MINNESOTA SEA GRANT

Report of Activities for 1984 (for funding year 1983-84)

Contents

This report covers research and extension activities conducted between October 1984 and 1985 under funding year 1983-84.

The Cover
Fly fishing at the mouth of the Lester River on Lake Superior. Photo by Rob Levine.

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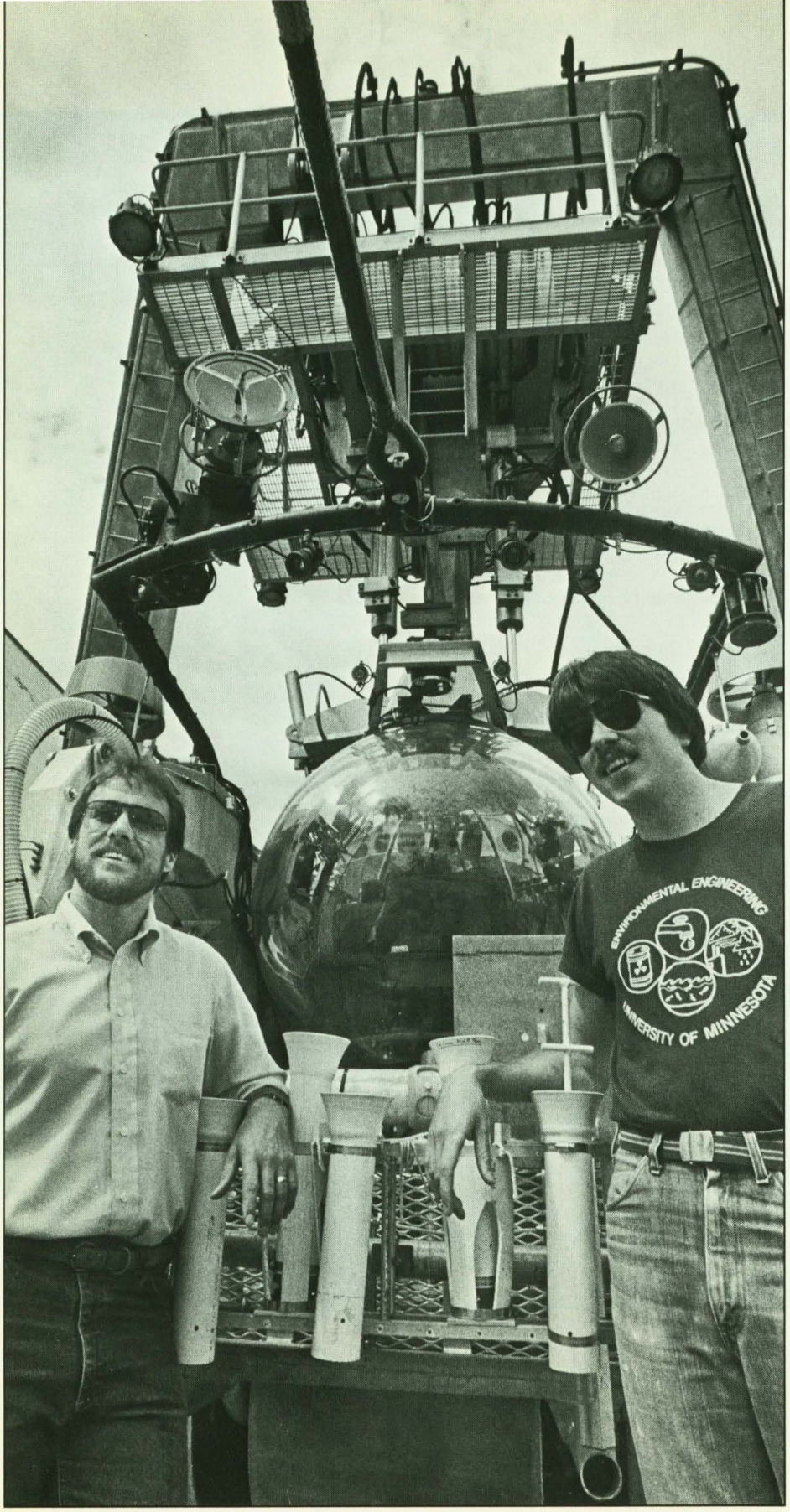
Photographer: Rob Levine. Additional photographs provided by the Minneapolis Star and Tribune, the Duluth Herald-Tribune, and the U.S. Army Corps of Engineers.

Published by the Minnesota Sea Grant College Program, University of Minnesota, St. Paul. 612-373-1708.

Copies are available from Minnesota Sea Grant, 116 Classsroom-Office Building, 19914 Buford Avenue, St. Paul, MN 55108.

This work is the result of research supported by NOAA, Department of Commerce, Office of Sea Grant, under Grant NA83AA-D-00056. The U.S. Government is authorized to produce and distribute reprints for government purposes.

We would like to thank the Minnesota Legislature, the University of Minnesota Agricultural Extension Service, the Graduate School, and Midwest Energy Resources.



Professor Steven Eisenreich (left) and graduate student Joel Baker with the submersible used to explore the bottom of Lake Superior.

Director's Letter

October 1985

The University of Minnesota received Sea Grant's highest honor this year when it was designated a Sea Grant College by Malcolm Baldrige, the Secretary of Commerce. Only Sea Grant programs that have achieved excellence in research, graduate education, and extension efforts are awarded this status.

Many individuals played a part in Minnesota's achievement. The faculty and graduate students on the Twin Cities and Duluth campuses have conducted scientific research of exceptional quality. After publication in scientific journals, their findings are taken to the community by Sea Grant extension agents. The agents' hard work has allowed businesses, communities, and individuals throughout Minnesota to benefit from Sea Grant's research and extension programs.

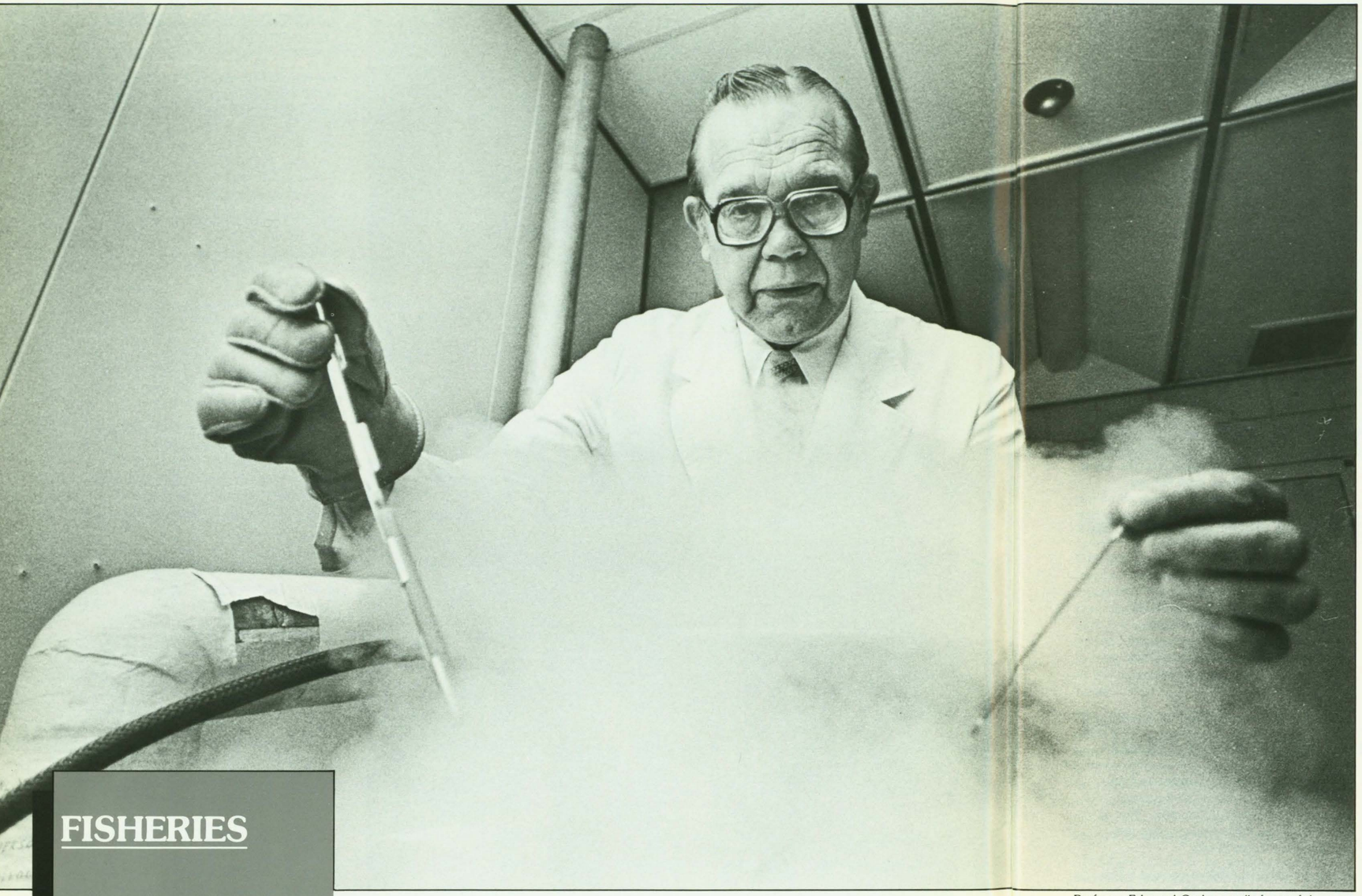
Our advisory committees have provided guidance and innovative ideas to improve both our research and extension efforts. The University administration has been extremely supportive and actively involved in helping Sea Grant develop into a College Program.

Minnesota Sea Grant has matured and expanded since its beginning in 1974. New areas of research have been added, allowing the program to keep abreast of changing concerns. For example, new research on water policy and law will provide needed information on such important issues as water diversion from the Great Lakes.

Sea Grant is also expanding its natural products research. New work in this field may provide exciting results on ways to use bacteria to clean up pollution. This research area also includes a project to develop a biodegradable herbicide from algae (see story, page 7).

Finally, Sea Grant is proud to have helped fund this summer's exploration of the bottom of Lake Superior. University Professor Steven Eisenreich was one of 20 scientists to explore the lake for the first time in a submersible. Sea Grant is funding his research on the movement of organic contaminants in the lake.

Donald McNaught
Director
Minnesota Sea Grant College Program
Twin Cities Campus



FISHERIES

Professor Edmund Graham pulls frozen fish sperm out of a tank of liquid nitrogen.

New Techniques to Breed Better Fish...

Professor Edmund Graham perfected the first cryopreservation (preservation by freezing) of mammal spermatozoa 35 years ago. Today, he is investigating techniques to cryopreserve and revive the sperm cells, eggs, and embryos of freshwater fish.

Graham's work could mean increased hatchery output and bigger, stronger fish for stocking the country's lakes and streams. He has successfully preserved many species' sperm and has reached 80 to 90 percent fertilization rates with cryopreserved sperm of rainbow and brown trout.

Graham and his fellow researchers "milk" or squeeze spermatozoa and eggs from the fish. Before the sperm can be stored in tanks of liquid nitrogen at minus 320°F, they are placed in an extender solution to keep them inactive. They are then frozen, slowing their biochemical processes until the day they will be thawed, activated, and used to fertilize eggs.

Graham is now working to develop short and long-term storage methods for eggs and embryos. Although many types of mammalian embryos have been successfully cryopreserved, preservation of fish eggs and embryos is technically much more difficult.

If successful, Graham's research could bring dramatic changes to the hatchery and aquaculture industries. "Frozen sperm or fertilized eggs could be shipped between hatcheries, allowing greater flexibility in hatchery operations," Graham said. "Breeders could also develop hybrids with certain characteristics suited to their particular regions: strains which grow more rapidly or resist disease, perhaps."

Similarly, the aquaculture industry, which rasies fish for food, could develop strains or hybrids more suitable to intensive culture to produce higher quality fish at a faster rate.

Graham's techniques may also be used to guard against extinction through preserving eggs and sperm of endangered species. "Think of our liquid nitrogen tanks as safety deposit boxes," he said.

Edmund Graham, Professor
Marcia Schmehl, Assistant Scientist
Alan Erdahl, Sea Grant Trainee
Department of Animal Science
University of Minnesota, Twin Cities

...and Improve Production

Hatcheries will be able to raise more of Minnesota's best sportfish without increasing costs with techniques developed by Sea Grant researchers.

Muskellunge (muskies), rainbow trout, and walleye all present fertilization problems that can be solved by a semen extending solution developed by Professor Edmund Graham and his graduate student Alan Erdahl. The solution is used by hatcheries to fertilize eggs after semen and eggs have been collected during the spawning season.

Muskies have a very short spawning season and the two sexes may not be ready to spawn at the same time. Graham and Erdahl's solution will extend and store the male's semen until the female is ready to spawn.

Muskies also produce relatively small amounts of semen compared to other fish. Using the extender, the DNR's Waterville hatchery is able to increase the volume of semen to fertilize more eggs. The hatchery

also uses the extender solution in breeding walleyes, since it is difficult to simultaneously collect males and females ready to spawn.

Trout hatcheries can also use the extender. They generally raise one male rainbow trout per female fish to ensure a high rate of fertilization in broodstock. Graham and Erdahl's techniques could make it possible to stock one male for many more females. Since the number of males could be cut and the number of females increased, production of fertilized eggs would rise dramatically.

Erdahl has found that it takes about 5,000 live sperm cells to guarantee 80 pecent success in fertilizing a single fish egg. By collecting semen from male rainbow trout repeatedly rather than only once during their spawning season, Erdahl discovered that males are capable of producing up to 100 ml of semen, containing about 300 billion sperm, per season.

"This amount was ten times the volume we expected to be able to collect," Erdahl said. "With 100 ml of semen you could *theoretically* fertilize about 60 million eggs, or all of the eggs from over 1,000 female rainbow trout. Obviously, this has tremendous potential for use in hatcheries."

Under laboratory conditions, it is possible to fertilize 1,000 females per male, Erdahl said. In a hatchery, this would not be practical since such a ratio of males to females would limit genetic diversity among the offspring, he added. However, genetic diversity might be increased quickly and less expensively with this technique since the hatchery could mix the semen from additional males of different strains each year.

About Pink Salmon

Pink salmon are an irony of nature. They were accidentally stocked in Lake Superior yet they have become the only Pacific salmon to successfully reproduce in the lake. The popular coho and chinook salmon must be stocked.

Since 1956, when bad weather forced a plane bound for Hudson Bay to eject its cargo of 21,000 pink salmon fingerlings into Lake Superior, the pinks have colonized all the Great Lakes. Their successful adaptation led Sea Grant researchers to study the pink's potential as an important commercial or sport fish.

After three years of study, Professor George Spangler believes that in spite of their ability to reproduce in Lake Superior, pink salmon will probably never be important to the lake's fishery.

Spangler and his students studied the abundance, fertility, and behavior of mature pinks entering North Shore streams to spawn. They observed a large number of three-year-old spawners. Pink salmon in their natural habitat usually mature and spawn at age two, so the reason for so many three-year-olds is uncertain. Spangler thinks that Lake Superior's cold, nutrient-poor water may not allow some pinks to reach sexual maturity in two years.

In spite of the extra year to mature, three-year-olds generally produce fewer eggs which are of poor quality. Consequently, reproductive efficiency of the population might decline if the number of three-year-old spawners increases.

The pink salmon population peaked in 1979 and has since leveled off or perhaps declined, according to Spangler. When first introduced to Lake Superior, the pinks experienced what biologists call a population "irruption," otherwise known as a "newcomer response," in which the population grew rapidly to fill an unoccupied ecological niche. The population has subsequently declined to the lake's carrying capacity.

It is unlikely that pinks will ever be an important sport or commercial fishery. The sportfishery for pinks is primarily a snagging fishery that "does not have an important following in the Great Lakes," Spangler said. When pinks are caught in the stream it's usually too late in the spawning season. Since they die soon after spawning they are already beginning to deteriorate, and their mushy flesh and mottled skin are unappealing.

Although the Sea Grant research is ending, there are intriguing questions left unanswered, including how many fish are in the open lake and how they behave, Spangler said. Also, little is known about the effect pinks have on other species—whether they provide forage for lake trout or burbot or if they eat valued sportfish.

George Spangler, Professor
Department of Fisheries and Wildlife
Jane Bush and Joe Nicolette
Sea Grant Trainees
University of Minnesota, Twin Cities

Catch and Release May Help Lake Trout

Sportsfishermen can help restore the natural population of lake trout in Lake Superior, according to fisheries agent Jeff Gunderson. Along with Lake Superior fishing clubs, Gunderson is encouraging anglers to catch and release lake trout.

Although catch and release of other species, such as bass, is widely accepted, catch and release of lake trout has never been seriously considered. Generally, sportsfishermen have regarded the lake trout as strictly a "put and take" fishery, even though fisheries managers stock trout in hopes of establishing a self-sustaining population. "A catch and release program among sportsfishermen could significantly aid the growth of the native lake trout population in Lake Superior," said Gunderson.

Gunderson has compiled studies showing that if properly handled, lake trout do survive when released. "There are many things a fisherman can do to increase chances of fish survival," he said. "For example, some treble hooks cause less damage than single hooks."

Although where the fish is hooked is the most important factor in fish survival, handling of the fish after it is caught is also important. For instance, properly puncturing the inflated gas bladder of trout pulled in from deep water can significantly aid their recovery. Gunderson urges anglers not to prolong the fight with a fish they don't intend to keep, since the length of time the fish fights affects survival. He also encourages release of trout with unclipped fins, since these fish are probably naturally produced and are more likely to successfully spawn than stocked fish.

A lake trout caught near Isle Royale in Lake Superior

Restoring the Lake Trout

Fifty years ago, there were millions of lake trout in the Great Lakes. But with the invasion of the sea lamprey in the 1940s, their populations crashed. Today, 15 years after the lamprey came under chemical control, fisheries managers are still struggling to bring the lake trout back to their position as the dominant predator in the Great Lakes.

Rehabilitation of the lake trout has been difficult for many reasons. One is that it is hard to determine the effect of fisheries managers' actions upon the trout's ability to recover, said Professor George Spangler. A computer model that can predict the consequences of managers' actions may be the key to bringing back the lake trout.

"Trout are known to be sensitive to the traditional management activities of harvesting, stocking, and lamprey control," said Spangler. Along with graduate student Larry Jacobson, Spangler is refining an existing computer model to include these factors. The result will be a model that can predict the effects on trout of changes in these three key areas.

Today, fisheries managers such as departments of natural resources, can only *react* to changes in the lake trout's population. It cannot *predict* its ups and downs. "They (the DNR) react to how many fish should be stocked according to what sportfishing takes," Jacobson said. "They do not predict population changes. This model would allow them to do some of that."

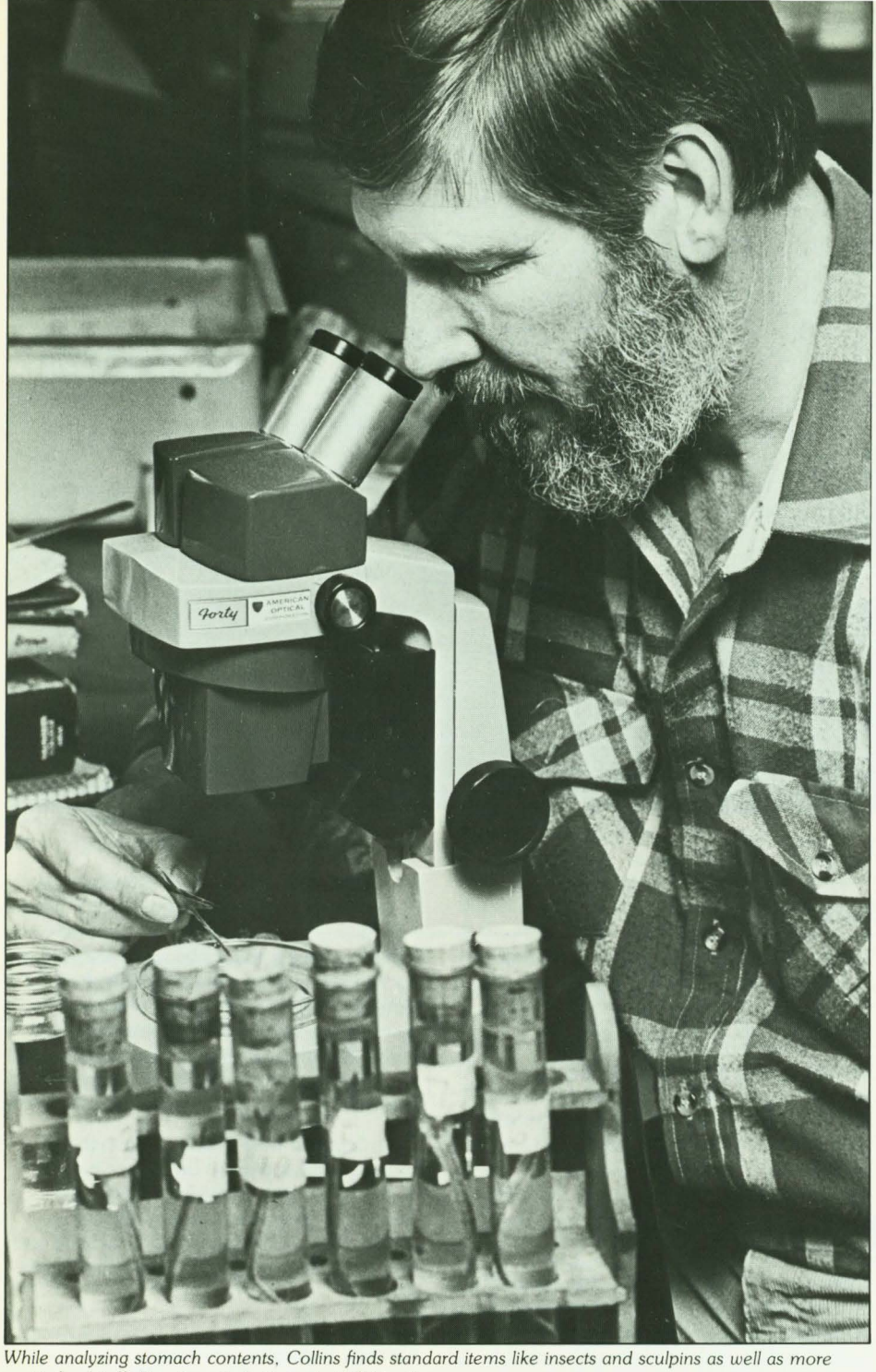
Predicting trout abundance is only one benefit. The model will go one step further and estimate the maximum number of lake trout that can be harvested to still allow for rehabilitation. Once that maximum is estimated, fishing regulations and stocking strategies can be recommended to ensure rehabilitation of the lake trout.

Controlling the number, size, and age of the trout caught in Lake Superior is important since lake trout don't reach sexual maturity until their fifth, sixth, and seventh years of life. When anglers catch big, mature spawners, they disrupt the fish's ability to reproduce. In Lake Superior, the fish living off-shore in the deeper parts of the lake range more widely in age because they have experienced less lamprey predation and less fishing pressure. It is these stocks that show the greatest signs of increasing natural reproduction.

"Lamprey remain a very real threat to trout rehabilitation," said Spangler. The chemical TFM has helped reduce lamprey populations by 90 percent since the mid-1960s. But lamprey could grow resistant to TFM, as insects have grown resistant to pesticides. Using the computer model, managers may be able to predict the results of alternative methods of lamprey control.

Lake Superior may benefit more than the other Great Lakes from Spangler's model since it is the only lake where substantial trout reproduction is occurring. Similar models are used in managing whale and seal harvests, Antarctic krill, and walleye in Lake Erie.

George Spangler, Professor
Larry Jacobson, Sea Grant Trainee
Department of Fisheries and Wildlife
University of Minnesota, Twin Cities



While analyzing stomach contents, Collins finds standard items like insects and sculpins as well as more exotic foodstuffs like cigarette butts and old fishing lures.

What Do Fish Eat?

To most anglers, knowing what a fish eats is of interest only if it helps them catch one. But knowledge of fish diets can also help manage the fishery, and recreational anglers provide much of the data for this Sea Grant research.

Scientists throughout the Great Lakes are studying whether salmonids (trout and salmon) are running low on some types of food and if their diets vary over time and by location.

The answers are found in fish's stomachs. Professor Hollie Collins and his students collected 2,500 stomachs this year by offering to clean the freshly caught fish at fishing derbies on Lake Superior. Derbies are a major source of stomachs; a small number are also contributed by commercial fishermen.

"This is exciting research," Collins said. "It's the first time the Great Lakes system has been studied in its entirety and it is the first time angler-caught (versus commercially caught) fish have been used. This allows for some different comparisons on what fish are eating and lets us do the research much more cheaply."

Stomach content analysis is an experimental technique for studying predator-prey relationships. Researchers will test whether this method can quickly and inexpensively detect changes in forage populations such as smelt, herring, and alewives. It might supplement information obtained from more expensive, time-consuming methods like trawl sampling. Eventually, researchers hope to understand the entire Great Lakes forage base.

"The aim is to get a handle on what should be stocked," Collins said. "Should it be a large number of one kind of predator or a mix of species?" Since much of the sportfishery in the Great Lakes is dependent on stocking, this research will help determine how to manage the fishery to balance populations of predators and their prey.

Hollie Collins, Associate Professor
Dave Conner, Research Assistant
Department of Biology
University of Minnesota, Duluth

NATURAL PRODUCTS

Algae: A New Source of Herbicides

Professor Florence Gleason produces cyanobacterin with special grow-lights.

Herbicides are applied to millions of acres of Minnesota farmland each year. Herbicide residues remain in the soil into the next growing season, cutting crop yields and flowing with runoff water into Minnesota's lakes and streams. A Sea Grant researcher may have found the key to creation of a biodegradable herbicide that would end the carryover problem.

The solution may come from algae. The blue-green alga, *Scytonema hofmanni*, produces cyanobacterin, a chemical which is toxic to other algae. Cyanobacterin may eventually be an economical and environmentally preferable alternative to conventional herbicides and algicides, according to Professor Florence Gleason.

The benefit to farmers may come from Gleason's discovery that growth of higher plants is inhibited by cyanobacterin. Duckweed, a minute flowering plant that floats on ponds, either stopped growing or died after cyanobacterin was added. Cyanobacterin also inhibited growth of corn and pea seedlings although it may not be toxic to other crops, Gleason said. She is now testing cyanobacterin's action on a variety of common weeds, including cocklebur and foxtail.

Gleason's results indicate that cyanobacterin, like conventional herbicides, disrupts photosynthesis, making it an ideal herbicide or algicide. It could have several major advantages over the chemical herbicides now being used. "It is toxic only to plants, not to fish or other animals," Gleason said.

"Unlike conventional herbicides, cyanobacterin is rapidly biodegraded, breaking down within four to six weeks." Conventional herbicides can remain in the soil for a year or longer. In addition, many weeds have developed resistance to herbicides now in use. "We need to develop new products from different sources to deal with resistance problems," she said.

Cyanobacterin production costs are now a major obstacle to commercial use. However, Gleason has been able to increase the rate of cyanobacterin production by limiting the light in which *S. hofmanni* is grown.

Cyanobacterin may also serve as a molecular model for manufacture of similar synthetic compounds. Gleason is now trying to create an alga strain that would produce cyanobacterin more efficiently and she is studying other algae for similar properties.

"You never know where an important organism may come from," Gleason said. "During the search for penicillin, a housewife brought in a melon with fungus growing on it. The fungus became the major producer of penicillin."

Researchers have isolated more than 10,000 naturally produced compounds, some of which are now used as painkillers, antibiotics, and anti-tumor agents. Although natural products research is a comparatively new field, products with medical, industrial, agricultural, and environmental uses have been discovered.

Most research has involved marine rather than freshwater organisms, Gleason said. But interest is increasing in freshwater ecosystems and organisms, which may lead to more discoveries of useful products. The metal-binding properties of freshwater algae, for example, may have applications in metal poisoning and pollution problems.

Florence Gleason, Assistant Professor
Cheryl Baxa, Sea Grant Trainee
Gray Freshwater Biological Institute
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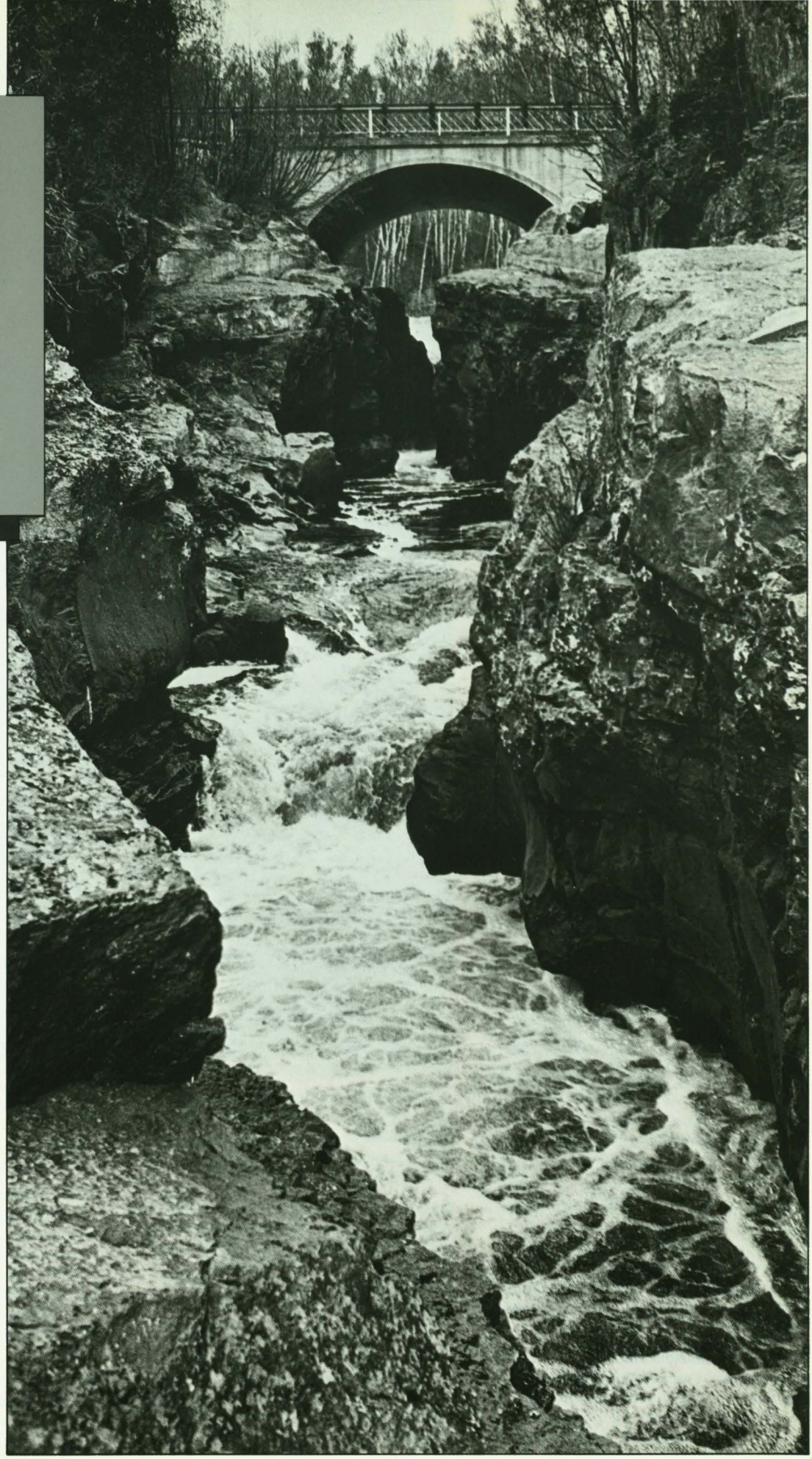
TOURISM



Cascade River

Good fishing and no crowds attract visitors to Lake Superior

Keeping Tourists Happy

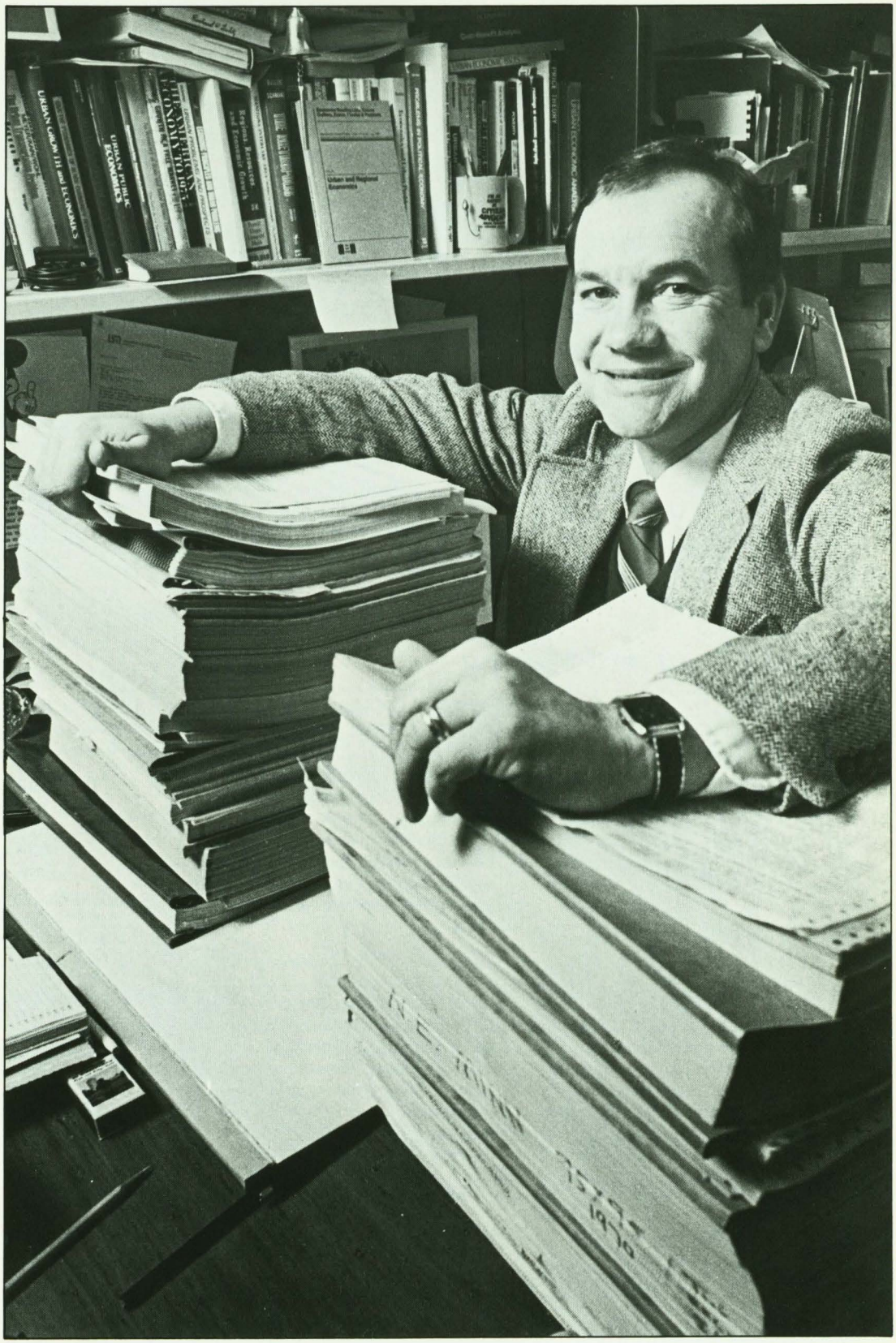
Tourists spent $63 million in Duluth last year. Tourism creates a substantial number of jobs and pays a lot of salaries, especially since most of Duluth's tourists are repeat customers. But clean lakes and beautiful scenery may not be enough to keep them coming back if the desk clerk was rude and the waitress haughty. It takes a smile and a thank you—a little hospitality—to make or break a vacation.

Hospitality is a part of every job in the tourism industry. But it is a skill that often needs to be taught. Sea Grant, along with the Agricultural Extension Service, the Small Business Development Center, and the state's Office of Tourism provided 12 hospitality workshops in seven communities in the first half of 1985. In Duluth, Sea Grant tourism agent Chad Dawson conducts an annual workshop for employees of motels, restaurants, public attractions, and others working on the "front line" with the public.

"Visitors could form their entire perception of a community from one conversation," Dawson said. That means tourism employees must realize how important they are as representatives of their community. And they should know what their town offers tourists. In Duluth, for example, workshop participants are briefed by representatives of several attractions and annual events so they can answer tourists' questions.

The impact of the hospitality program accumulates over time, Dawson said. "Our experience indicates that as hospitality skills and attitudes are improved, community information systems get better and new facilities emerge. The ultimate end-product is increased economic activity in the community and in the state." Duluth tourism dollars are spread throughout the community to pay salaries, open new retail shops, and increase the tax base. The effect is that "tourists make Duluth a better place for residents," said Dawson.

The benefits of tourism are starting to be recognized in other communities as well. "Many communities consider tourism as an industry to supplement others that are having economic problems, such as mining, forestry, and agriculture," Dawson said. Consequently, interest in this program is widespread across the state. "Nearly every community realizes it can enhance the quality of its tourism services with the appropriate information."



Stacks of survey data help researcher Richard Lichty determine what tourists like to do on the North Shore and what facilities should be developed to meet future needs.

Tourism's Potential on the North Shore

Tourism is a unique business. It creates jobs and stimulates local economies. And it can be the industry that allows a once depressed region to prosper. Yet, because it is a diversified industry, its contribution to a region's economic base is often underestimated.

For the first time, tourism *as an industry* is being identified in a nationally recognized computer model called SIMLAB. SIMLAB allows planners to analyze national and regional growth in individual industries. It can provide data on a region's or a state's potential for increased income and employment according to each industry.

Professor Richard Lichty is continuing Sea Grant research started in 1980 to study the Lake Superior/North Shore region's potential for growth in recreation and tourism. Lichty and his fellow researchers organized the region's existing facilities into 13 categories, including hiking and skiing trails, motels, restaurants, boat launches, etc. Then, using DNR and Sea Grant survey results, they matched what visitors to the area like to do with the facilities needed to accommodate them.

"By matching, we can tell what people like to do when they visit the North Shore and where we need to direct investment to attract those people," Lichty said. This, however, is not as simple as it sounds.

"Because tourism includes input from local residents, and from people from outside the area, it is difficult to measure only tourism dollars," Lichty said. To determine where the dollars go in a regional economy, you have to consider tourists as users. Twin Cities visitors may use the area differently than the local residents use it and differently than the Illinois visitors do, he added. "It may turn out that the local residents want Twin Cities visitors more than they want Illinois visitors because the patterns of use are more matched to the available facilities and to the way they want to develop the area."

The SIMLAB model will allow local governments and developers to choose the most desirable development options, Lichty said. "We can say: here are the users, here's what is expected in growth. Either through assumptions or from survey data, you can tell what difference it makes to develop a harbor instead of a restaurant."

Probably the most useful portion of the SIMLAB model is its ability to answer "What if . . ." questions. For example, the largest untapped market for the North Shore is the Upper Midwest, Lichty said. "It is a huge market, and one that the region needs to exploit to support continued growth. We can ask the model: what if we get more visitors from the Upper Midwest? What would they want to do, what would they need to attract them? If their interests change, the model could tell us what we need to do to accommodate those interests. What if hikers become fishermen, and then become gamblers?"

"We don't necessarily assume that what people like to do in the area will change," Lichty said. "But we do assume there will be some changes in preferences."

The SIMLAB model also allows for specific questions on new development and tourist attractions, Lichty said. "It could help answer some current concerns, such as what happens when a local ski area has only 50 percent use? Are the local residents subsidizing the ski hill or are the economic spinoffs from those skiers coming into the community providing a net benefit?"

Richard Lichty, Professor
Wayne Jesswein, Professor
Department of Economics
William Fleischman, Associate Professor
Department of Sociology-Anthropology-Geography
University of Minnesota, Duluth
Wilbur Maki, Professor
Pat Dalton, Research Assistant
Department of Agricultural and Applied Economics
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Sea Grant Helps a New Business

Sea Grant research proved "invaluable" in the successful financing and marketing of a new North Shore condominium development, according to developer Robert Buntz.

The research, completed in 1981, studied North Shore tourism. It included both an evaluation of the tourism industry and a survey of tourists' demographics and interests. Buntz learned about the survey soon after buying two old resort sites on Lake Superior.

Sea Grant's research report told Buntz—and potential investors—that the North Shore tourism market is a healthy one. It also described the services considered inadequate by tourists, helping Buntz plan and market his Bluefin Bay restaurant and condominiums.

The report convinced Buntz that many tourists go to the North Shore primarily to see Lake Superior. As a result, he modelled the design of Bluefin Bay after a New England fishing village to emphasize its setting on the lake. "I decided to focus the design on the water," said Buntz. "Where else in the Midwest do you find a rocky-cliffed shoreline with an ocean in front of it?"

The development will eventually include a restaurant, conference rooms, an indoor pool, exercise room and whirlpool, tennis courts, and bar. Buntz is also interested in building a harbor. A 1985 Sea Grant survey has shown there is growing demand for harbors on western Lake Superior.

The Duluth-Superior Harbor

Dredging Disposal Studied

The Duluth Superior Harbor is relatively clean compared to other major ports on the Great Lakes. However, the harbor is contaminated with organic pollutants, including PCBs, and with industrial wastes. Consequently, disposal of polluted dredge spoils remains a controversial issue. The current on-land disposal site is expected to fill up within five years, according to the Corps of Engineers in Duluth. The corps has proposed disposing of some future spoils in deep holes in the harbor.

Public hearings on the proposal have attracted opposition from people worried about movement of pollutants around the harbor and into the open lake. The state's Pollution Control Agency and the Department of Natural Resources have both questioned the corps' plan.

Sea Grant research results show that deep hole disposal is a good option to on-land disposal. Steven Eisenreich, a professor of environmental engineering, said the damage to the lake is done by dredging, rather than by the disposal of the spoils. "As long as we dredge, we have an environmental problem," he said.

Pollutants are released to the water column through dredging, from both the dredged sediments and the porewater (the water between the sediment particles). "The result is that you expose the harbor water to pollutants through movement of the porewater," Eisenreich said. "The sediment will be disposed of but some of the porewater remains in the water column and contributes to the pollutant load in the harbor." No matter where the spoils are dumped, most of the release of pollutants occurs through dredging.

One reason deep hole disposal is a good option, Eisenreich said, is because it takes the polluted sediment out of circulation. The material still in the ship lane actually has a greater chance of moving around the harbor because it is resuspended by ship traffic, he said. It is more likely to eventually move into the open lake than the material in the deep holes. The holes are outside the ship turning area in a relatively quiet part of the harbor.

Eisenreich challenged the notion that putting polluted spoils on land is a better option than leaving them in the lake. "Experience with toxic waste disposal has shown that on-land disposal is not safe," he said. "With deep hole disposal, you keep the waste in the same system, you can control it with a clay top, and keep it stable. It's a great option."

Steven Eisenreich, Professor
Joel E. Baker, Sea Grant Trainee
Department of Civil and Mineral Engineering
University of Minnesota, Twin Cities

How Harbor Pollutants Move

In related research, Professor Patrick Brezonik is studying whether sediments suspended in the harbor are a source of pollutants or if they act as a sink for pollutants. He is studying two nutrients—ammonia and phosphates—and three heavy metals—cadmium, copper, and lead. These substances are abundant enough in the harbor to be of concern, Brezonik said.

The relationship between sediment resuspension and water quality is a fairly new area of research, Brezonik said. "There is a lot of interest in sediment resuspension in the Great Lakes, particularly in how it affects the transport of pollutants. We are linking sediment resuspension to water quality, which is a new approach."

Sediment resuspension occurs in the harbor as a result of wind and waves, dredging, and movement of large ships. Because wind and waves are not controllable, harbor managers concerned about water quality will be most likely to use research results to manage dredging and ship traffic.

Brezonik and his graduate student, Steve Preston, collected sediment and water samples from ten sites in the harbor. They are now doing laboratory studies on what happens to resuspended sediments in the water column and under what conditions sediments release or absorb pollutants.

Ultimately, this research will provide a computer model to predict how pollutants move and how quickly they are transported in the harbor.

Patrick Brezonik, Professor
Steve Preston, Sea Grant Trainee
Department of Civil and Mineral Engineering
University of Minnesota, Twin Cities

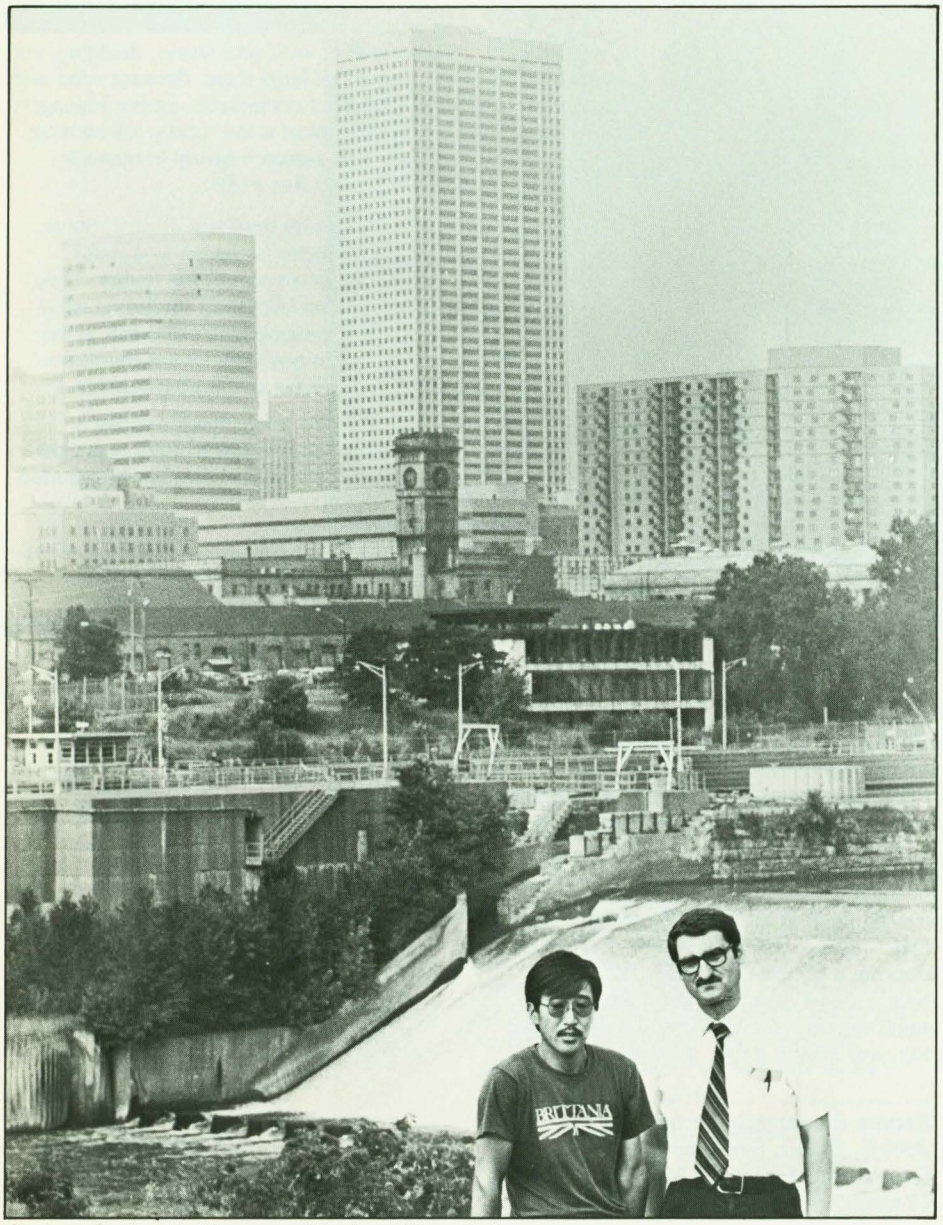
Tracking Wastes in Lakes and Oceans

Wastes have been dumped into lakes and oceans for decades. Only recently has there been concern about where those wastes are ending up. Sea Grant researchers are conducting one of the first studies on how underwater currents can move and redistribute wastes and sediments.

Professors Gary Parker and Heinz Stefan are studying turbidity currents, which are similar to underwater rivers. They erode and carry sediments, form deltas, and shape lake and ocean floors. On steep slopes, turbidity currents may be associated with underwater landslides. Their erosive power can form deep canyons.

One of the most controversial turbidity currents—and the stimulus for this research—was Reserve Mining's taconite tailings disposal near Silver Bay, Minnesota. The slurry that for 25 years dumped 60,000 metric tons a day of taconite tailings into Lake Superior formed a man-made turbidity current.

Parker and Stefan have developed a computer model, based on data from Silver Bay, that can predict a turbidity current's speed, depth, sediment content, and the distance it will travel. They recently built two laboratory models to verify the model's predictions.



Graduate Student Y. Akiyama and Professor Heinz Stefan

"When we started this work, there was no data on turbidity currents," Parker said. "So we looked at river flows as a similar phenomenon to determine what these underwater currents might be doing." Their model can predict the volume of sediment a current will erode and deposit. The Reserve Mining turbidity current, for instance, deposited a delta of tailings similar to those found at the mouths of large rivers. It also moved a portion of the tailings from the disposal site to deeper water.

The model is useful since it is based on a process, rather than on data alone, Stefan said. Consequently, the data can be changed so it can be used under many different conditions. "In the past, a company (dumping tailings) would have data only on what happened to tailings at previous sites," Stefan said. "Now we can give them information for several sites, including how the processes work in each area."

There are still many unknowns about how natural turbidity currents operate, Stefan said. "Field data is scarce because the phenomenon is intermittent and very difficult to measure. It's like trying to measure an underwater storm."

"As waste disposal in oceans and lakes continues, data from this research will become more useful," Parker said. "For instance, scientists are studying submarine canyons as possible sites for disposing of toxic wastes. The idea is to use the currents that occur in these canyons to move wastes from shallow to deep water."

"We still don't know what is happening in deep water," Stefan added. "People who want to put toxic wastes there should look at the Silver Bay situation first."

Gary Parker, Professor
Heinz Stefan, Professor
J. Akiyama, Sea Grant Trainee
St. Anthony Falls Hydraulic Laboratory
Department of Civil and Mineral Engineering
University of Minnesota, Twin Cities

WATER SAFETY

Staying Alive in Lake Superior

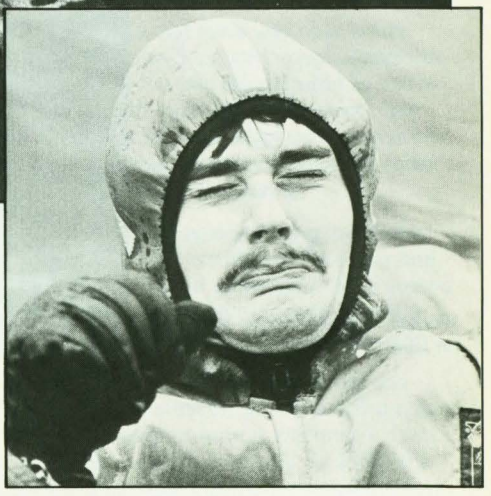
Imagine the cold of a gray, snowy November day on Lake Superior. Then imagine jumping into the lake and staying there for almost 40 minutes with only a flotation suit to keep you warm. For only 100 dollars, graduate students Scott Eskuri and John Spielmann floated in 38 degree Lake Superior to help Sea Grant researchers learn more about hypothermia.

For seven years, Drs. Robert Pozos and Lorentz Wittmers have been studying the range of human response to immersion hypothermia, the drastic lowering of body temperature in cold water. In their laboratory at the Duluth campus, they immerse volunteers in a tank filled with cold Lake Superior water. By measuring the volunteers' heart rate, respiration, and blood pressure, they can determine how different physiological responses affect people's ability to deal with the cold.

"What has surprised us is the range of responses in subjects of comparable age, body build, and physical fitness," Wittmers said. "Some are fast droppers (in rectal temperature) and some are slow droppers. Most of our subjects are well-fit individuals but some just couldn't stand the pain. They'd hyperventilate and show considerable emotion, even when they were not that cold."

Hypothermia, if experienced long enough, will cause heart failure. Before that, loss of memory, drunken-like behavior, slurred speech, and loss of dexterity and strength may occur. Some people will die in cold water before they ever become hypothermic. From the shock of the cold, they may drown from heart failure, sucking in water while hyperventilating, or from unconciousness caused by extended hyperventilation. In Minnesota, hypothermia is a contributing cause in 50 percent of the state's drownings.

John Spielmann (left) and Scott Eskuri float in the 38 degree waters of Lake Superior.



Because state of mind affects a person's ability to survive the cold, the researchers decided to see how their subjects react outside the lab in the more realistic lake environment. "Psychological factors are likely to be important in influencing heart rate and blood pressure," Pozos said. "There's likely to be more apprehension when you are out in a large body of water."

Pozos and Wittmers also study shivering and its importance as a survival reflex. Shivering, an involuntary contraction of muscles, raises metabolism, producing more body heat, Pozos said. "Some people don't shiver at all and some shiver violently. Shivering and muscle contractions are saving his life," Pozos said as he watched Eskuri.

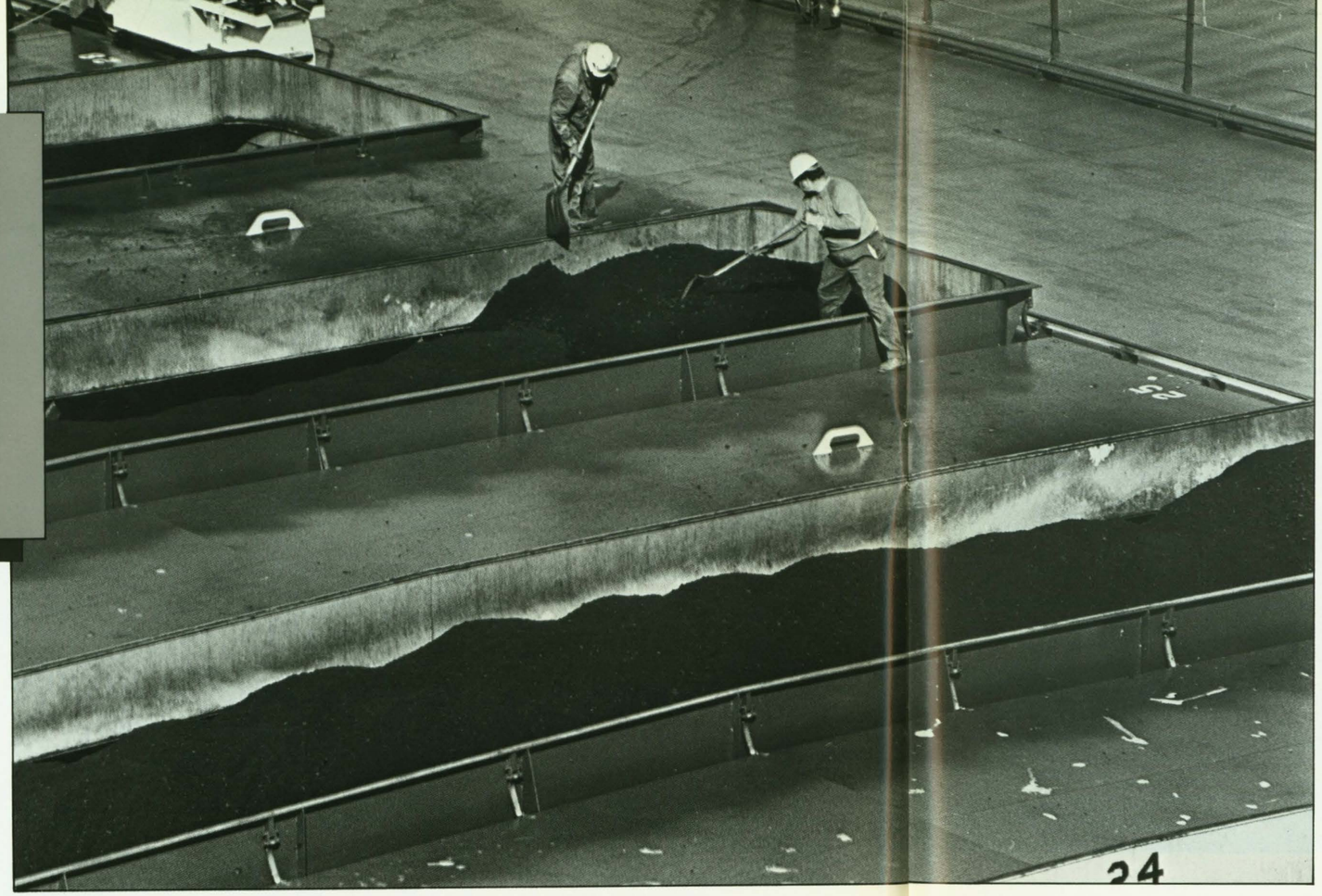
Before Eskuri's stint in the cold water ended, Pozos and Wittmers tested the body's second survival response—the dive reflex. Eskuri flipped over on his stomach and put his face under water. Receptors on the face apparently trigger the reflex, causing the heart rate to drop (as much as 50 percent), reducing circulation in the extremities, and raising blood pressure to increase oxygen to the heart, brain, and lungs. The process turns the body into an insulating layer around the vital organs, decreasing heat loss.

The dive reflex may be what saved young children who have survived immersion in cold water. Pozos is not certain it is the complete answer, but it deserves further study, he said.

It is too early to determine yet how much the researchers learned in the Lake Superior experiments. These tests were the first in a series to be held in the lake. Further testing next spring may help determine why the subjects' temperatures fell so much faster in the lake than they do in the laboratory.

Robert Pozos, Associate Professor and Head
Lorentz Wittmers, Associate Professor
George Fall and Dave Howard, Sea Grant Trainees
Department of Physiology
University of Minnesota, Duluth

SHIPPING



Workers at a coal storage facility on Lake Superior

Poor Market for Coal Exports

Just a few years ago, increasing coal exports out of the Great Lakes looked promising. But today, Sea Grant research shows that Great Lakes exports are unlikely to increase until after the year 2000. Economist Jerry Fruin and graduate student Dave Senf studied the potential for increases in both exports and domestic shipments out of Great Lakes ports. Through a computer model, they compared the cost of transporting western coal from 65 U.S. and foreign supply ports to 52 foreign ports. Duluth-Superior was included in the model.

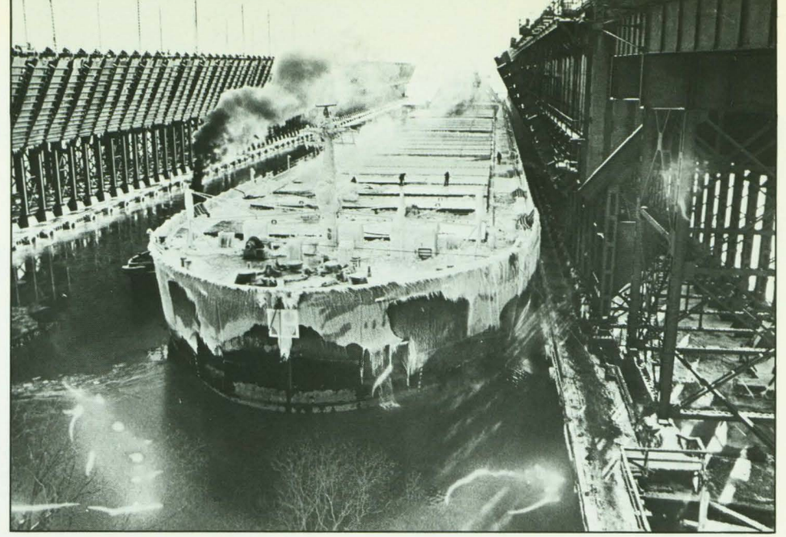
Originally, Fruin's model predicted that from 5.5 to 15 million tons of western coal (located in the Dakotas, Montana, and Wyoming) would leave Duluth-Superior each year for western Europe. But growth in world coal demand is 80 to 100 percent lower than originally predicted. The result is "lower U.S. exports with no exports out of the Great Lakes," Fruin said.

When the research began in 1980, projections for increases in world coal demand were optimistic. Oil prices were rising and power plants around the world were expected to switch from oil to coal as oil costs increased. Poland, a major coal supplier for western Europe, was in the midst of a labor strike. As a result, eastern U.S. ports were exporting Appalachian coal at capacity. Under these conditions, international demand for coal was expected to increase enough to give Great Lakes ports a share of the market.

Today, oil prices have declined 25 percent, decreasing demand for coal. Existing demand can be easily met by foreign suppliers, even though the U.S. is the world's largest exporter of coal, Fruin said. "The U.S. has a lot of coal but many places around the world can produce as good a product cheaper."

Domestic coal shipments out of the Great Lakes will not increase either, Fruin said. All of the coal shipped out of Duluth-Superior is from the western mines. Since most of the new coal-powered plants are south and west of the mines, the coal is moved by rail. "The problem is related to the decline in the frost belt and the boom in the sun belt," Fruin said. "When new industry and electric generating plants are being built in the Southwest instead of in the Northeast, the Great Lakes will not be a major coal shipping area."

Jerry Fruin, Associate Professor
David Senf, Sea Grant Trainee
Department of Agricultural and Applied Economics
University of Minnesota, Twin Cities



Longer Shipping Season Has Few Benefits

Extension of Lake Superior's winter navigation season has been a source of controversy for some time. Advocates of a longer season say extending the eight-month season to 10 or 11 months would bring more business to the Duluth port and help improve the area economy.

Sea Grant researchers, however, do not agree. In a one-year study, Professors Jerry Fruin and C. Ford Runge found that extension of the winter shipping season would not have a major impact on the Duluth area economy.

"Season extension, by itself, won't solve the Twin Ports' problems," said Runge. Instead, season extension should be thought of as one of a set of possible strategies for increasing the port's business. "Our finding is that it will not have a major impact on the port's economy without a broader set of economic stimuli."

Runge and Fruin studied Lake Superior weather and ice formation data from the past 80 years, Twin Ports shipping volume, and the direct impact of port activity on the local economy. Using this information, they projected the effects of extending the season from an additional two weeks to two months.

"At current levels of demand, a short extension would probably be the most cost-effective and the best use of resources," Fruin said. "The benefits would not be great enough to justify spending a lot of money to keep the system open a great deal longer."

Ice formation is the critical factor in determining a closing date, Runge said. Weather and ice formation data showed substantial variability from year to year. Ice maps showed that there was open water over all of Lake Superior through December, with parts of the lake still unfrozen as late as January 31 in most years. However, data from the last 20 years suggests that days of freezing weather have been occurring earlier more frequently in this period.

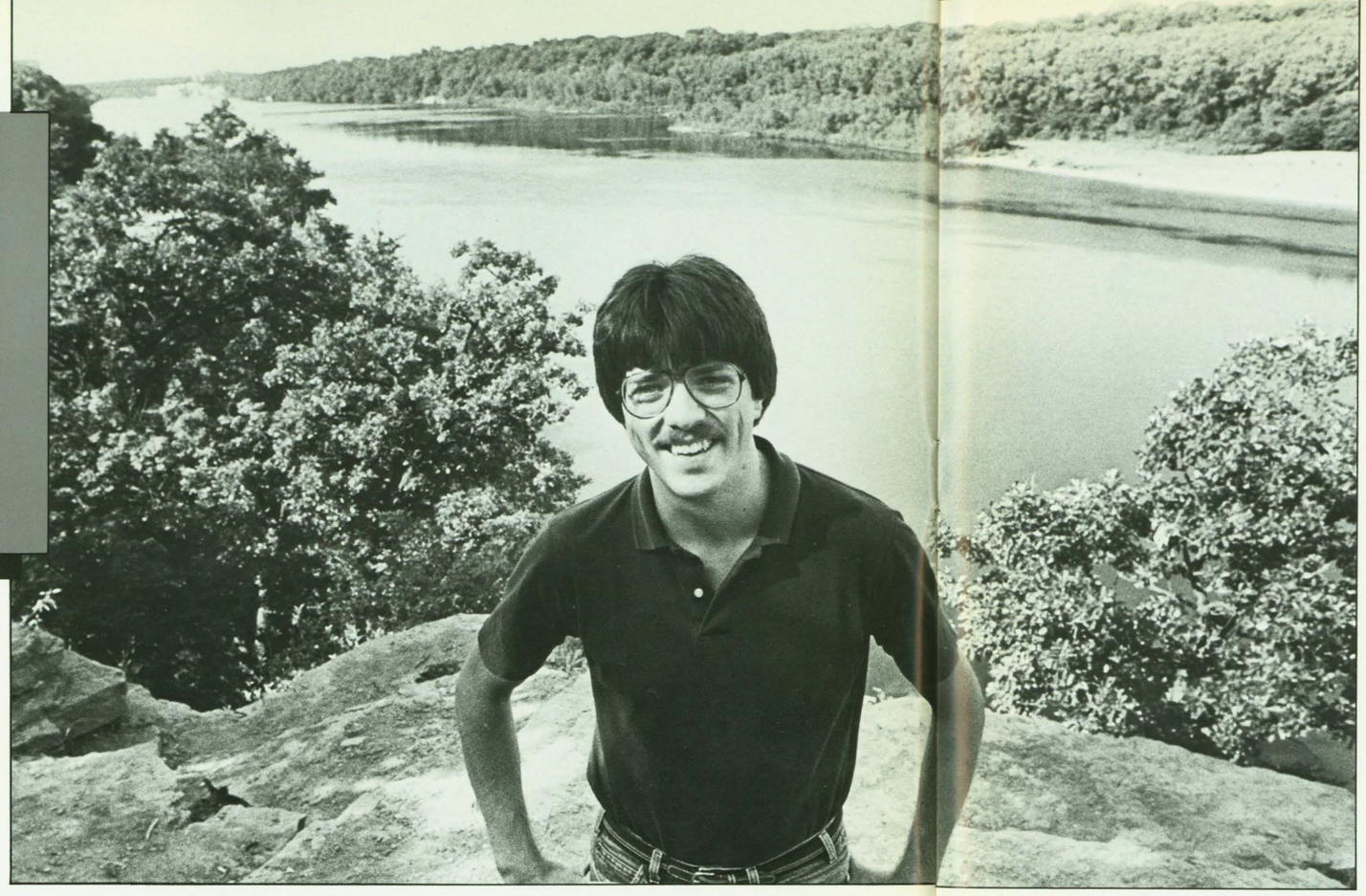
Runge cautioned against basing the closing date on "normal" conditions. "Weather and ice formation varied substantially from season to season, and the data suggests this wide variability will probably continue," he said.

In studying economic benefits, Fruin and Runge used annual income of longshoremen as one indicator of season extension's direct impact on the local economy. In 1984, the total annual wage income for longshoremen was $2.8 million. However, the researchers found that because of the relatively few workers needed for grain loading, the effect of a short season extension on employment would be minimal.

"Part of what has kept the port competitive has been the substitution of capital for labor, of machines for men," Runge said. "The increasing use of technology and less manpower will mean a decrease over time in the importance of season extension to employment."

C. Ford Runge, Assistant Professor
Jerry E. Fruin, Associate Professor
Department of Agricultural and Applied Economics
University of Minnesota, Twin Cities

EDUCATION



Sea Grant Trainee Joel Baker

Indian Scientist Benefits Reservation

Almost one-half of the 2.6 million acres of water in Minnesota are owned or managed by Chippewa Indian reservations. Until recently, there were no Chippewa aquatic scientists trained to manage these vast resources.

Today, with a degree in environmental studies and two years of research experience, Mike Swan has gone back home to help protect the waters of the reservation. Swan is the second graduate of Sea Grant's American Indians in Marine Science program (AIMS). He is now senior aquatic researcher at the Chippewa Environmental Research Laboratories (CERL) near Cass Lake, Minnesota.

CERL Director John Pursell recognized the critical need for Indian aquatic scientists seven years ago. He and others asked Sea Grant to develop the AIMS program to train students in marine sciences. Now in its fifth year, AIMS is the only program of its kind in the country.

AIMS students receive a monthly stipend and tuition from Sea Grant. They are required to maintain a B average and to supplement their studies with Sea Grant research during their last two years of undergraduate study.

Swan says his Sea Grant experience was invaluable. "The people in the program were really supportive," he said. "My research and the chance to work with several different Sea Grant researchers gave me experience that helps me in my work now."

Swan's responsibilities at the lab include analyzing water quality, fisheries, and wild rice habitat in the waters of Leech Lake, Fond du Lac, White Earth, and Mille Lacs reservations. One of his primary interests is in checking nutrient loads for possible pollution problems. There are no problems now, he said, "but there is potential from acid rain, sewage seepage from cabins close to the lakes, and industrial pollution."

Although his work as an AIMS student is done, Swan is still helping to further one of the program's goals: providing role models for young Indians and encouraging them to continue their education. Swan visits area high schools to talk about science careers, hoping other Indian students will follow in his footsteps.

"Many times people don't come back to the reservation because there are no jobs in their fields," he said. "I was able to put my training to use here. I felt it was important for me to come back."

A classroom aquarium may be as close as most kids get to hands-on experience with aquatic life. Lacustrine Lessons provides creative ways to teach water-related subjects.

Lacustrine Lessons

Even in the land of 10,000 lakes, most Minnesota teachers have little background in the aquatic sciences. And they have few resources for teaching aquatic and marine topics to their students. *Lacustrine Lessons* helps teachers bring Minnesota's lakes and ponds into the classroom.

Lacustrine Lessons has been published by Sea Grant five times per school year for the past five years. Each issue contains three lesson plans, ranging in complexity from kindergarten through high school level.

A recent survey of *Lacustrine Lessons* readers brought rave reviews. "It brings to my young students a keener awareness of the life found in lakes and ponds nearby," one teacher wrote. "I appreciate how the lessons tie in so closely with our Minnesota waters," another responded. A museum worker wrote: "We use *Lacustrine Lessons* as an excellent example of what our classroom resources could be like."

Lacustrine Lessons contributes to good science education and an appreciation of Minnesota's water resources, says education agent Bruce Munson. "Teachers have a significant impact on students' knowledge of Lake Superior and the hydrocycle," Munson said. "They also profoundly affect their students' attitudes and values concerning aquatic resources."

Munson is incorporating readers' suggestions into a revised *Lacustrine Lessons* format. He also plans to expand the mailing list, distributing the publication to interested teachers nationwide.

Research Supports Students

Joel Baker has worked on Sea Grant research through a master's degree and the first year of a Ph.D. "I've always had Sea Grant support," he said. "I don't know what I would have done without it."

Baker, a student in environmental engineering at the Twin Cities campus, is studying the behavior of organic pollutants in freshwater lakes. With Sea Grant funding, he and his major professor, Steven Eisenreich, were able to participate in this summer's submersible exploration of the bottom of Lake Superior.

The 22-foot-long submersible took more than 20 scientists to the bottom of the lake to study Superior's biology, fisheries, and sedimentary processes.

"It was a great opportunity," Baker said. "We learned so much about the lake in a short time, because we could see everything firsthand instead of having to take remote measurements." It was also an exciting educational experience, he said, since he worked with Great Lakes scientists from many different fields.

Baker is one of 15 graduate student trainees supported by Sea Grant this year. Each student receives a stipend of $6,200, tuition, and the opportunity to work closely with faculty on Sea Grant research.

"Students are Sea Grant's most valuable product," said Director Donald McNaught. "We hope when they graduate and enter the work force that they will be a testimony to the Sea Grant ethic: to promote the wise use of our water resources."

EXTENSION AND PUBLICATIONS

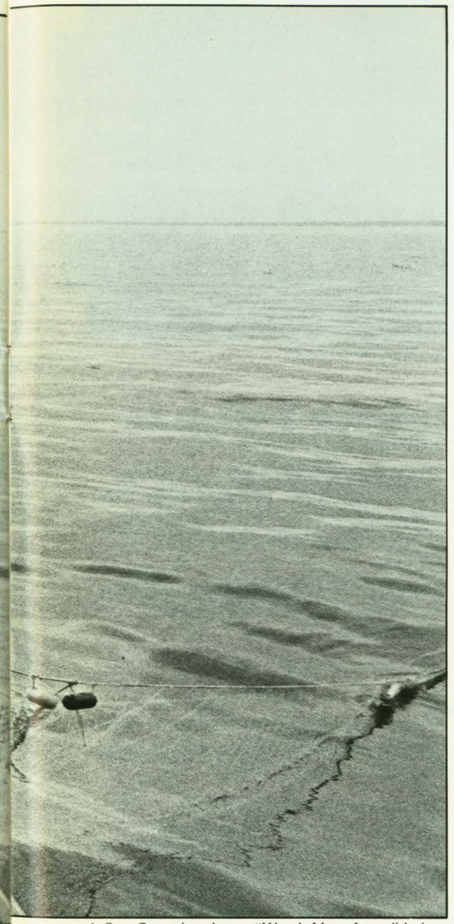
Watch Your Lines

Sportsfishermen usually know to steer clear of commercial fishing nets to avoid getting their lines tangled. Until this year, however, boaters and fishermen couldn't tell which way to pass around the nets since the inside and outside ends were not identified.

"We were seeing more problems with the increase in sportfishing activity on Lake Superior," said fisheries agent Jeff Gunderson. "It was getting to be a boating hazard."

The Department of Natural Resources (DNR) met with representatives from sports and commercial fishing groups to agree on the best way to mark the nets. Their suggestions resulted in new guidelines on the marking of commercial fishing gear in Minnesota waters of Lake Superior.

Gunderson has written a brochure, "Watch Your Lines," explaining the regulations and how to avoid the nets. The brochure also explains what to do if your boat or fishing gear become entangled in a net. It includes an overview of Minnesota's commercial fishing regulations on Lake Superior.



A Sea Grant brochure, "Watch Your Lines" helps people fishing from boats determine how to avoid commercial fishing lines.

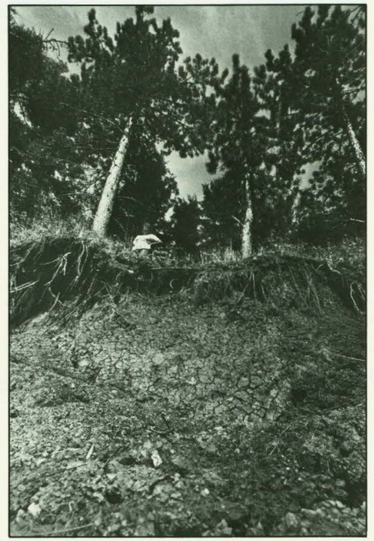
Ideally, the brochure should be in every sportfishing boat on Lake Superior, Gunderson said. "But it's more likely for people to request it after they have already gotten tangled in someone's nets." Gunderson expects to provide the brochure to bait shops, marinas, and sportfishermen along the lake before next year's fishing season.

"Watch Your Lines" was produced in cooperation with the DNR, and sport and commercial fishing groups.

Erosion Damage Studied

For years, portions of the North Shore have been sliding into Lake Superior leaving muddy banks, damaged highways and threatening private homes. Last spring, when the Great Lakes reached record high water levels, concern about the erosion problem peaked.

To begin looking for possible solutions, Sea Grant Extension Director Dale Baker organized a meeting with local erosion experts. As a result, the North Shore Erosion Task Force was formed. Members include county commissioners, highway planners, the Corps of Engineers, the Soil Conservation Service and the Minnesota Department of Natural Resources.



Erosion damage is evident in some areas of the North Shore. The red clay shoreline may erode at rates of three to four feet a year.

The task force's first step was to gather information. Aerial photos of the shoreline told Cook and Lake County officials that the erosion problems there are not as serious as anticipated. The most serious erosion areas lie in St. Louis County, which includes the southernmost section of the North Shore. In that area, the rocky coast is covered with a clay topsoil susceptible to erosion by wave action and water seeping through the banks.

The task force will try to find the rate of erosion in different areas, the effect of the higher water levels, less expensive erosion prevention techniques, and the effect of timber cutting in the uplands on the shore's erosion rate.

Finally, the group hopes to negotiate solutions and help fund them. "There is a lot to be learned about the erosion problem," said Baker. "And because the North Shore is a statewide resource, there should be enough concern about it to raise funds to study possible solutions."

Additional information for property owners is provided by Sea Grant's fact sheet, "Smooth Sailing Through Coastal Permits," which explains regulations on building erosion control structures. A slide/tape presentation, "Coastal Erosion and Real Property Values," is designed for real estate agents and appraisers.

Teach a Kid to Fish

Seventy years from now, Minnesota 4-Hers may still be using the fishing skills they're learning today.

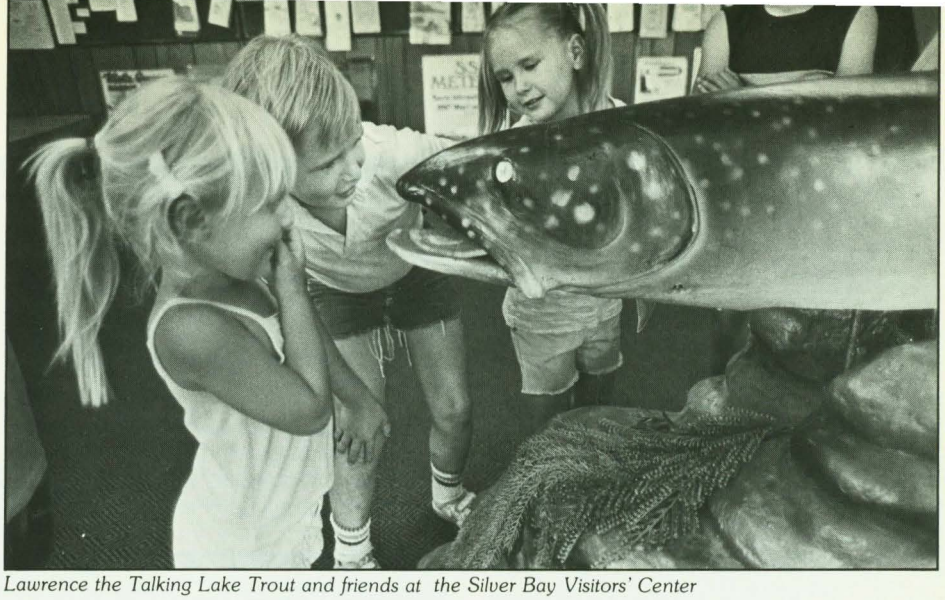
Education agent Bruce Munson likes to picture today's 4-Hers in their 80s, enjoying the beauty, peace, and appreciation of nature that fishing can bring. Munson is one of the originators of the new Minnesota 4-H fishing project.

In the project's first year, 371 kids from 17 Minnesota counties participated. In 1985, Munson hopes to double both the number of counties and kids involved.

Munson and fisheries agent Jeff Gunderson train adult and junior 4-H leaders in the fishing skills used in the program. The leaders then share their new skills, which range from finding fish to fixing it for dinner. 4-Hers also learn fish identification and biology, choosing equipment, fishing regulations and safety, fish handling, and preparation techniques.

Teaching kids how to fish is also an opportunity to get them concerned about environmental resources, Munson said. "Fishing sensitizes people to the environment. If they value fish and fishing they'll be concerned about preserving water quality and protecting the environment."

Lawrence is Back!



Lawrence the Talking Lake Trout and friends at the Silver Bay Visitors' Center

It's amazing what people will say to a mechanical fish. Adults will carry on long conversations about fishing and boating on Lake Superior. And kids, of course, will discuss just about anything with Lawrence—from what he likes to eat to why he can't come live in their backyard swimming pool.

Lawrence the Talking Lake Trout returned to Sea Grant in grand style this summer when he made his first appearance in six years at the Minnesota State Fair.

"Last time I was here, I was the most popular attraction at the fair," Lawrence bragged.

Everyone was obviously delighted to have him back. Fans of all ages stopped to talk. "Don't you remember me?" a youngster asked. "We came all the way from Tennessee to see you."

"Talk to me, please?" a little boy pleaded while Lawrence was taking a much needed break.

Sea Grant created Lawrence in 1978 as an educational tool. His expertise is in just about any topic related to the Great Lakes, particularly his home: Lake Superior.

Lawrence has proved more popular than anyone imagined. He has travelled around the country to sports fairs, appeared on television at least 20 times, and even spoken to the U.S. Congress.

Sea Grant retired Lawrence to the Silver Bay Vistors' Center on Lake Superior when his schedule—and that of the agents who talk for him—got too hectic. But this year, Lawrence decided he was too young for retirement.

"There are plenty of people out there who haven't met me yet," Lawrence said. "They may never have another chance to learn about Lake Superior straight from the fish's mouth."

Lawrence lives on the North Shore in Silver Bay but visits Sea Grant for occasional special events.

Seaway Conference Presents Opposing Views

The St. Lawrence Seaway connects Duluth to the Atlantic Ocean, making Duluth the largest inland seaport in the country. But in 1984, the Seaway celebrated its 25th anniversary in the shadow of economic and technological changes that threaten its future as an international transportation route. Sea Grant organized the "Seaway in the Year 2000" conference to bring users and government officials together to talk about the Seaway's problems and its future.

The major concern at the conference was whether the Seaway will again be as important as it once was. Will the Seaway realize the original goal of becoming the nation's fourth sea coast? Will it survive user fees, a sagging bulk commodities market, and a growing fleet of bigger, more efficient ships that use ocean ports instead of the Seaway? Can it remain competitive against Mississippi River barges, railroads, and east coast ports?

There were distinct differences of opinion between Seaway users—shippers, farmers, industries, and port authorities—and the deficit-burdened U.S. and Canadian governments.

Government representatives stressed that Seaway users must adapt to conditions that didn't exist when the Seaway opened in 1959. These include: shrinking markets, ballooning federal deficits, and bigger ocean vessels. The Seaway has not outlived its usefulness, they said. It must simply change the way it operates.

Seaway users disagreed with the governments on several major points, especially whether new locks should be built to accommodate larger ships. They also challenged the fairness of additional user fees. "Our Seaway remains the only deep-draft navigation project in the U.S. that requires users to repay construction and fund operation and maintenance," said Mark Thompson of *Seaway Review* magazine. User fees would unfairly double the burden for Seaway users, he added.

A 50-page summary of conference proceedings is available for $2 from Sea Grant Extension.

Boating Increases on Superior

One of Minnesota's fastest growing boating areas is the western portion of Lake Superior. It is also one of the most rugged. The rocky cliffs and shorelines of the North Shore provide scenic boating and good fishing but few harbors or marinas. Although a number of marinas exist between Knife River and Duluth, the 90-mile coast from Knife River to Grand Marais offers no harbors or docking facilities. On a huge lake like Superior, boaters need the security of a nearby harbor in case of a sudden storm or accident.

Wisconsin and Minnesota Sea Grant programs did a joint survey this fall on boaters' use of the western portion of the lake and of their needs for additional facilities. They found a significant need for more marinas, harbors of refuge, and transient docking, particularly in the Knife River to Grand Marais area.

"New facilities would encourage more boating in the region," coauthor and agent Chad Dawson said. "The majority of boaters reported that they would boat more often if a new harbor of refuge or transient docks were built where they suggested." Survey respondents also indicated that they would not object to paying for use of new facilities.

"This has important implications for lake communities," Dawson said. The demand for new facilities is expected to grow over the next few years, and these communities need to start planning to accommodate the increase in boaters, either through public or private development.

Survey results are available from Sea Grant Extension.

ADMINIS-TRATION

Journal Reprints

Johnson, Thomas C. 1984. Sedimentation in Large Lakes. *Ann. Review Earth Planet. Science* 12:179-204.

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Gleason, Florence K. and Joy L. Paulson. 1984. Site of Action of the Natural Algicide, Cyanobacterin, in the Blue-gree Alga, *Synechococcus* sp. *Archives of Microbiology* 138:273-277.

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Tilman, G.D. and R. Sterner. 1984. Invasions of Equilibria: Tests of Resource Competition Using Two Species of Algae. *Oecologia* (Berlin) 61:197-200.

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Some Aspects of the Early Life History of Lake Herring (Coregonus artedii) in Western Lake Superior, Jay T. Hatch and J.C. Underhill. 1984. No. 10.

1984 Barge Rates for Upper Mississippi River Commodities. Dan Halbach, Jerry Fruin, Scott Wulff, and Chuck Eldridge. 1984. No. 12.

Superior Advisory Notes

Survival in Cold Water: Hypothermia Prevention. C. Dawson, 1985. No. 16.

Superior Pursuit: Facts About Lake Superior. H. Bell, 1985. No. 19.

SCUBA Diving the Minnesota Shore of Lake Superior. H. Bell, 1985. No. 21.

The following three publications are based on survey findings of boater use and needs, conducted during the summer of 1985.

Recreational Boating on Western Lake Superior During 1984. C. Dawson, J. Clark Laundergan, 1985. No. 18.

Western Lake Superior Marinas. C. Dawson and K. Plass, 1985. No. 17.

Minnesota Boater Registration. C. Dawson, 1985. No. 20.

General Publications

Chances Are . . . Sea Grant. A brochure describing Minnesota Sea Grant. A. Tibbetts and H. Bell, 1985.

Watch Your Lines, a guide to the marking of commercial fishing nets and how to avoid them. J. Gunderson, 1985.

The St. Lawrence Seaway in the Year 2000, conference Proceedings. H. Bell, 1985.

Recreation and Weather Guide to the Minnesota Shore of Lake Superior. C. Dawson and H. Bell, 1985.

Twin Ports Fishing Guide, a directory of services for the angler in Duluth-Superior and a guide to fishing the area. J. Gunderson, 1985.

Periodicals

The Seiche. A quarterly newsletter published by Sea Grant Extension about the Minnesota coast of Lake Superior.

Lacustrine Lessons. For teachers—to provide aquatic-related lessons for grades K-12. Three lessons in each issue, published five times during the school year.

For a complete list of all Sea Grant's publications, contact the Sea Grant Extension Office, 208 Washburn Hall, University of Minnesota, Duluth, MN 55812, 218/726-8106.

Project Number	Section and Project Title	Investigator(s)	NOAA Sea Grant Funds	Legislative & University Match	Status
Fisheries and Aquaculture and Marine Natural Products					
R/F-10	**Population Dynamics and Yield Potential of Lake Superior Pink Salmon *(Oncorhynchus gorbuscha)***	George Spangler	$14,109	$2,861	O
R/F-14	**Food Habits and Forage Base of Lake Superior Salmonids**	Hollie Collins	5,705	12,668	O
R/F-15	**Biomass Dynamics of Lake Trout, *Salvelinus namaychush*, in Lake Superior**	George Spangler	16,095	5,723	O
R/F-12	**Application of Gamete Preservation Techniques to Enhance Aquaculture**	Edmund Graham	9,021	23,701	C
R/NP-1	**Isolation and Characterization of Antibiotics from Freshwater Algae**	Forence Gleason	26,272	4,768	O
Coastal and Environmental Processes					
R/CL-7	**Redistribution of Tailings Deposits by Turbidity Currents in Lake Superior**	Gary Parker and Heinz Stefan	20,508	4,349	C
R/CL-10	**The Scientific Basis for Assessing Dredged Material Disposal in the Duluth Harbor**	Steven Eisenreich	20,965	13,456	C
R/CL-12	**Role of Sediment Resuspension as a Source or Sink for Aquatic Pollutants in the Duluth-Superior Harbor**	Patrick Brezonik	15,416	7,592	O
Economics—Tourism and Shipping					
R/C-9	**Economic Analysis of Competitive Position of Northern Great Plains Coal Exported Through Great Lakes Ports**	Jerry Fruin	9,699	21,747	O
R/C-11	**Stimulating Effects of Tourism/Recreation Activities on Market Based Recreation Facility Investment and Location Options in Minnesota's Coastal Zone**	Richard Lichty, William Fleischman, Wilbur Maki, and Wayne Jesswein	6,255	23,765	O
Water Safety and Health					
R/S-4	**Relationship Between Shiver, Metabolic Rate, and Glucogenic Hormones**	Robert Pozos, Edwin Haller, and Lorentz Wittmers	11,815	25,817	C
R/S-5	**Cardiovascular Changes Induced by the Diving Reflex—A Field Study (Drowning and Diving Reflex)**	Lorentz Wittmers	24,449	5,126	O
Education and Training					
E/T-3	**Sea Grant Traineeships**	Donald McNaught	70,400	13,000	O
E/T-4	**American Indians in Marine Sciences**	Robert Diver and Bruce Munson	31,406	—	O
Sea Grant Extension Program					
A/SE-1	**Minnesota Sea Grant Extension**	Dale Baker	230,558	107,130	O
Program Management and Development					
M/P-1	**Program Management**	Donald McNaught	67,836	43,476	O
M/C-1	**Communications**	Alice Tibbetts	18,942	8,517	O
M/P-2	**Program Development**	Donald McNaught	15,549	—	O
M/P-3	**Ship Time**	Donald McNaught	10,000	—	O

C = Completed
O = Ongoing

Grant NA83AA-D-00056

Budget Summary

Activity	NOAA Office of Sea Grant	State Match	University Match	Industrial Match	Federal Pass Through
Research	$180,309	$82,931	$68,642	$500	$86,054
Education	101,806	13,000	—	—	—
Extension	230,558	69,405	37,725	—	—
Communications	18,942	8,517			
Program Management	93,385	43,476	—	—	—
Totals	$625,000	$217,329	$106,367	$500	$86,054

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