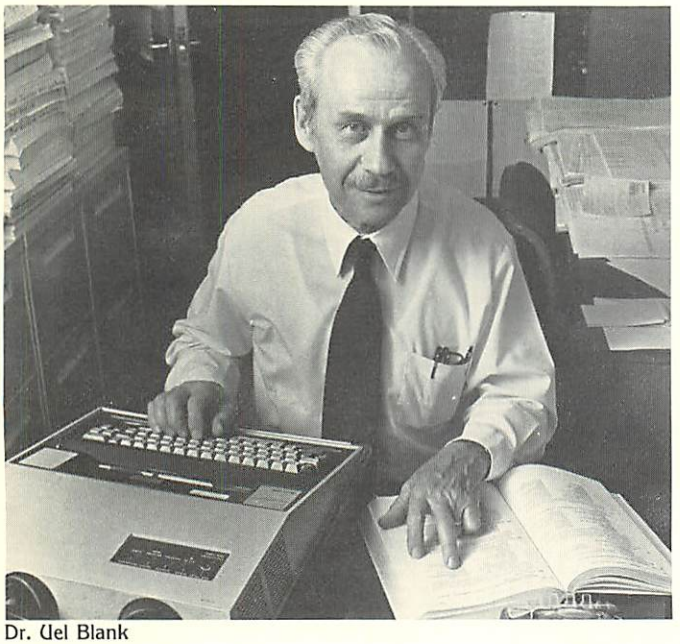
Great Lakes coregonine populations have declined rapidly over the years since 1955. With their decline has come the decline of the forage base for lake trout. Researchers have found that when there is a shift from a multiple species to a single species forage base the survival of top level predators, like lake trout, is jeopardized. Such a shift has been occurring in Lake Superior.

Sea Grant researcher James Underhill and Sea Grant research assistant Jay Hatch from the University's Ecology and Behavioral Biology Department have been studying aspects of the early life history of the most important forage species in Western Lake Superior, the lake herring. While the natural history of adult lake herring is well documented, virtually nothing is known about the larval period of their life cycle. The researchers believe that the size of the adult population may be determined during the larval period of the life cycle and, therefore, an understanding of larval ecology must be gained if informed management decisions are to be made. Methods and data that help rehabilitate lake herring populations also may help sustain or increase lake trout populations.

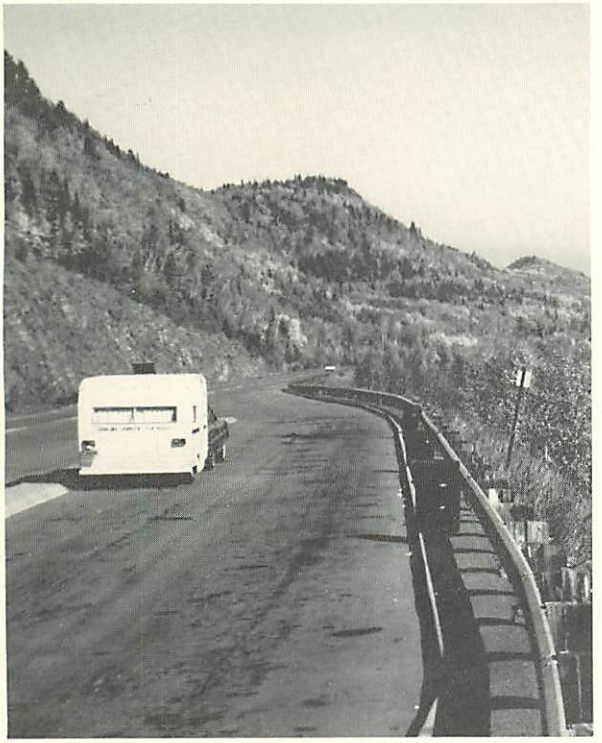
During the first year of the project, the biologists studied the spatial and temporal distribution of larval lake herring in the Duluth-Superior area and calculated preliminary growth and mortality rates during the first 30 to 40 days after hatching. Techniques for the refinement of these data have been developed. It is hoped that these techniques will be used to help assess factors affecting larval growth and mortality and to establish the relationship between larval dynamics and adult population size. In addition, the first developmental and taxonomic descriptions of wild-caught Lake Superior lake herring larvae have been produced. Work on developing multicharacter indices for separation of larval coregonine species also has been started.

The researchers feel further reduction in the ecosystem stability must be avoided. To maintain stability, rehabilitation of lake herring and other coregonine populations must be effected. The success of such rehabilitation may well depend upon a solid understanding of larval dynamics.

Potential users of this information and index would be environmental regulatory agencies, industries, and fisheries managers.



Dr. Uel Blank



North Shore Drive looking north on Highway 61.

MARINE APPLIED ECONOMICS

TOURISM—A Major Budding Industry in Northern Minnesota

At two-billion dollars annually, tourism is one of Minnesota's thriving businesses. In 1981 North Shore tourism revenues totaled approximately 22-million dollars. Sea Grant researchers Uel Blank and Timothy Knopp think the tourism market is just beginning to be utilized. Their completed investigation of northern Minnesota's tourism markets revealed the economic potential of the North Shore to be largely unexploited. Minnesota lags behind Wisconsin, Ontario, Michigan, South Dakota, and Manitoba in annual advertising dollars spent. Blank, Knopp, and Sea Grant trainee Sally Stanbrough found that Minnesota tourists have a lack of information when it comes to finding out all the things they can see and do on the North Shore. They hypothesized that if tourists had more information, they would spend more money on their pursuits.

The study investigated tourist's attitudes, suggestions, and opinions, and correlated the information with retail managers' specifications and statistical data from Canada and the United States travel bureaus.

The researchers found that the majority of tourists came to see nature and to recreate. The domininant appeal of the North Shore was the setting for the appreciation of nature and quiet, meditative types of activity. This involved a wide variety of options, and the Knopp/Blank project has been the first comprehensive and detailed report to generate a completed data base for tourism managers. Categorized by state of origin, type of recreational activity performed, and total amount of dollars spent, the study provides detailed breakdowns of total economic impact for each tourist region. These findings should give planners and developers the data necessary to protect the underlying resource and to develop a viable tourism industry on a sustainable basis. It is important to recognize and maintain the North Shore experience that has attracted visitors for decades.

Sea Grant Researcher Wins Award

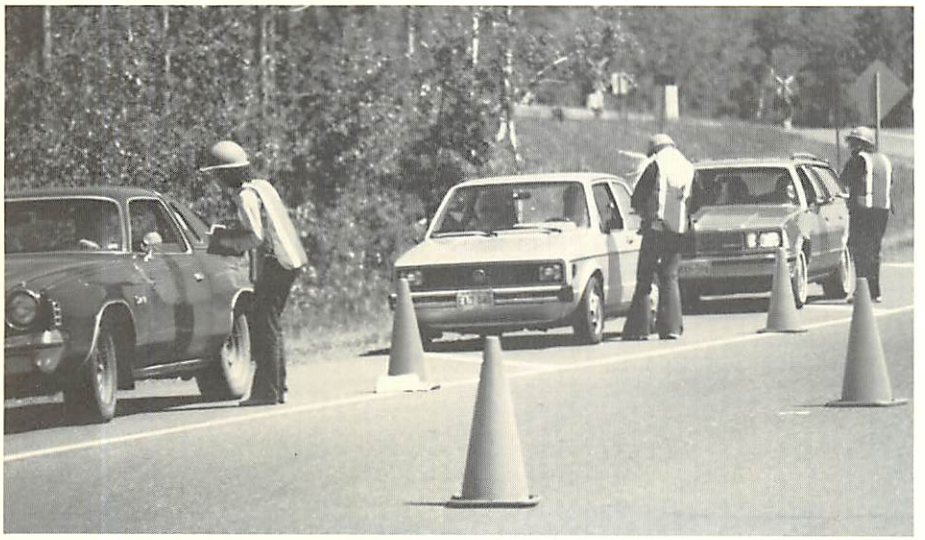
Determining how the industry can best accommodate the spending habits of tourists is especially important when tourism may be the only fully viable industry northern Minnesota currently has. In 1982 Dr. Uel Blank was given the Outstanding Individual in Travel Award for his contributions to Minnesota tourism over the past 16 years.

GENERATING AN ECONOMICAL TOURISM DATABASE

A companion effort in conjunction with the Knopp/Blank work is research by Wilbur R. Maki, Professor of Agricultural and Applied Economics, and his graduate assistant Kathleen Novak. Their efforts build on a computer forecasting module. Estimates of factors that impact upon recreational use are entered, and the cumulative effect on Minnesota's recreational industry is calculated.

The data bank generated serves as a factual base for assessing public and private investment. It elicits critical investment gaps, future trends, and resource use restrictions. Indicators such as jobs, personal income levels, and regional factors are entered. The future impact of the industry is run through possible scenarios.

In its second year, this work will provide a generalizable model for effective resource management and for planning of resource use. The Minnesota Department of Natural Resources, Department of Economic Development, The National Heritage and Conservation Service, and the United States Forest Service have all expressed interest in the project. They anticipate becoming users of the model once access to their topical area is available.



University of Minnesota researchers collecting tourism data.

Grand Marais campground during 1981 camping season.

WATER SAFETY

HYPOTHERMIA PREVENTION

During the past two years Sea Grant's Hypothermia Laboratory at UMD has contributed a great deal to the understanding and dissemination of information about hypothermia. Divers, marine workers, people recreating out of doors, joggers, mountain climbers, and even people who are deprived of heat or who turn their thermostats down too far in cold weather are susceptible to hypothermia, a lowering of the body temperature to potentially fatal limits.

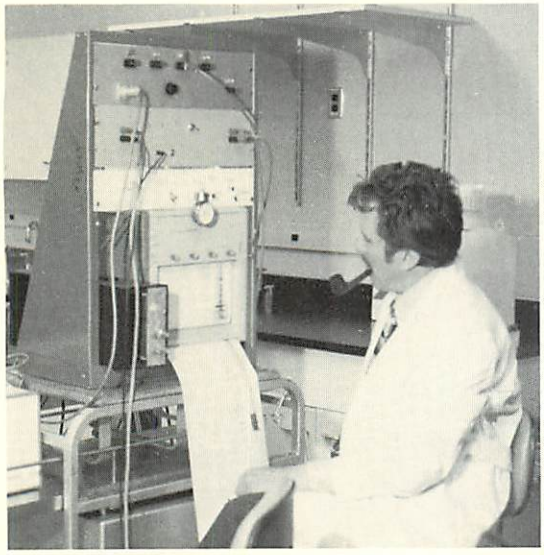
In Minnesota this can happen frequently with our cold temperatures and large number of lakes. The average temperature of Lake Superior is only 39 degrees Fahrenheit. Those who must work in this environment are subject to potential danger—hypothermia can be a killer.

One of the lesser known reactions to cold water immersion is the dive reflex or the oxygen saving reflex. Sea Grant researcher Dr. Lorentz E. Wittmers has been involved in studying this reflex for the past few years in an effort to uncover its importance in life preservation.

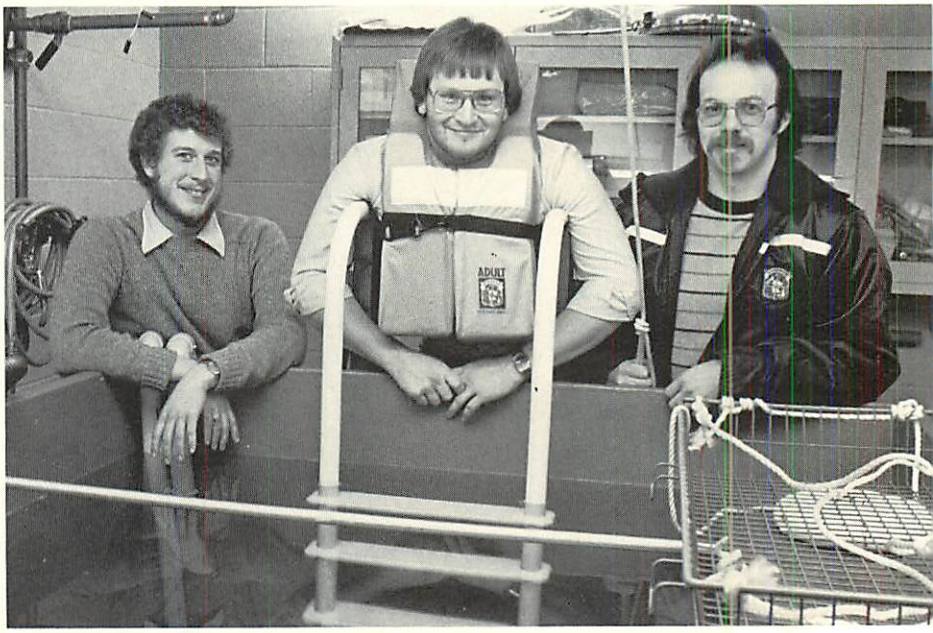
The reflex can help or hinder an individual, altering the blood flow from the extremities and less essential organs, such as the gastrointestinal tract, kidneys, and skin, and diverting it to the more essential heart and brain. This may save one's life, or in some cases it has been thought to lead to heart attacks.

Wittmers and Sea Grant trainee George Fall are involved in documenting this response in a large sample population to determine exactly how it works. The researchers are taking age, health, and alcohol intake into account to determine the effect on the cardiovascular system.

Users are many and widely informed. Something potentially as life saving and crucial as understanding hypothermia has a direct effect on the resuscitation of cold-water drowning victims. Wittmers and Howard suggest not using the commonly taught Red Cross method of chest massage for the victim since it may cause the heart to go into fibrillation. Instead they suggest making sure that the respiratory passage is clear, removing cold clothes, and wrapping the victim in warm blankets. It is also important to give the individual warm fluids when he can manage to drink. They suggest not putting the victim next to a fire or throwing him into a hot tub but warming the individual gradually.



Dr. Larry Wittmers monitoring data in the Physiology/Hypothermia Laboratory.



Hypothermia Laboratory staff: (L. to R.) Graduate Students (Physiology) David Howard, George Fall, and Laboratory Technician Bob Dromeshauser.

With colleague Dr. Robert Pozos, three books have been written to date for the layman, and numerous articles and brochures have been distributed at conferences the world over.

SHIVER AND SUGAR IN HYPOTHERMIA

Dr. Robert Pozos and Dr. Edwin Haller, physiologists at the UMD Hypothermia Laboratory, have been involved in determining the relationship between shiver, metabolism, and glucogenic hormone in individuals who are becoming hypothermic.

Shivering, they found, is not always an entire body response. Legs and arms appear to shiver first, followed by chest and trunk muscles. In addition they have found that not every individual shivers at the same temperature nor to the same degree. Temperature regulation of the body is complex, and a large number of variables enter into the system: fatigue, body size, amount of fatty tissue, intake of alcohol, and whether or not the individual shivers at all.

Hypothermia is the leading cause of death among those involved in boating or shipping accidents. Once in the water, many marine workers have been dependent upon their survival suits to keep them warm. Most of these suits have been designed to incorporate body shiver as the key to survival. Pozos' research helped redefine proper survival suit design.

Pozos has, in the first year of this study, begun decisive work on the quantification of the shiver response and its relationship to metabolic rate. Efforts are underway to separate non-cold stress response from cold stress response and to document the results for a wide sample of the population.

Potential users of this information are those who work in the cold and can benefit from essential lifesaving and nutritional information, physicians using revival techniques, and individuals who suffer from alteration in their glucose metabolism. Outdoor enthusiasts and marine researchers and workers will benefit greatly.

Dr. Haller, Dr. Pozos, and Dr. Wittmers by the immersion tank.

FINANCIAL STATEMENTS Fiscal Year 1982

Status of Research Projects

PROJECT NUMBER	SECTION AND PROJECT TITLE	INVESTIGATOR(S)	NOAA SEA GRANT FUNDS	LEGISLATIVE & UNIVERSITY MATCH	STATUS*
	LAKE SUPERIOR FISHERIES AND AQUACULTURE				
R/F-5	Estimation of Yield Potential of Suckers (Catostomidae) from Minnesota Tributaries to Lake Superior	George Spangler	$18,259	$ 4,689	C
R/F-6	The Relationship of Growth Rate Changes to Smoltification of Chinook Salmon	Ira Adelman	12,900	2,229	O
F/F-8	Early Life History of Lake Herring and Bloater in Western Lake Superior	James Underhill	13,717	3,035	C
R/F-9	Nutrients, Productivity and Water Quality in Lake Superior: A Mechanistic Approach to an Oligotrophic Food Web	G. David Tilman	3,456	14,538	O
F/A-1	Bait Leech, *Nephelopsis obscura*, Culture and Economic Feasibility	Hollie Collins Linda Holmstrand Wayne Jesswein	11,240	6,921	C
R/F-12	Application of Gamete Preservation Techniques to Enhance Minnesota Aquaculture	Edmund Graham	4,897	32,861	O
	COASTAL AND ENVIRONMENTAL PROCESSES				
R/CL-1	Microcontaminant—Air, Water, Sediment, Biota Interactions in Lake Superior	Steve Eisenreich	18,834	2,929	C
R/CL-6	Sediment Mass Movement on the Tailings Fan in Lake Superior by Turbidity Currents	William Busch Thomas Johnson	17,759	2,420	O
R/CL-7	Redistribution of Tailings Deposits in Lake Superior by Turbidity Currents	Gary Parker Heinz Stefan	5,778	5,778	O
	MARINE APPLIED ECONOMICS				
R/C-4	A Market Segmentation Study of North Shore Tourism	Uel Blank Timothy Knopp	17,334	5,636	C
R/C-8	Recreation Industry—Activity Cluster Assessments for Recreation Resource Management	Wilbur Maki	11,498	3,417	O

*C = Completed
O = Ongoing

PROJECT NUMBER	SECTION AND PROJECT TITLE	INVESTIGATOR(S)	NOAA SEA GRANT FUNDS	LEGISLATIVE & UNIVERSITY MATCH	STATUS*
	WATER SAFETY				
R/S-2	Diving Reflex: Cardiovascular Adjustments to Cold and Water Stress	Lorentz Wittmers	8,550	7,193	O
R/S-3	Hypothermia-Induced Ventricular Fibrillation in Normal and Hypertrophied Hearts	Lois Heller	3,600	2,251	C
R/S-4	Relationship Between Shiver, Metabolic Rate, and Glucogenic Hormones	Robert Pozos	22,607	5,177	O
	MARINE EDUCATION AND TRAINING				
E/T-3	Sea Grant Traineeships	Donald McNaught	54,000	—0—	O
E/T-4	American Indians in Marine Sciences	Bruce Munson Robert Diver	28,817	9,600	O
E/T-5	Inservice Training in Marine Education for Elementary and Secondary Teachers-A Dissemination Model	Eugene Gennaro	11,419	3,895	C
	SEA GRANT EXTENSION PROGRAM				
A/SE-1	Minnesota Sea Grant Extension Program	Dale Baker Barbara Stuhler Gordon Rose	175,460	98,915	O
	PROGRAM MANAGEMENT AND DEVELOPMENT				
M/P-1	Program Management	Donald McNaught Dale Baker	64,873	62,317	O
M/P-2	Program Development	Donald McNaught	15,000	—0—	O
M/P-3	Ship Time	Donald McNaught	15,000	—0—	O

*C = Completed
O = Ongoing

BUDGET SUMMARY

	NOAA Office of Sea Grant	State Legislative Special	University Match
Research	200,429	45,899	53,175
Education	94,236	—0—	13,495
Extension	175,460	40,260	58,655
Program Management	64,873	62,317	—0—
Total	534,998	148,476	125,325

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The Marinated Classroom—Secondary Curriculum and Elementary Curriculum, S. Rakow, 1982.

Seiche, Lacustrine Lessions, North Shore Correspondence, Superior Advisory Notes, N. Berini, T. Mack, and B. Munson, University of Minnesota, Duluth.

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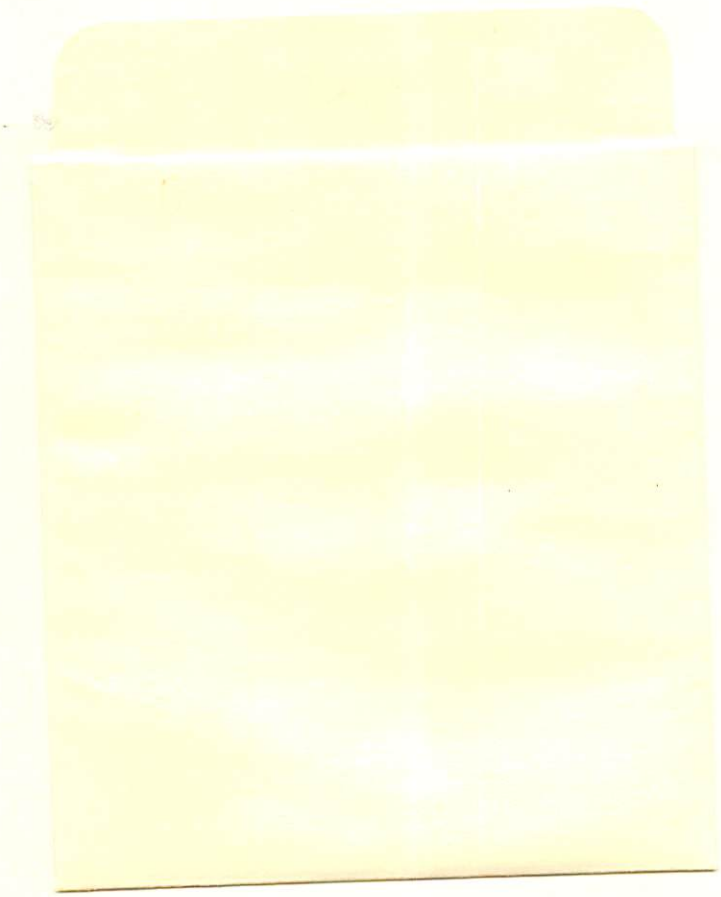

Credits

Photography: Uel Blank, Bruce Borich, Ryck Lydecker, Ken Moran, Steve Schneider, Naomi Wainer.
Editor/Writer: Cynthia L. Osborn

Design: University of Minnesota Graphic Design
Printing: University of Minnesota Printing Department
Typography: University of Minnesota Printing Department