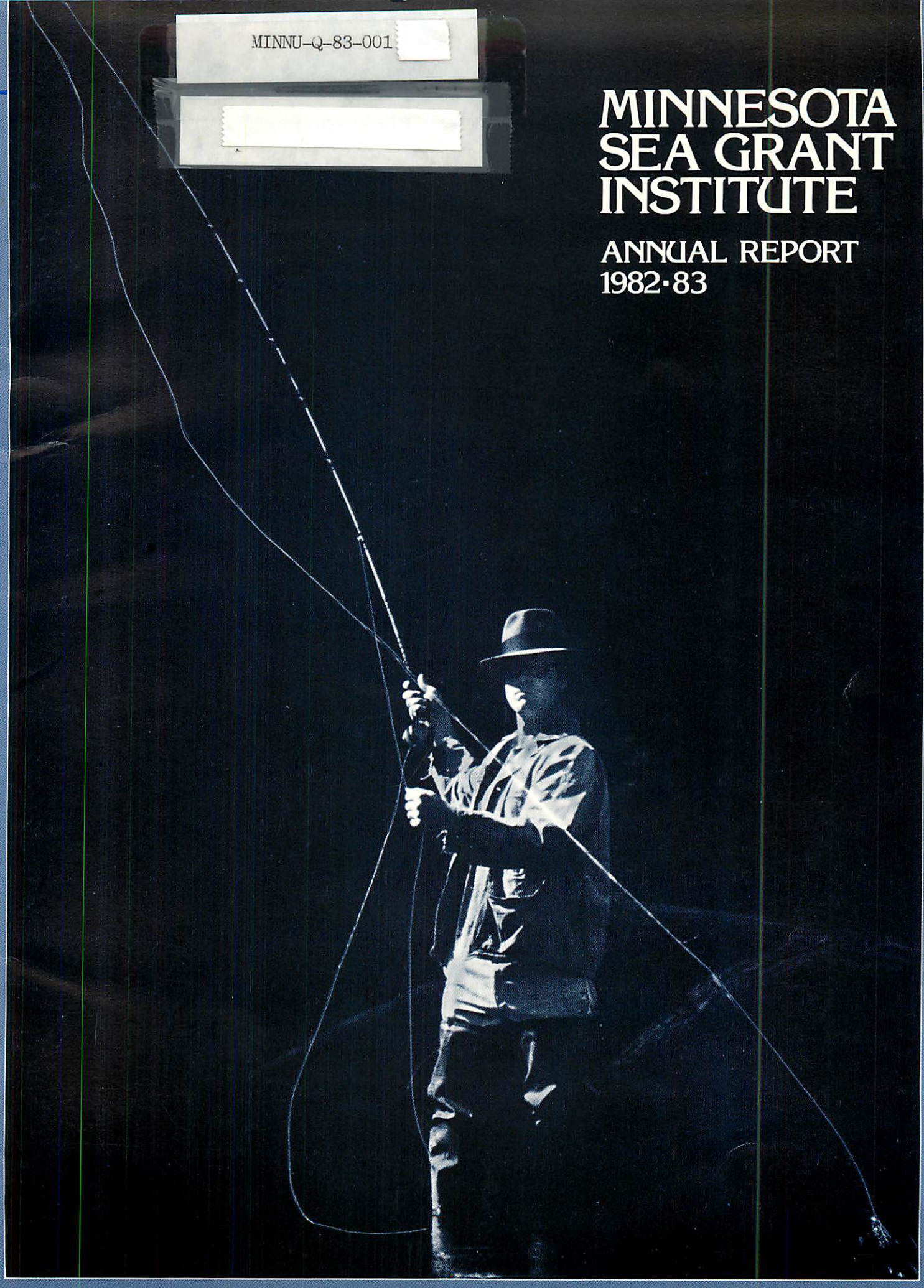
MINNESOTA SEA GRANT INSTITUTE

ANNUAL REPORT 1982-83



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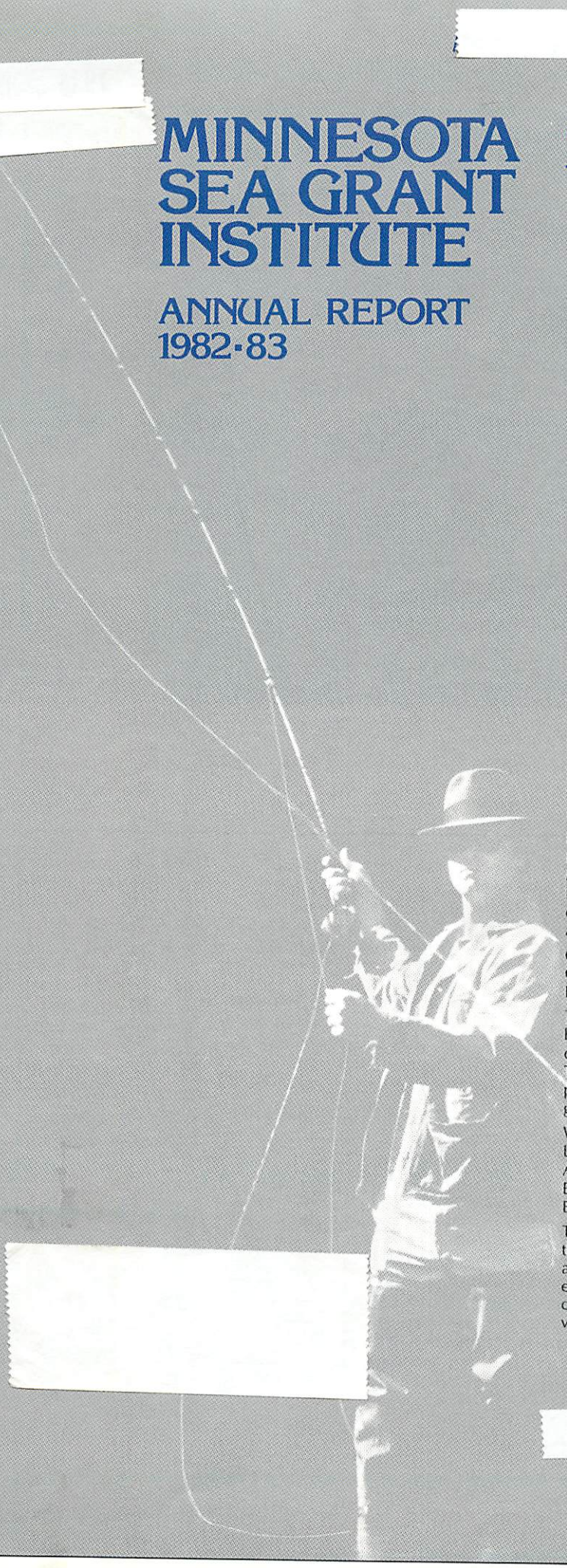

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The Cover
Fly fishing for trout at the mouth of the Lester River on Lake Superior. Photo by Rob Levine.

Credits

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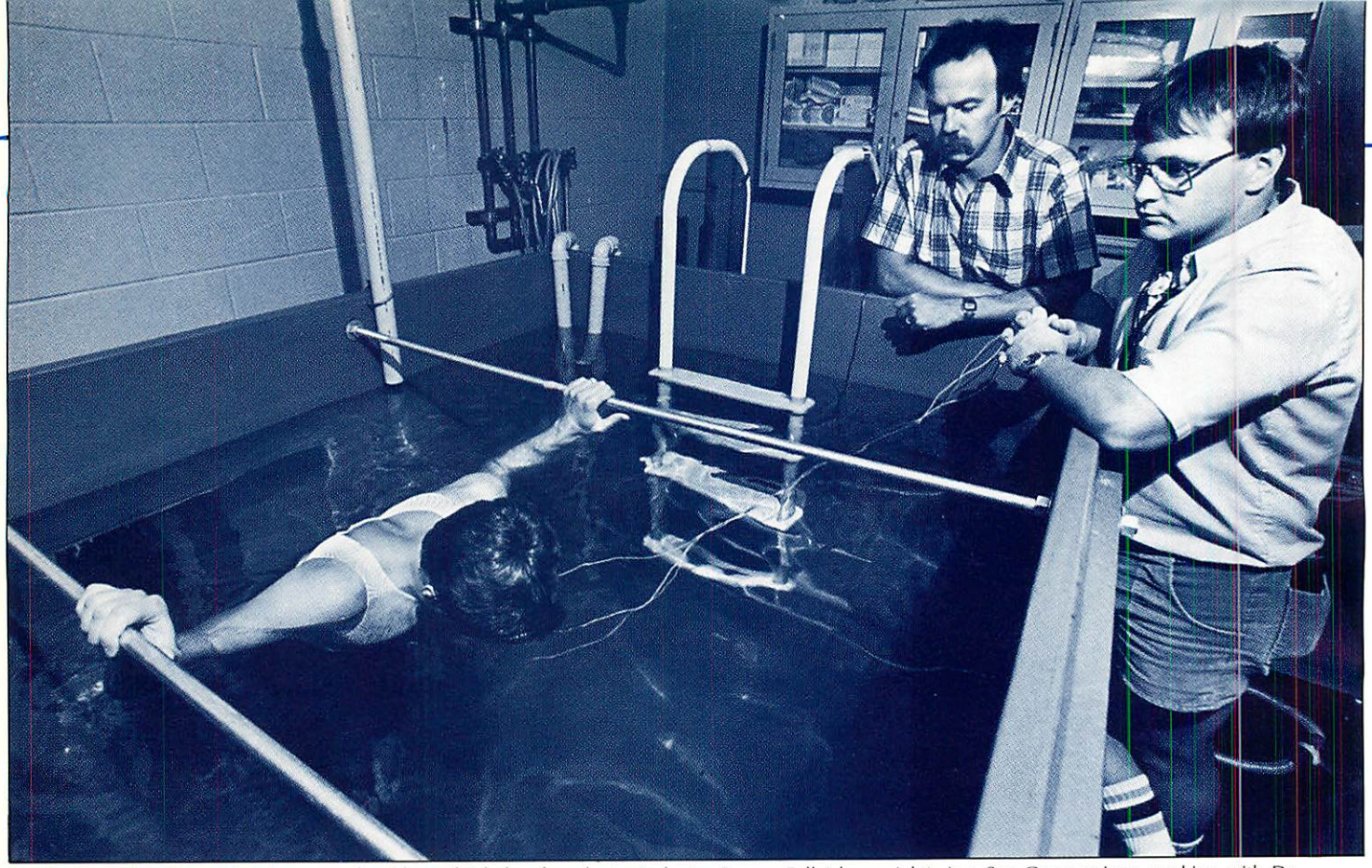


Sea Grant could not conduct its research without the help of graduate students. George Fall (above right), is a Sea Grant trainee working with Dr. Lorentz Wittmers at the University of Minnesota-Duluth Hypothermia Laboratory.

Letter From the Director

The National Sea Grant College Program funds research, education, and advisory services in the nation's coastal states and Great Lakes states. In Minnesota, Sea Grant is concerned with Lake Superior and the surrounding region. Although our research on the lake has certainly benefitted Minnesota and the other Great Lakes states, our most valuable product is not research, it is the students we place in the work force. Trained by University faculty, these students help increase the resources of the Great Lakes sportfishery, solve the problems of shore erosion, increase commodity shipping through the Great Lakes ports, and prevent potential cold water drownings.

The research covered in this report would not have been completed without graduate student involvement. For instance, Joe Nicolette (M.S.) studied pink salmon populations with Professor George Spangler. He discovered that pink salmon have great potential as a major recreational or commercial fish. Joe is now working on an acid rain survey for New York's Department of Environmental Conservation.

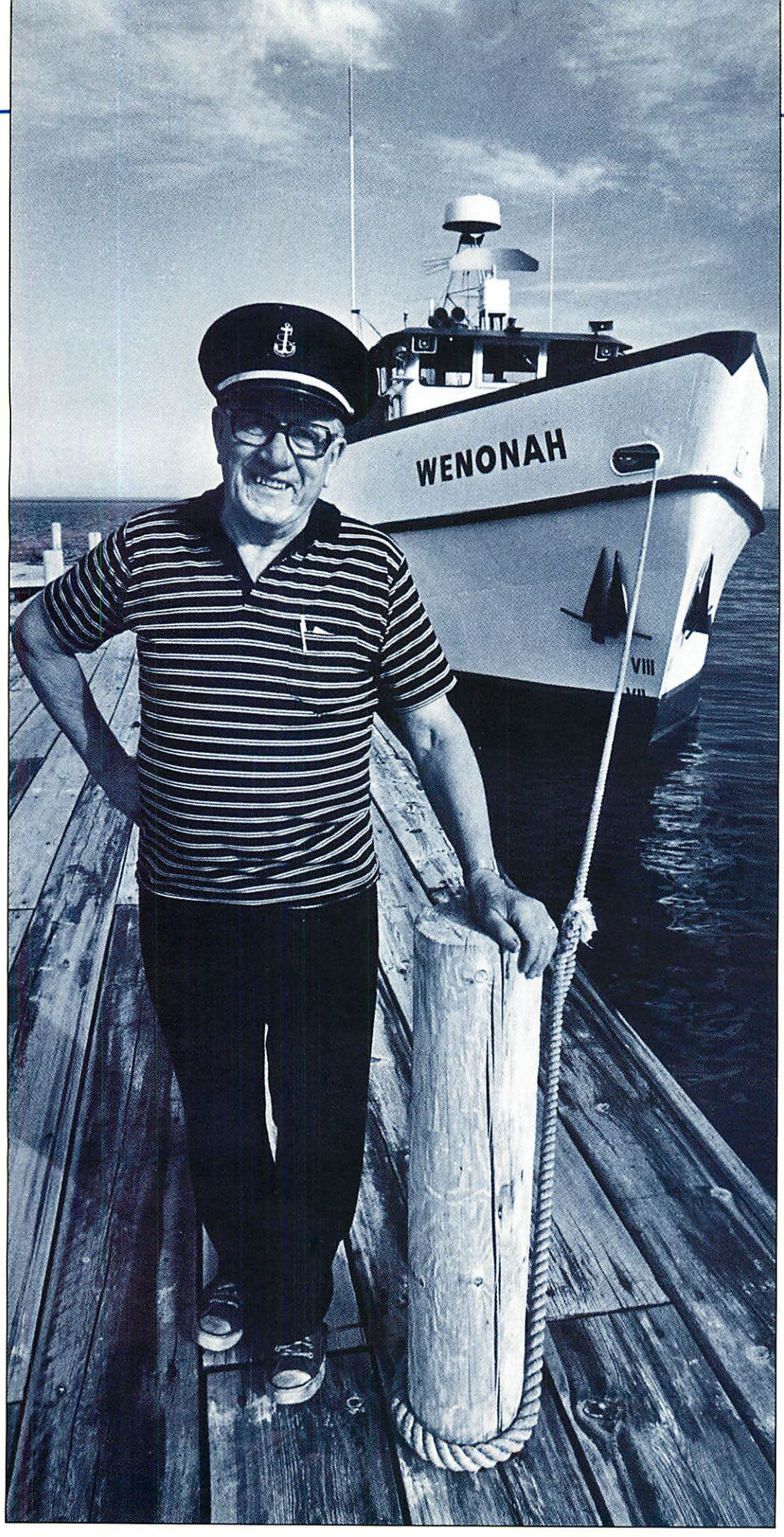
Brian Looney (Ph.D.) researched with Professor Steven Eisenreich, the fate of PCBs in Lake Superior. His training qualified him for an important position with the Nuclear Regulatory Commission's Savannah River Lab.

Dora Barlaz (M.S.) worked with Professor Thomas Johnson on the resuspension of sediments and toxic PCBs by ore boats in the Duluth harbor. She intends to take her Sea Grant training on to law school.

Each year, Sea Grant also trains three to four American Indian undergraduates in the marine sciences. Mike Swan (B.S.) researched with Professor Hollie Collins ways to improve production of leeches, a valuable bait to Minnesota's walleye fishermen. Mike is now a senior aquatic researcher for his tribe, the White Earth Band of the Chippewas. He completed his training at the Duluth campus and returned to the reservation, meeting one goal of the program: to provide trained scientists so the Indians can manage their own water resources.

Graduate students trained in fisheries, civil engineering, or economics may work in a variety of positions. We cannot insure that they will all work in fields dealing only with marine resources. But the University has influenced these students' futures through a quality graduate experience. So from our perspective, we hope the Sea Grant philosophy—to help marine-related business through research—remains with our graduates for their lifetimes.

Donald C. McNaught
Director, Minnesota Sea Grant



FISHERIES

"No one will lament when Stanley Sivertson can't catch fish anymore. He's caught too many already." But Sivertson will lament—and loudly—what has happened to the lake he's spent his life fishing.

Sivertson has been a commercial fisherman on Lake Superior since the 1930s. He can tell you exactly which years the herring catches were the best, when the smelt first showed up in his nets, and how long it took them to wipe out the herring. He recalls,"In 1938, we'd catch six to eight tons of herring. In those days, there was so much herring we had to hire farmers to help us process it. By 1960, the herring were demolished. By 1962, mine was one of the only boats fishing herring on Superior."

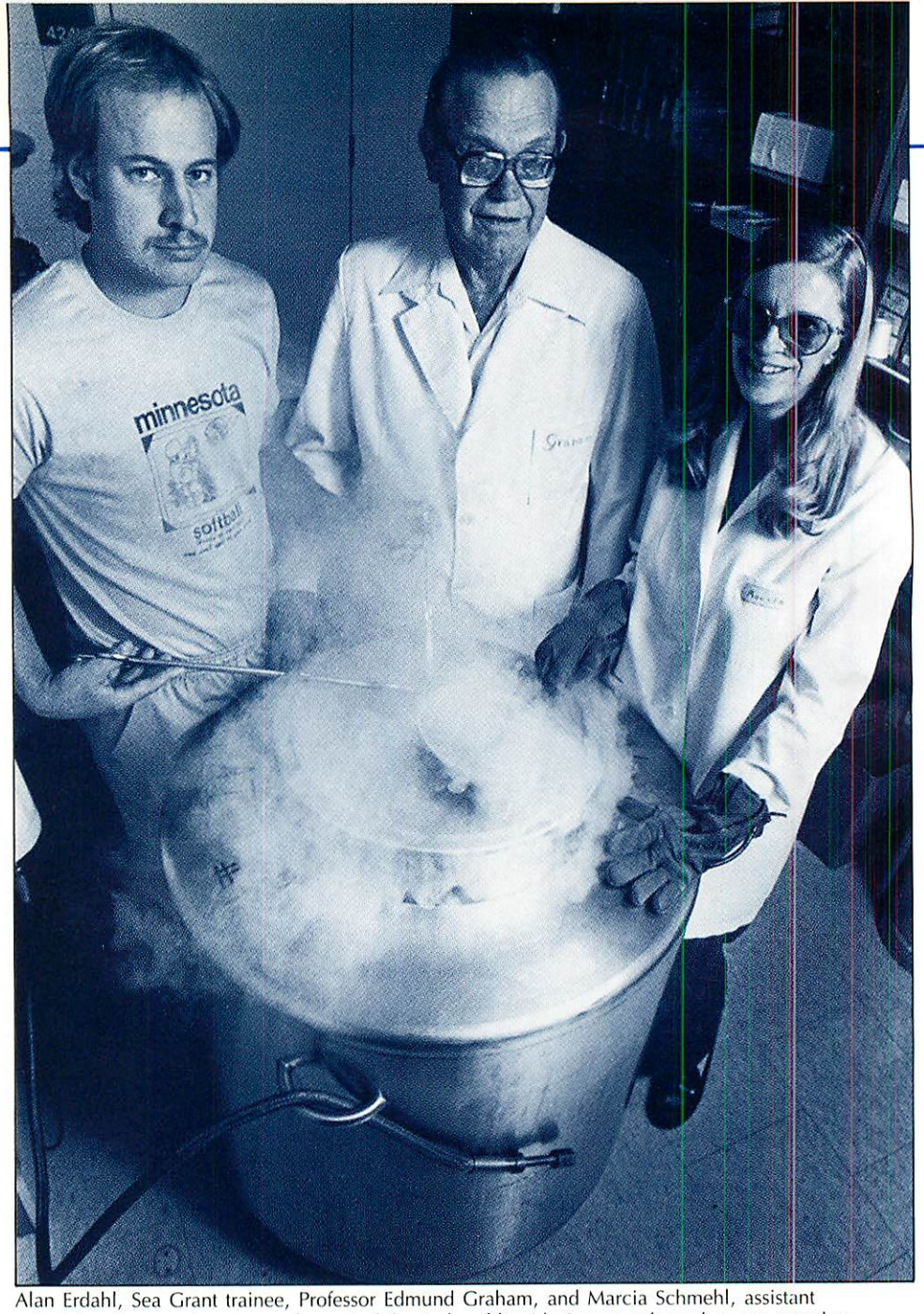
It was the smelt's sudden increase and the resulting collapse of the herring that drove many fishermen out of business, Sivertson said. "With herring weighing three to the pound, a fisherman could dress 100 pounds in less than an hour. At 25 smelt per pound, it takes eight times longer to dress the same amount. It was way too much work and fishermen caught so much smelt at one time, they would be too cheap and we couldn't make any money."

Today Sivertson still fishes for smelt."But smelt is all I can fish," he said. "There is nothing else."

It's hard to be not bitter about what's happened to the commercial fishermen, Sivertson said. Somehow, he has retained his humor and the energy to keep fighting for what remains of his industry. Through Sea Grant and other groups, he tells his side to sports fishermen who want to eliminate commercial operations on the Great Lakes. "The sport fishermen have never hit me while I've been talking, but I don't know what they say when I've gone," he says, laughing.

Sivertson has served on various advisory boards of Minnesota Sea Grant for the past nine years. "Stanley motivated a lot of Sea Grant's early research," said Extension Director Dale Baker. "His suggestions resulted in research on smelt, alternatives to gill nets, and extending the shelf life of fresh fish."

The results of Sea Grant's current fisheries research, described in the following pages, may eventually help revive commercial fishing on Lake Superior.



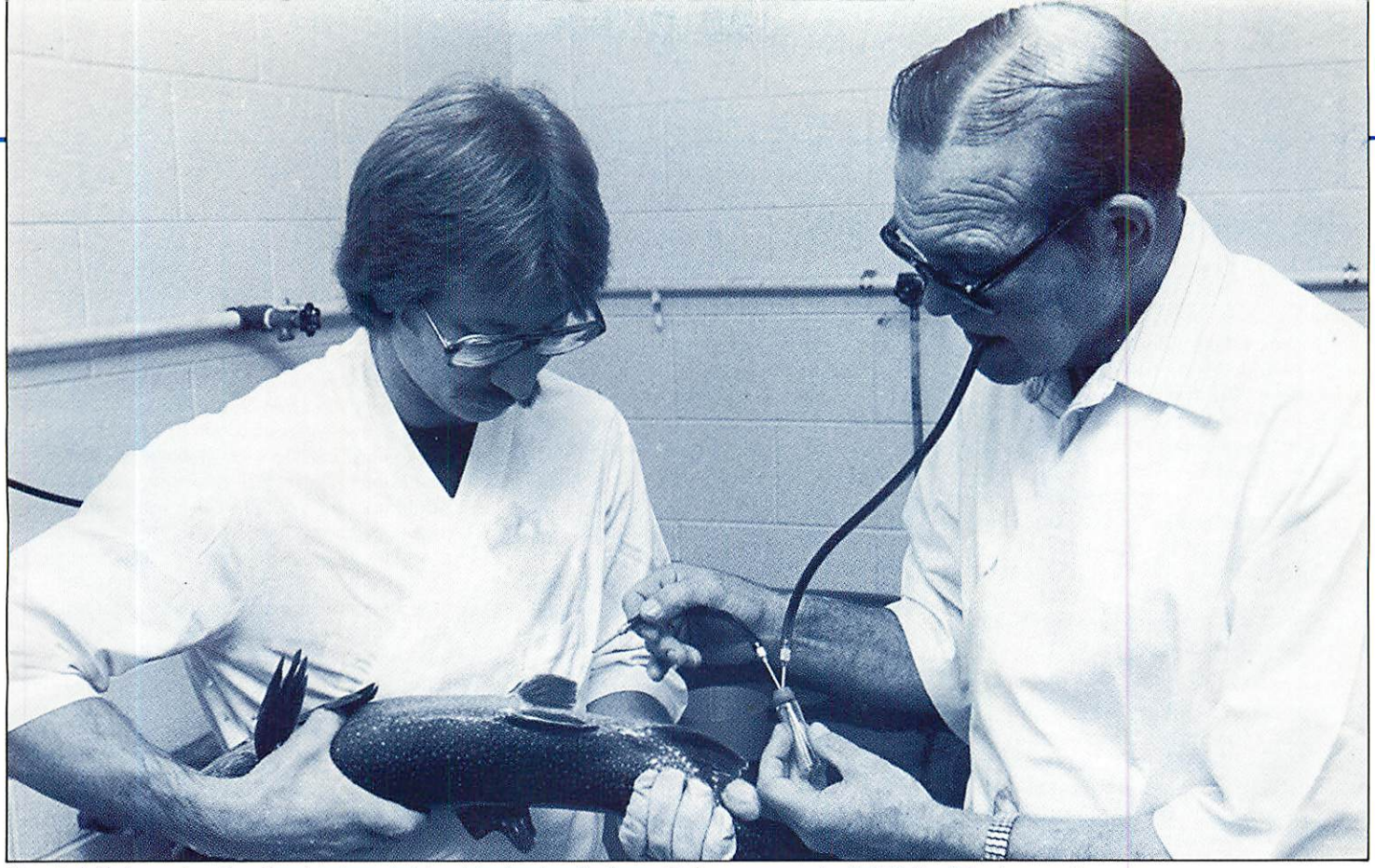
Alan Erdahl, Sea Grant trainee, Professor Edmund Graham, and Marcia Schmehl, assistant scientist pull spermatozoa samples out of the tanks of liquid nitrogen where they are stored at minus 320°F.

Cryopreservation May Breathe New Life into Fisheries

Is it possible that commercial fishing might someday make a comeback on Lake Superior? Or that sports fishermen will travel to Minnesota to fish for a specially bred species—one that will fight longer and harder on their line? It may happen, if Professor Ed Graham's research with fish continues to be as successful as his past work with cattle and other mammals.

Graham perfected the first cryopreservation (preservation by freezing) of mammal spermatozoa 34 years ago. Today, he is researching techniques to cryopreserve and revive the sperm cells, eggs, and embryos of freshwater fish.

Graham's work could mean increased output from hatcheries providing bigger, stronger fish to 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. In addition to trout, Graham works with other fish native to Minnesota that are also important to sport and commercial fishing.



Dave Erdahl, formerly a Sea Grant trainee, holds a lake trout as Professor Graham prepares to "milk" the fish of spermatozoa.

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 extending solution to keep them inactive. The sperm are diluted and treated with a cryoprotective agent to protect them during the freezing process. 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 on the same freezing process for fish eggs and embryos. Because eggs are larger, they may not absorb enough cryoprotectant to prevent damage from the intense cold, said Marcia Schmehl, Graham's research associate. "Evaluating viability is also a bigger problem with eggs," she said. "With sperm, we see recovery through their motility. Some will survive, others won't, and we can tell immediately. But with eggs, it is all or nothing and we have to wait some time before we know the results."

Fish reproduction is a fragile process. Fish sperm, activated by contact with the water, remain viable for only 17 to 25 seconds. Most fish's eggs must be fertilized within 60 to 90 seconds. Beyond that time, the egg takes on water and becomes infertile. It is during that brief minute or so that the male must release its sperm to fertilize the eggs.

Clearly, a process to help make nature's course more efficient could have dramatic results for fish hatcheries. A supply of sperm cells in storage could help solve the fertilization problem that occurs when male and female fish of the same species do not ripen simultaneously. This situation not only tends to reduce the total offspring at a hatchery, but may also mean the loss of an entire year's production of a species. With frozen sperm on hand, a female's eggs can be fertilized whenever she spawns, either by semen from her own or another species.

"Cryopreservation has opened the door to a lot of genetic possibilities that were never even thought of before, because there was no tool."

Through the preservation of eggs, a hatchery would not have to wait for spawning runs to produce new fish, Graham said. Instead, they could thaw the embryos or the sperm and eggs and begin rearing them at at any time. This would reduce the number of broodstock and allow hatcheries to operate year-round instead of having to rely on the natural spawning cycles.

"Frozen sperm or fertilized eggs could be shipped in cryogenic containers between hatcheries, Graham said. "This would allow greater flexibility in hatchery operations and breeders could develop hybrids with certain characteristics suited to their particular regions: strains which grow more rapidly or resist disease, perhaps."

Similarly, the aquaculture industry could develop strains or hybrids more suitable to intensive culture so it could produce more food fish at a faster rate.

Graham's techniques may also be used to guard against extinction through preserving eggs and sperm of endangered species.

Edmund F. Graham, Professor
Marcia K. Schmehl, Assistant Scientist
Alan Erdahl, Graduate Student and Sea Grant Trainee
Department of Animal Science
University of Minnesota, Twin Cities

Lake Superior's Water Quality Linked to Nutrient Input

What makes a lake good for fish? You wouldn't expect one answer to be runoff and effluents. But the runoff and muncipal and industrial discharges entering a lake contain nutrients that may help, rather than harm the lake. In cold, nutrient-poor Lake Superior, nutrients help produce algae, the food source on which the entire lake depends. But the lake can get too much of a good thing. Recent findings by Professor David Tilman indicate that stricter, long-term limits are needed on nutrients entering Lake Superior.

The North Shore, Duluth harbor, and estuaries of Lake Superior receive the most nutrients. These come from fertilizer runoff, particles dropped on the lake by air and rain, and by other industrial and municipal sources along the lake.

The nutrients promote algal growth, which provide food for zooplankton, and ultimately for fish. As a result, these areas are the most productive for fishing. That's good for now, Tilman said, but it could cause problems in the future.

Of the three most common nutrients entering the lake—phosphorous, silicates, and nitrates—only phosphorous is regulated. The other nutrients have been considered less critical to water quality, Tilman said. His research shows that the ratio of all three nutrients, along with water temperature, affect water quality and the type of algae that will thrive.

Some algae are more desirable than others, Tilman said. Blue-green algae, which form the common scum on lakes in late summer, thrive in warmer water with low nitrate to phosphorous ratios, and are generally indicators of poor water quality. They are often toxic to zooplankton and they clump up and form flakes and scums that cannot be eaten.

Diatoms, on the other hand, are indicators of good water quality, are a good food for fish, and they dominate in cooler water with a low phosphorous to silicate ratio.

Phosphorous is the most common nutrient entering Lake Superior and is probably the easiest to control, Tilman said. But limiting only phosphorous without also considering the water's nitrate and silicate content will not ensure good water quality or a good environment for fish.

"With Lake Superior, we cannot increase fish productivity by input of nutrients without some long-range problems. Before the lake gets too eutrophied, we must understand enough about the food web to manage the lake."

Tilman points to Lake Erie as an example of what can happen when the long-range effects of nutrient input are not considered. "Lake Erie had heavy nutrient loading and high algal abundance and activity. At first, it was great for the fish but as the algae settled to the lake bottom and were consumed by bacteria, the lake became anaerobic and useless. It just recently became good for fishing again."

Some of Tilman's previous research formed the basis for applied nutrient management, a water management tool which helped clean up Lake Erie.

His Sea Grant research answers some basic questions about how nutrients affect algae. However, Tilman said,"We are at least ten years from understanding the nutrient to fish interaction. In the meantime, we can't assume that more nutrients mean more fish."

G. David Tilman, Professor, Ecology and Behavioral Biology
Richard Kiesling, Graduate Student, Sea Grant Trainee
University of Minnesota, Twin Cities

Helping Salmon Return Home

When Minnesota hatcheries spend a lot of time and money raising salmon, we want them to spawn in Minnesota's streams, not Wisconsin's. But once those fish enter Lake Superior, how do we keep them for Minnesota's fishermen? The answer, says Professor Ira Adelman: release the fish at the right time so they will imprint on their home stream and return there to spawn. The problem is finding when that right time is.

Adelman has completed a three year study to accurately determine when chinook salmon smolt. At smoltification, fish are able to identify the chemical odor of a stream so they will return there three to five years later to spawn. It also seems to be the point at which a fish raised in freshwater is capable of living in saltwater.

Chinook salmon, typically a saltwater fish, are a major, non-native stocked fish in Minnesota. Even though Minnesota salmon live in freshwater throughout their lives, smolting signs must be accurately monitored before the salmon are released, Adelman said. Whether fish are heading to the ocean or a lake, they have similar problems if they are released too soon from the hatchery into the stream. They may linger in the stream where planted and compete with other species, or they may migrate into the lake but fail to return to their home stream to spawn.

Adelman studied several factors influencing smoltification, including daylength and the fish's size. He found two "right sizes" for release: when the fish is 5 centimeters long and 8 to 14 centimeters long. The right time is at approximately 12 or more hours of daylight. Once a fish reaches the right size, a hatchery could then manipulate the amount of light so the fish will begin to smolt faster. The duration of daylight will not make a difference if the fish are the wrong size, Adelman said.

Hatcheries have traditionally decided when to release fish according to visual signs of smoltification. The fish's behavior changes, it starts to swim with the current instead of against it, and its skin becomes silver.

"These are not always effective indicators of smoltification, especially for stocks not native to the location," Adelman said. "For instance, readiness to migrate and readiness to enter saltwater are not the same. A fish moving for weeks in a river in migration to saltwater is different than the fish reared close to the ocean that has a short distance to travel to saltwater."

Hatcheries are always looking for more efficient ways to raise fish and the possibility of releasing them sooner would lower costs. Adelman's research provides a better understanding of how light, if provided when the fish is the right size, may speed up smoltification, potentially decrease hatchery expenses, and improve the number of fish that return to spawn.

Ira Adelman, Professor and Head, Fisheries and Wildlife
Donald Pereira and James Bodensteiner, Graduate Students, Sea Grant Trainees
John Dobie, Fellow.
University of Minnesota, Twin Cities.

From Ugly Eelpout to Delicious Dinner

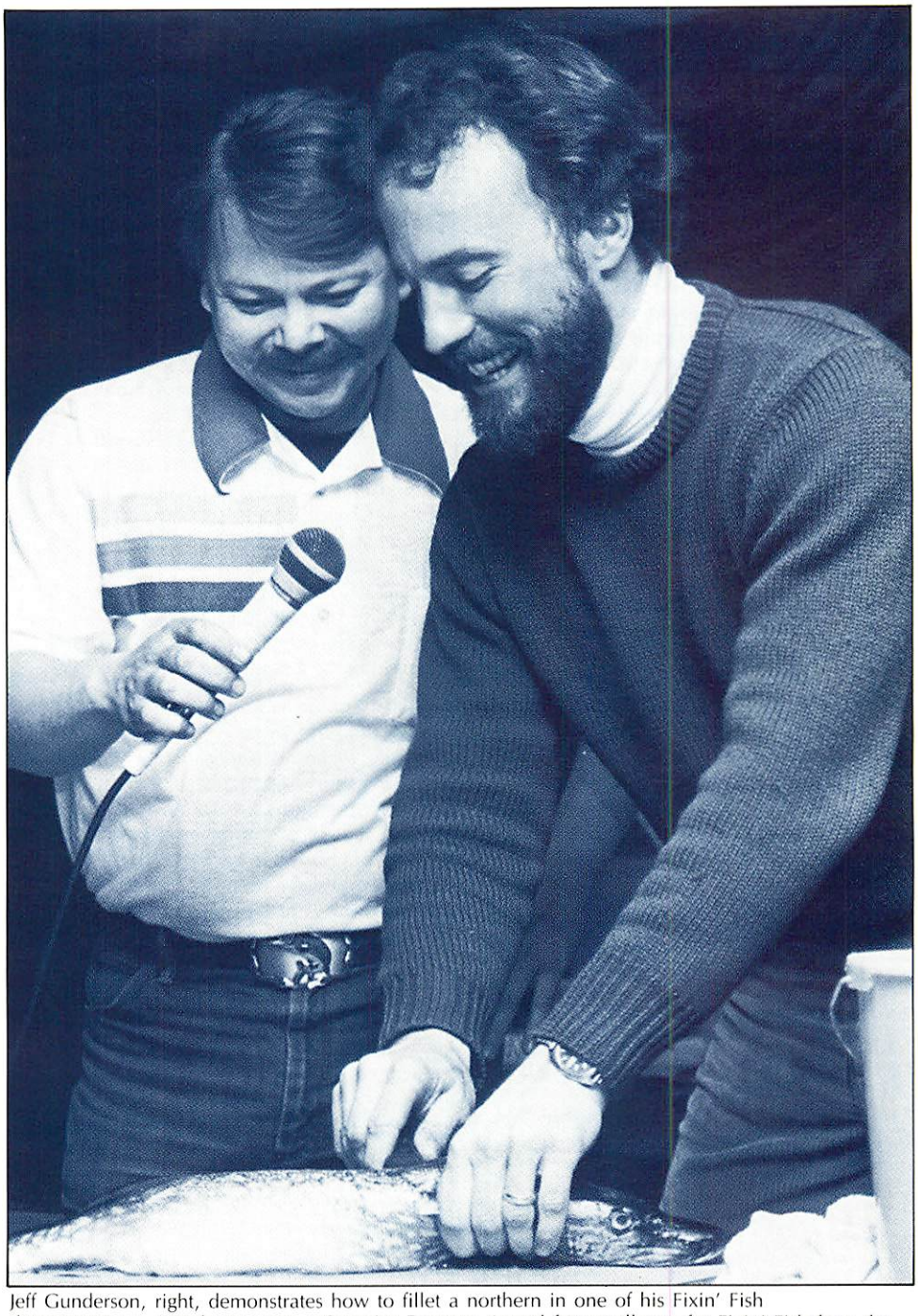
A lot of Minnesotans do two things with fish that drive Jeff Gunderson crazy: they refuse to eat perfectly good fish like suckers and eelpout, and they treat the day's catch miserably, destroying its quality before the boat ever docks.

In an effort to eliminate both of these common blunders, Gunderson, a Sea Grant extension agent, has written a book called "Fixin' Fish: A Guide to Handling, Buying, Preserving, and Preparing Fish." First published by Sea Grant in 1980 and revised in 1984, this slim paperback contains all the information Upper Midwest anglers need to know about those topics as well as information on common fish parasites.

The book,"Fixin Fish" grew out of Gunderson's great success with workshops and demonstrations by the same name. Since he started the workshops in 1979, he has taught fish handling techniques to more than 1700 people throughout Minnesota. Commercial fisherman and processors have supplied the 200 to 400 pounds of fish needed each year for Gunderson's workshops.

Underutilization of certain fish has been a particular concern of Minnesota Sea Grant, because it represents waste of a resource, Gunderson said. "The two reasons fish like eelpout (burbot), suckers, and carp are overlooked are that they're ugly and they're inconvenient to prepare," he said. "It has nothing to do with their taste—they're good."

There isn't much Gunderson can do about the ugliness factor, but there's a lot he can do about the preparation problem. In "Fixin' Fish" Gunderson explains how to fillet, score, flake, and grind fish, such as the sucker, that contains y-bones—the floating, forked bones not attached to the backbone or skeleton, which cannot be removed with normal filleting techniques.



Jeff Gunderson, right, demonstrates how to fillet a northern in one of his Fixin' Fish demonstrations. Gunderson won a Superior Program Award for excellence for Fixin' Fish from the Great Lakes Sea Grant Network.

Knowing how to debone these fish may break down some of the resistance to eating them, but Gunderson is realistic enough to admit that Midwestern fish prejudice runs deep. "Eelpout is the only freshwater member of the cod family and is a nice, firm, white fish with a good flavor," said Gunderson. "But it is so ugly that I know macho fishermen who will cut their line rather than bring an eelpout in the boat. There's some strange kind of myth or mystery about this fish."

Mishandling fish, especially during the crucial period between catching it and cleaning it, is the other most common failing among people who fish. "I've always been an avid fisherman myself," said Gunderson,"but it wasn't until I became an extension agent and started examining preservation techniques myself that I realized how many things fishermen commonly do wrong."

Pulling a stringer of fish in and out of a boat all day is the single biggest handling mistake made in fishing, Gunderson said. "People would never think of throwing a t-bone steak into the bottom of a dirty, oily boat, but that's what they do to fish and fish are actually more delicate than most other meats. They bruise easily and can spoil rapidly." Gunderson figures that one of the reasons walleye is such a popular fish in Minnesota is that it is very lean and doesn't develop off-flavors quickly so it still tastes pretty good in spite of mistreatment.

Gunderson's other fish crusade is to keep people from wasting parasite-infested fish. There is quite a variety of parasites found in Upper Midwestern fish, Gunderson

said, but only the broad fish tapeworm is harmful to humans, and even that can be killed by heating the fish flesh to 140 degrees or freezing it for 48 hours at 0 degrees. "I've known people who have tossed whole coolers of fish because of harmless parasites," Gunderson said.

Cooking methods are also of special interest to Gunderson. "People in Minnesota think that frying is the only way to prepare fish," said Gunderson. In his book, he not only explains such common preparation methods as baking, broiling, and poaching, he also devotes chapters to drying, smoking, pickling, canning, and salting fish and even explains how to make fish jerky and caviar.

Probably the most unusual preparation method Gunderson promotes, however, is the grinding of fish to use it like hamburger in dishes such as chili, lasagna, and casseroles. "Most people in this part of the country have a onetrack mind in fish preparation, but you can't eat it every day if you'll only eat it fried," Gunderson said. At his Fixin' Fish demonstrations, Gunderson takes along some fish chili for audience members to sample; most are surprised at how good it is, he said.

"I like to get people into the demonstrations on one interest they have—often it's smoking fish—and then try to teach them about handling or freezing, which they don't even know they're doing wrong," Gunderson said.

There's plenty of misinformation among people who fish. One of Gunderson's favorite stories is of the man who told him he'd heard that a person would starve to death trying to live on burbot and suckers because they had no nutritional value.

Pink Salmon's Future in Lake Superior

There are three species of Pacific salmon in the Great Lakes. But only one, the pink salmon, reproduces in large enough numbers to maintain its population; other species must be stocked.

Pink salmon were inadvertently introduced into Lake Superior in 1956. Since then, their abundance and range have increased and they have survived better than other salmon in the Great Lakes.

Pink salmon's success in the Great Lakes led to research on their potential value to sport and commercial fishing. Before researchers can determine how abundant or important pink salmon may become in Lake Superior, they need to know more about the species, including its growth, reproduction, and mortality rates. Professor George Spangler is completing the second year of a study to estimate the yield of pink salmon over a five year period.

Spangler traps the salmon to determine their sex, then measures, and fin clips them. Females are sampled to calculate the total eggs deposited and estimates are made on their survival and the percentage of eggs fertilized. After the eggs hatch, the number of fry are counted and the Lake Superior data are compared with Pacific Ocean data. The result is an estimate of the yield for each year's stocks in selected tributaries of Lake Superior. The yield estimates will be entered into a computer model to produce different scenarios for exploiting and managing the salmon.

Because so little is known about pink salmon, its hard to tell if they will be a detriment or an advantage to the Lake Superior fishery, Spangler said. "Since herring populations are so low, it is possible that pink salmon might replace them in the Superior ecosystem. If they do, they could become a significant part of the fishery. We don't know yet if that will happen."

Researchers and the DNR also want to know how pink salmon affect native fish, Spangler said. "Introducing exotics (non-native fish) is very high risk. There is some concern that salmon will compete with lake trout or other naturally occurring fish." Also, no one knows what adult pink salmon eat so its hard to tell what effect they may have on other fish, Spangler added. "They are plankton feeders at early stages, but we don't know what they eat later."

Of all the Pacific salmon, pink salmon have the greatest potential to make a contribution to the fishery without stocking, Spangler said. Pinks require less time in streams for rearing and they have persisted longer in Lake Superior than any other salmon in the Great Lakes. And they "run in everything that flows," Spangler said, giving them an advantage in Minnesota's many small tributaries.

George R. Spangler, Associate Professor
Department of Entomology, Fisheries and Wildlife
Joe Nicolette, Graduate Student, Sea Grant Trainee
University of Minnesota, Twin Cities

Sucker Harvesting Discouraged

As the trout, herring, and other fish harvested by commercial fishermen have declined in number, some of the less valuable fish are receiving greater attention from fishermen. One of those fish is the sucker.

"Suckers have been of varying importance to the commercial fisherman's catch for the past 50 years," said Professor George Spangler. "Mostly they have been encountered as an incidental species while they were fishing for something else."

In the late 1970s, commercial fishermen on Lake Michigan started selling their incidental catches of sucker for $1 a pound (after processing). New equipment to debone sucker had made it a more appealing and profitable fish. Naturally, commercial fishermen in Minnesota wanted to know if there were enough suckers along the North Shore of Lake Superior to make fishing them economical.

Spangler studied the two sucker species, the longnose and the white, and found that they are not a good bet for Minnesota fishermen and food processors because of small breeding populations. Processors require large quantities and a continuous supply of fish to make their businesses profitable.

"We haven't found enough of a population to warrant harvesting," Spangler said. "Both sucker species utilize tributary streams for spawning and we don't have many large streams that provide suitable habitat for suckers." They also grow relatively slowly because they have a fairly limited food resource in Lake Superior, he added.

"People along the North Shore say there are lots of suckers because for every rainbow trout they see in a stream, they see 200 suckers," Spangler said. "But there really are not a lot of suckers in the lake."

George R. Spangler, Associate Professor,
Sheryl Middlemis, Graduate Student, Sea Grant Trainee
Department of Entomology, Fisheries, and Wildlife
University of Minnesota, Twin Cities

COASTAL PROCESSES

Every morning Barbara Compton looks out her window toward her mother's cabin, which sits precariously on the edge of a cliff overlooking Lake Superior. "I check to see how far that fir tree has dropped below the roof. If I can still see the top, I breathe a sigh of relief."

When Compton and her family bought their land—with Lake Superior on one side and the Sucker River on another—they could walk 50 feet from the cabin to the cliff's edge. Today, the cabin is propped up on metal supports as the cliff erodes, slides down the hill, and into the lake. A fault line moves across the hill toward the house, moving just below it, luckily, instead of under it.

Instead of a bluff overlooking the beach, there is a muddy clay slump, oozing down the hill, swallowing the beach below. Trees slide down the hill to rest by the lake. "It reminds me of how Mount St. Helens looked with the lava creeping down the mountain," Compton says.

Unfortunately, the Compton's problem is not unique. Erosion of Lake Superior's red clay shore can average three to four feet a year with much larger losses in some areas, said Dale Baker, Sea Grant Extension Director. Sea Grant has held workshops for coastal residents to encourage them to take preventive measures before they see damage. Baker advises homeowners

to plant grasses and other plants to hold the soil and to reroute drainage water around an eroding area. Once the erosion begins, the only solutions are put rip rap along the shore or to drive in steel pilings, Baker said. Both are prohibitively expensive.

"We get most of our calls after a rainy spring when large chunks of shore have disappeared," Baker said. "By then the damage has started and its too late to do much. We can only encourage people to take a human approach to slow it down because ultimately, nature will take its course."

Sediment Movements Important to Lake Ecosystems

The rapid erosion of Lake Superior's red clay bluffs is of concern to scientists as well as homeowners. The erosion, occurring at a rate of three to four feet each year, drops a huge amount of sediment into the lake.

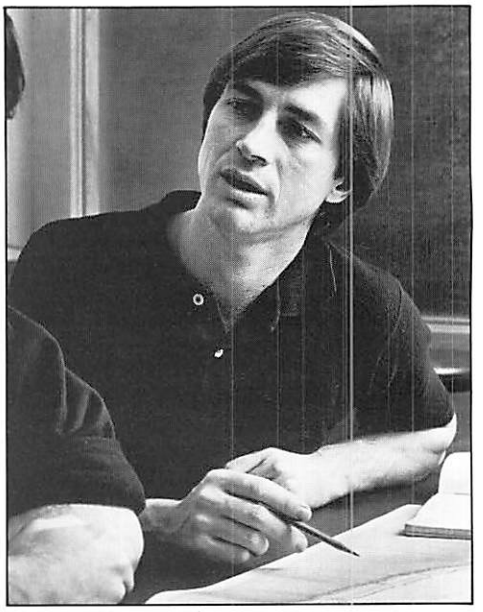
Because clays are fine sediments, they do not settle directly to the bottom. Instead, they are suspended in the water and move around the lake with currents, waves, and storms. Clays also attract other substances, which is a concern for environmental reasons, said Professor David Darby. "A lot of pollutants adsorb onto other particles. Clays have a negative charge so they suck up a lot of material. Assuming that toxics attach to clays (pesticides, organics, and mercury all have an affinity for fine particles) then if we can trace the fine particulates, we can find out where in the lake pollutants will wind up."

Darby, along with Thomas Johnson, John Kingston, and Barbara Halfman, have completed a study on the movement of suspended clays from the basin in the western arm of the lake into the open lake.

More than one-half of the sediment entering Lake Superior comes from erosion of only 50 miles of shoreline from Duluth-Superior eastward, Darby said. Although this area (the western arm) receives most of the sediment, only about one-third of it stays there. The rest moves into the open lake. Halfman discovered that a plume 20 meters high moves along the bottom of the basin, down a slope, and into the lake, carrying some of the sediment out of the area.

"If we were sure the suspended sediments and the pollutants that may be attached to them would settle onto the bottom of the lake and stay there, this movement might not be a problem," Darby said. "But evidence shows that a lot of sediment is resuspended in the lake so what happens in the western arm obviously affects the entire lake."

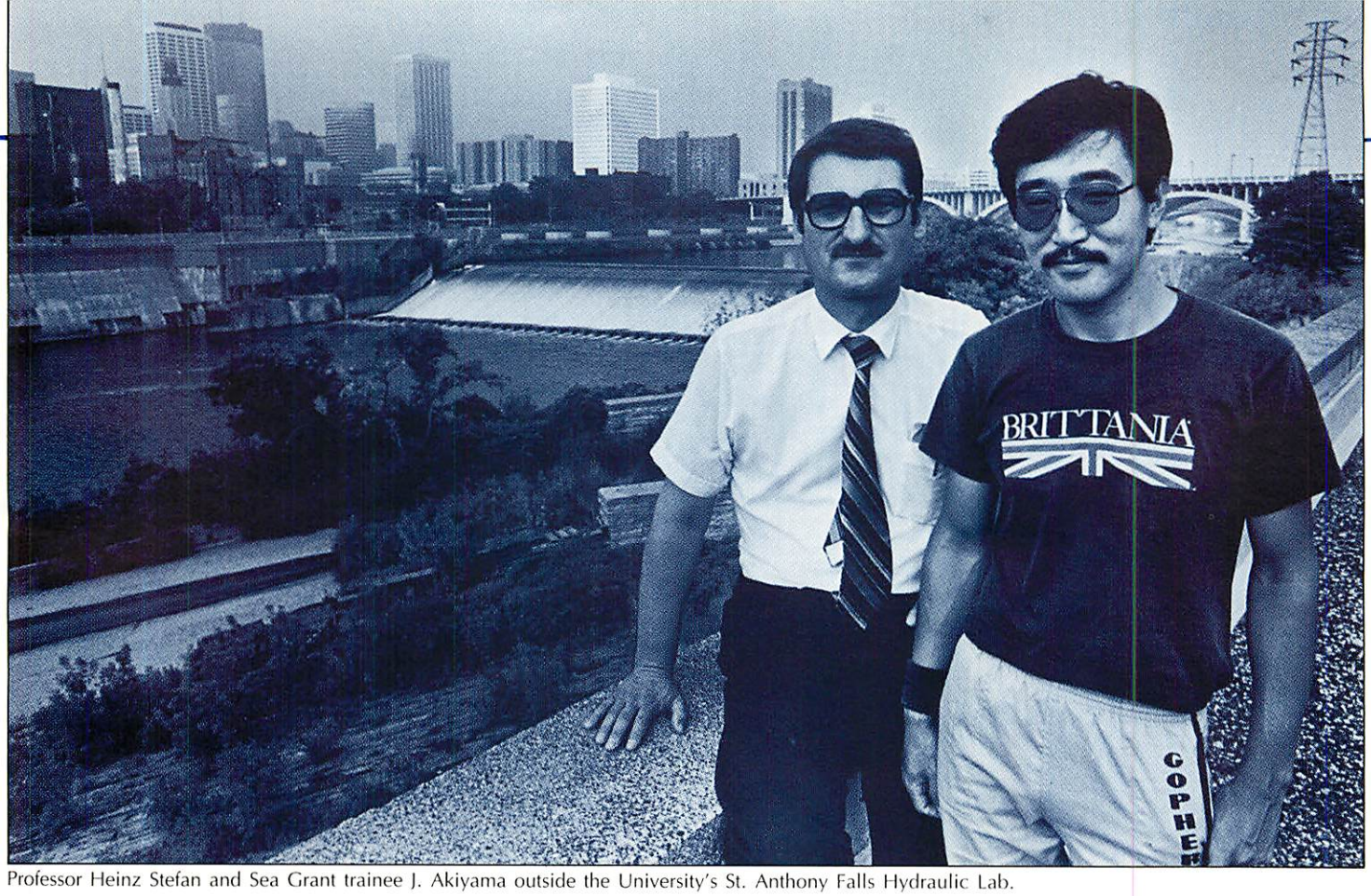
The fate of toxics and metals is not the only reason to study sediment suspension. Suspension affects the amount of light transmitted through the water, limiting the productivity of diatoms, a phytoplankton at the base of the food chain. It may also affect the intake of filter feeding animals. If offshore disposal of dredge spoils is considered again, this research could help show where and how the spoils might move from the disposal site to other portions of the lake. Harbor dredging now moves 125,000 cubic meters of sediment each year. The spoils are not dumped in the lake.



Professor Thomas Johnson

It is important to do more research on sediment movement in large freshwater lakes, Darby said, since suspended sediments behave differently than they do in saltwater. In the ocean, particles are more likely to clump and fall to the bottom. In lakes, they are suspended almost continuously with currents. "With very little turbulence, clays, and possibly pollutants, are carried further in freshwater."

Thomas C. Johnson, Professor
Limnology Program and Department of Geology
David G. Darby, Professor, Department of Geology
John Kingston, Research Associate, Limnology Program
Barbara Halfman, Graduate Student, Sea Grant Trainee
University of Minnesota, Duluth



Professor Heinz Stefan and Sea Grant trainee J. Akiyama outside the University's St. Anthony Falls Hydraulic Lab.

The Power of Underwater Rivers Studied

Everyone knows that rivers carry sediments. A swiftly flowing river has the power to choose its own meandering course, change the landscape, and to pick up whatever lies in its path to drop it again at the river's end.

Few people realize that rivers also exist in lakes and oceans. Called turbidity currents, these rivers erode and carry sediment, form deltas, and shape ocean and lake floors. Turbidity currents are strong enough to break transAtlantic cables. On steep slopes, they may cause underwater avalanches, and their erosive power can form deep canyons.

Very little is known about turbidity currents so Sea Grant researchers have recently built computer and laboratory models to study them. Heinz Stefan, Gary Parker, J. Akiyama and Y. Fukushima are developing computer models that can predict a turbidity current's speed, depth, sediment content, and the distance it will travel. They will eventually use the results from their lab models, along with field data, to verify their computer models.

Turbidity currents move very fast, often several meters per second, Stefan said. They originate by natural or artificial discharges of sediment-laden water, underwater landslides caused by earthquakes, or by waves generated by storms. They are driven by gravity force, which is related to the amount of sediment in the current. The heavier the sediment load, the faster the current moves; the faster it moves, the more sediment it picks up. Currents generally move from shallow to deep water, eroding and transporting sediment along the way.

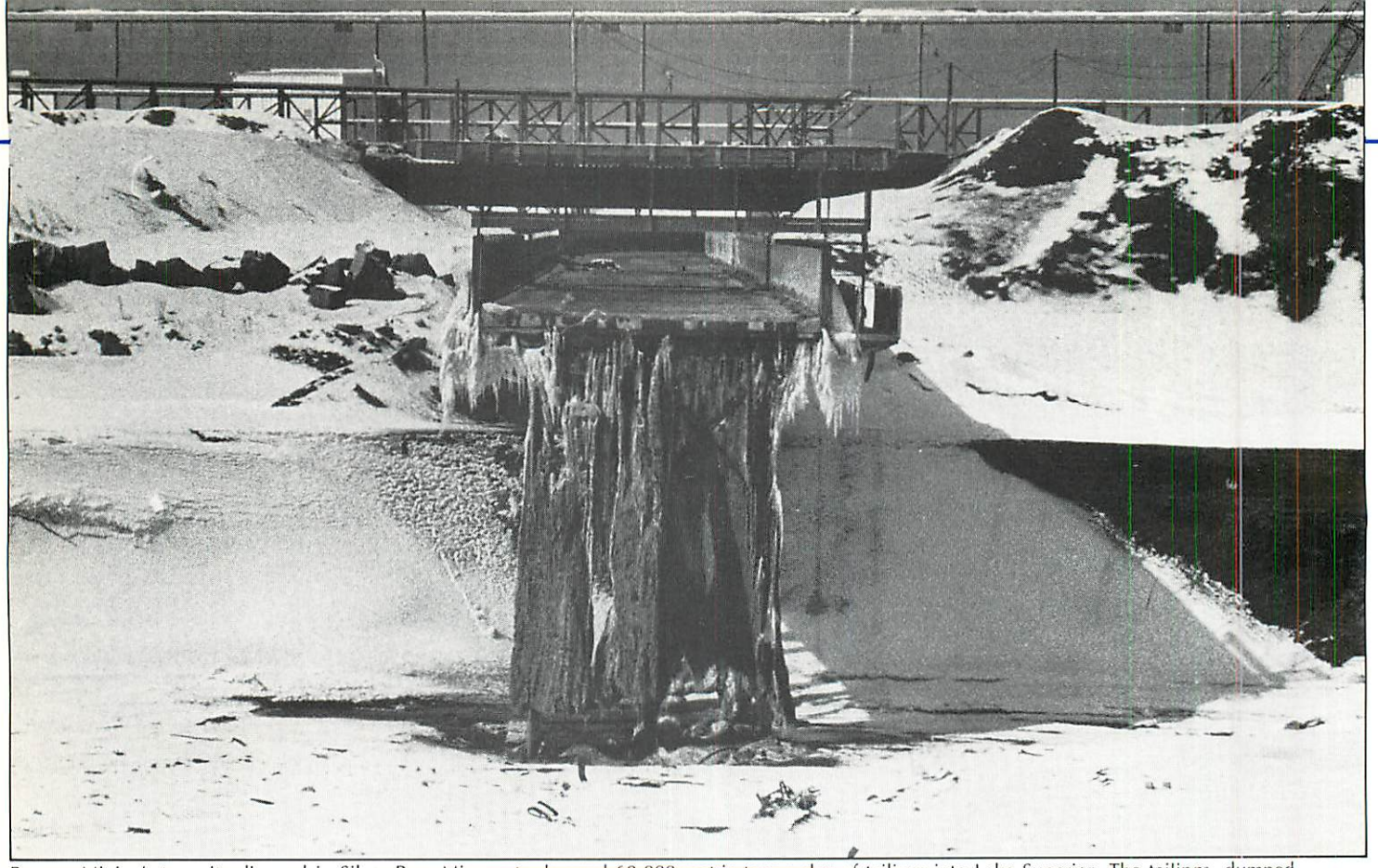
One of the most controversial turbidity currents—and the stimulus for this research—was Reserve Mining's taconite tailings disposal in Silver Bay, Minnesota. The slurry that dumped 60,000 metric tons a day of taconite tailings into Lake Superior was a man-made turbidity current. Between 1955 and 1980 the current deposited a delta of tailings similar to those found at the mouths of large rivers. It also created the force to move a portion of the tailings from the dump site down the slope to deeper water.

"Dumping into lakes or oceans is, at first glance, an appealing solution for getting rid of something," Stefan said. "The current carries it away and you don't have to pump it or carry it. But if more had been known more about turbidity currents, Reserve probably would never have been allowed to release their tailings into the lake. The state assumed that the sediments were sinking and being carried away. This happened, but no one studied how or where they would move, or how they would be resuspended in the water."

There has been very little research on turbidity currents, Stefan said. "In most cases, we know the input (where the current starts) but we don't know exactly what is going on underneath the water. It is a very unstable system and hard to predict." Yet turbidity currents affect most coastal or subsurface development, including off-shore mining and construction. They are very important in off-shore waste disposal, Stefan added, since "the waste certainly falls to the bottom but it doesn't just sit there; it continues to move."

Turbidity currents also play a role in silt-up, a common problem where a reservoir fills up with sediment. "This is especially bad in arid regions where there is much erosion and where there tend to be more reservoirs," Akiyama said. "If you can locate and measure the turbidity currents, you can build channels in the reservoir to allow the sediments to be released at the dam site."

Gary Parker, Associate Professor, Civil and Mineral Engineering
Heinz Stefan, Professor, Civil and Mineral Engineering, and Associate Director, St. Anthony Falls Hydraulic Laboratory
Y. Fukushima, Research Fellow
J. Akiyama, Graduate Student, Sea Grant Trainee
University of Minnesota, Twin Cities



Reserve Mining's taconite disposal in Silver Bay, Minnesota dumped 60,000 metric tons a day of tailings into Lake Superior. The tailings, dumped between 1955 and 1980, deposited a delta similar to those found at the mouths of large rivers. The picture above was taken on the last day the tailings were discharged into the lake. They are now stored on land.

Tailings Deposit Appears to be Stable

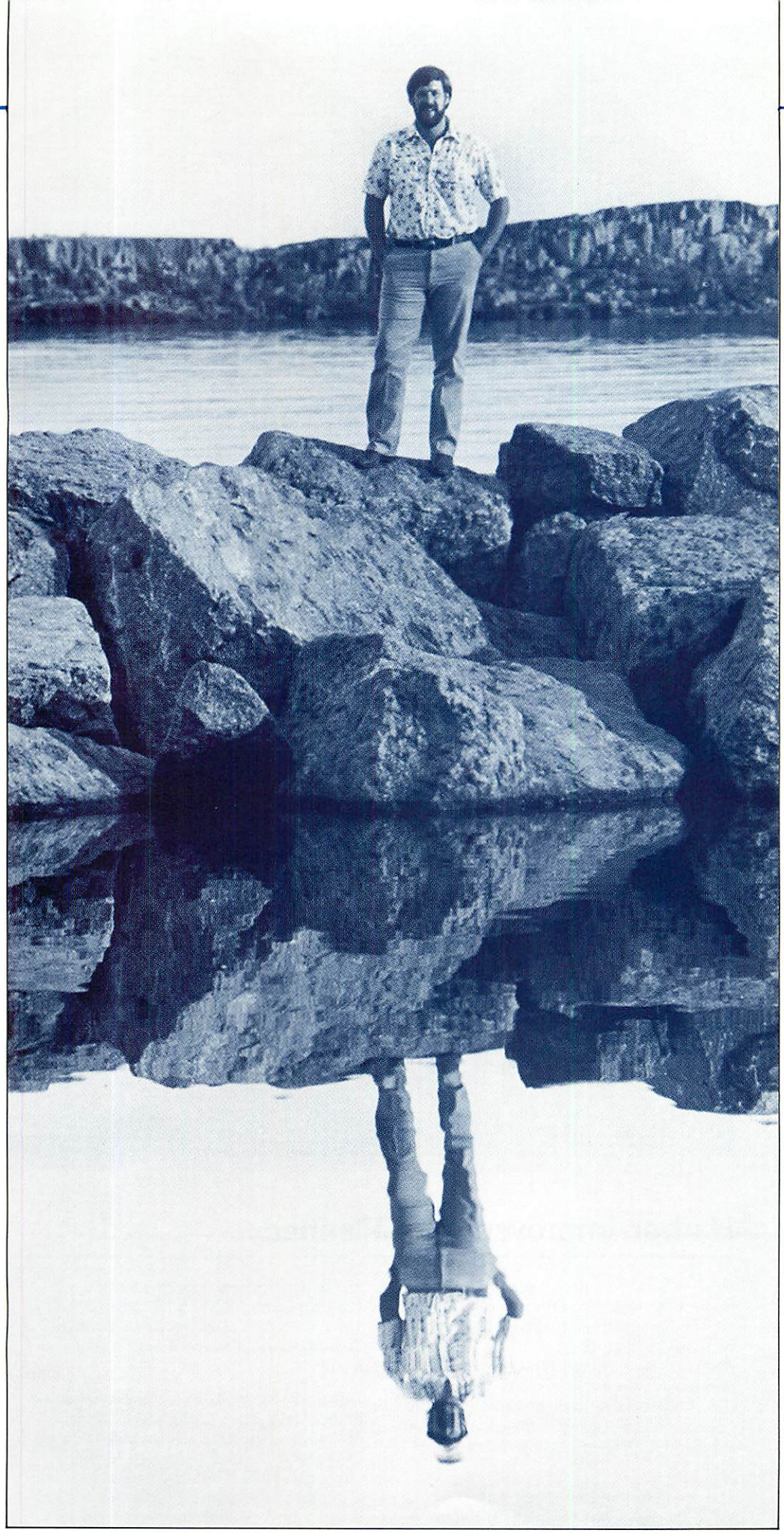
Reserve Mining stopped dumping taconite tailings into Lake Superior in 1980. But because the tailings contained asbestos-like fibers, many people were still concerned that fibers were being resuspended by slumping of the taconite delta. Communities along the lake were worried about the possibility of the fibers' presence in drinking water. The company and the U.S. Corps of Engineers wanted to know more about the stability of the delta.

Professor William Busch conducted a two year study of the area. He took core samples, photographed the contour and profile of the delta, and did seismic reflection surveys, which show details of the lake bed.

Busch's findings appear to alleviate concern that the asbestos-like fibers are being resuspended in the lake. He found that the tailings discharge had caused previous slumping but since the discharge has ended, the delta appears to be stable. Without the current produced by the discharge, more slumping—and the associated resuspension of tailings and fibers—is unlikely.

Busch's field data will be used by Professors Parker and Stefan to help validate their laboratory models on the action of turbidity currents and their role in submarine slumping.

William Busch, Assistant Professor,
Department of Geology
University of Minnesota, Twin Cities



ECONOMICS

TOURISM

Todd Smith grew up in Grand Marais, Minnesota. He intends to stay to see the small city prosper, even though he says, "I've been told for ten years that Grand Marais is a dying town and I shouldn't want to live here." Smith is optimistic that the town of 1300, which is surrounded by federally owned land, has little tax base, and a struggling timber industry, can become a thriving tourist area. His hope lies in what he calls the "most beautiful natural harbor on the Great Lakes."

Smith's enthusiasm for the town's potential as a tourist attraction is the result of a three-day Sea Grant workshop he attended in Traverse City, Michigan. The workshop was organized by the Great Lakes Sea Grant programs and by Minnesota Sea Grant agent Chad Dawson. It showed Smith, a city council member, and other representatives from the cities of Duluth and Two Harbors how they could take advantage of their harbors to attract tourism.

The trip included a tour of Traverse City and the surrounding area, interviews with developers, planners, businessmen, and others. The purpose of the trip, Dawson said, was to show an example of excellent small-scale coastal development and to create a network of coastal communities. "Those people who went to Traverse City can now talk to each other about what the entire North

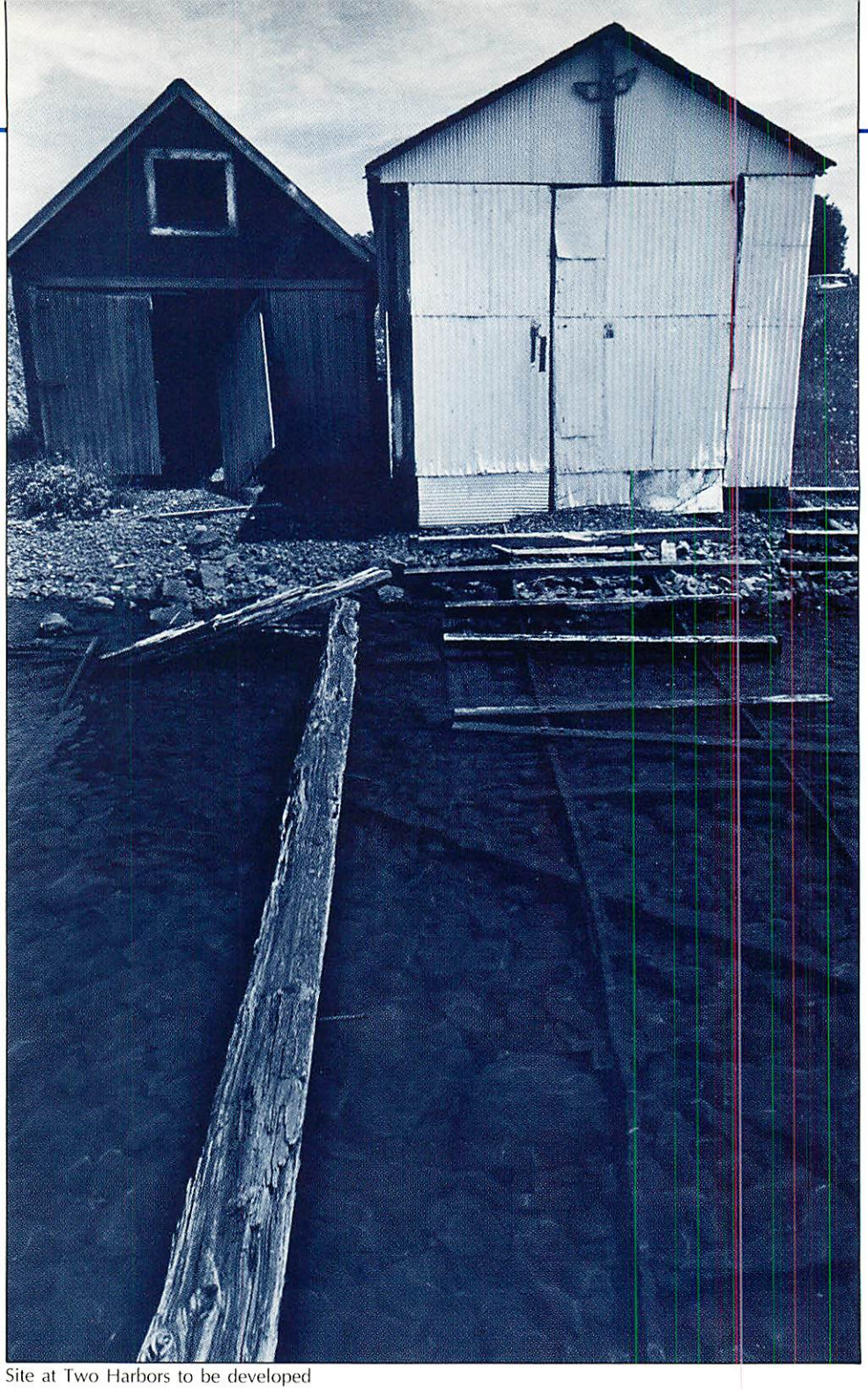
Shore can do to develop their communities and they can work with similar coastal towns in other states."

"I was glad to go to Traverse City," Smith said. "I learned how to win community support for new development and I realized how much Sea Grant can help us."

Since the trip, Dawson has presented slides and information on Traverse City to citizens of Grand Marais and other communities. Along with Wisconsin Sea Grant agent Phil Keillor, he has made suggestions on how the city can redevelop its harbor. "Chad shows his slides to one group, who then show it to another," Smith said. "It's been a good way to get people excited about the possibilities."

Demand for new harbor and public access facilities for the North Shore will be determined, in part, by a boater survey to be conducted in 1984. The survey is an update of a 1976 study conducted by Sea Grant. Minnesota Sea Grant, Grand Marais, Duluth, and the U.S. Army Corps of Engineers will provide funding. Smith is confident the survey will show a need for new harbor development.

"There's getting to be a lot of boat traffic on Superior and there are more affluent people coming here to vacation," Smith said. "Year after year, we hear people say, I wish you had a place to moor my boat, I'd buy a permit right now. But we don't have a place for them so they leave."



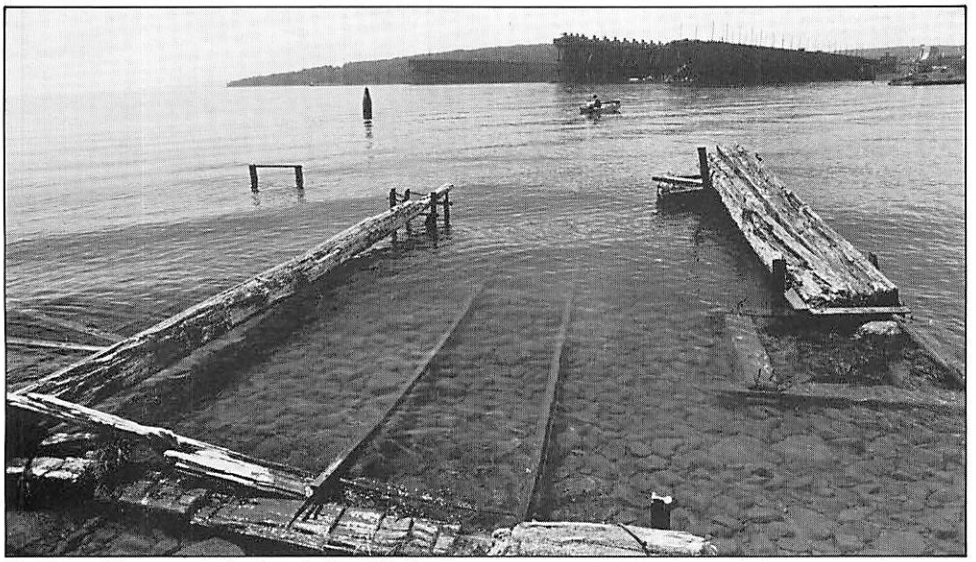
Site at Two Harbors to be developed

Harbor Improvements Planned

While Grand Marais is turning away boaters for lack of mooring space, the city of Two Harbors is dealing with an increase in boating pressure on a small, overused boat launch. The existing facility is popular and it can't handle the current use, said Sea Grant agent Chad Dawson. "There will be 100 cars there on a good weekend and no accessible place to put them."

The area's popularity is not surprising since the town has two natural habors and a tremendous flow of summer visitors. During June, July, and August of 1981, 736,000 travelers came through Two Harbors, a town of only 4,039 residents.

Development plans for a new marina and harbor have been in the works since 1978 when the city was awarded a grant to create a development plan for the city's two bays. Then it was shelved. For a number of reasons, the city found itself without anyone with the time,



Boat launching ramps at a bay in Two Harbors

commitment, or expertise to carry the ball. Sea Grant agent Tom Mack began acting as a facilitator on the project in September, 1981. "We were stalled and Tom's efforts helped put us on the road again," said Lyle Northey, the town's former mayor.

"I mainly helped the community arrive at a concrete idea on what it wanted," Mack said. "My job was to help bring about a dialogue between the community and government agencies, waterfront landowners, and funding sources. I also provided information on marketing and the costs associated with planned tourism development."

As the marina plans have taken shape, Mack's successor, Chad Dawson has critiqued blueprints and given advice on development plans.

Construction on the boat access facility will begin in the fall of 1984. Plans include: a parking area for boats and trailers, possible construction of an inner breakwall, and improvement in the launching and docking space.

Bringing New Business to Minnesota

Northeastern Minnesota, including the North Shore of Lake Superior, is the most economically depressed area in the state. But the region has great potential to build a strong tourism industry, according to Professor Wilbur Maki.

"The North Shore is one of the most unique scenic areas in the country," Maki says. It has lots of history, which is a great tourist attractor, accessible wilderness areas, and the potential to become a resort area attracting tourists from all the major midwestern cities.

The problem is, many people don't know about the area or what it has to offer. The North Shore is remote from most major urban areas, and there appear to be too few developers investing in year-round facilities to handle larger numbers of tourists.

Maki's research may be the first step in solving some of these problems. He is completing a three-year study to help show the state and private investors the best ways to invest in and develop new facilities and attractions to bring more people to the North Shore.

His research has three parts. First, he is studying options for new development by looking at the availability and use of private facilities such as restaurants, hotels, and bait shops, and public facilities such as skiing and hiking trails, boating access, and campgrounds.

Second, with this information, he will identify marketing options by finding the potential markets for the type of activities available. This work will build upon recent Sea Grant research conducted by Professors Uel Blank and Timothy Knopp on the North Shore's potential for market growth.

"We work backwards in market development to the origins of the visitors, the amount of money they spend, their attributes, and the type of activities they enjoy," Maki said. "People from different origins have different attitudes about what they do on vacation. We need to develop activities and settings for all different types of people and we need facilities—both public and private— to meet those preferences."

Third, Maki's research will show the spill-over effects of tourism on the regional economy. The final product will be a computer model forecasting the impacts of various economic development options on specific sectors of the economy. This information will be valuable to both the state and private investors. The private sector provides most of the facilities on the shore, but the public has a larger investment, Maki said. "These results will show what natural resources the state has already developed, the cost of future development, and the number of people who want to use those services." Maki hopes his model will also help build an investment strategy for North Shore tourism.

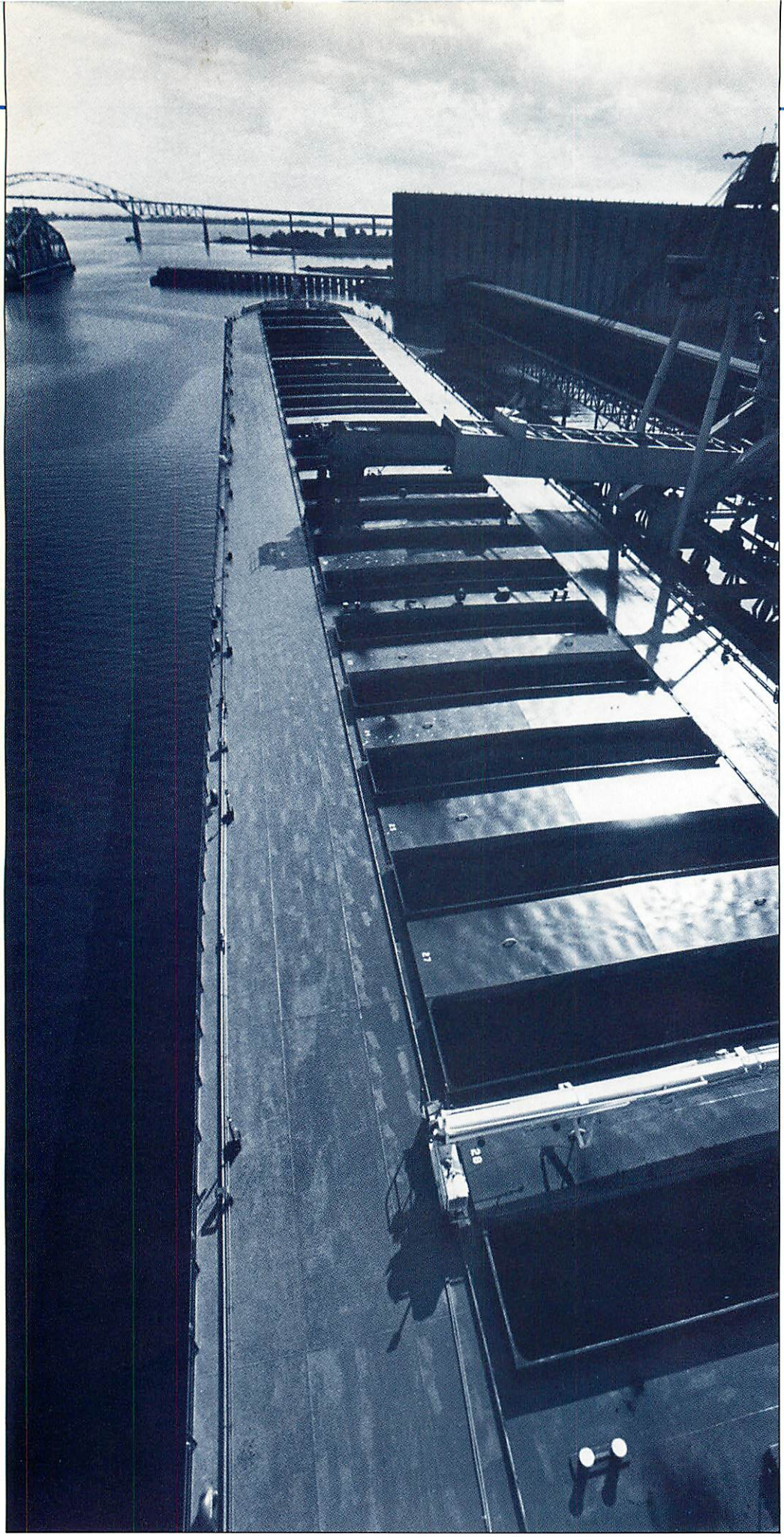
Private investors need this kind of information to be convinced that spending in the area will turn a profit, Maki said. "There are people with commitments to the North Shore but more capital for larger projects is needed. Investors need assurances that they will succeed financially."

What will new investments mean for the North Shore? "The area is close to a crisis situation now," Maki admits. Although many of the changes he advocates are beginning, they may not be occurring on a large enough scale to make a big impact on the economy. One development option, Maki said, is to provide facilities for year-round "skills vacations" where people can learn tennis, photography, or how to use computers.

Maki's computer model is unique since it studies tourism development on a local, regional level rather than as a statewide problem. Development on the North Shore can benefit the entire state, but the impacts on local areas are more important, he said. "We have ignored the local level for too long. People spend money in a particular place, they don't spend it all over the state."

Maki's model has also attracted international interest. "Tourism is a way of generating foreign dollars; every country has lagging regions and tourism is viewed as a means of local development," he said. Maki is helping Alaska and the U.S. Forest Service use his recreation model to forecast future investments and facility requirements.

Wilbur Maki, Professor, Agricultural and Applied Economics
Pat Dalton, Graduate Student, Sea Grant Trainee
University of Minnesota, Twin Cities.



ECONOMICS

SHIPPING

The United States exports more coal than anyone in the world. Yet very little coal is shipped out of the Midwest's Duluth/Superior port, even though the port is close to vast western coal reserves. That's because it is considered to be cheaper to mine, transport, and export eastern coal from an eastern port, said Professor Jerry Fruin. He is researching whether western coal, if shipped overseas through the Lake Superior port, could be cost competitive with eastern coal shipped from Atlantic ports.

Western coal has many advantages. It lies in thick, shallow seams that can be mined easily and comparatively cheaply. Mining areas are conveniently linked to the Duluth/Superior port by railroad. Western coal has the environmental advantage of being lower in sulfer than eastern coal although its heat content is also lower: 9,000 btus per pound compared to 12,000 btus per pound for eastern and midwestern coal. Because western mines are hundreds of miles farther from the major industrial and population centers, the btu per pound difference becomes more expensive if the coal is transported a long distance.

Consequently, eastern ports are exporting eastern coal at or near full capacity while the Duluth/Superior port operates at one-half its potential coal volume with plenty of accessible but unused coal nearby.

One terminal in Superior uses only 65 percent of its coal handling capacity. The 7 million tons it handles each year could be increased to 12 million tons with no capital improvements. With capital improvements, the capacity at Superior could be increased to 20 million tons.

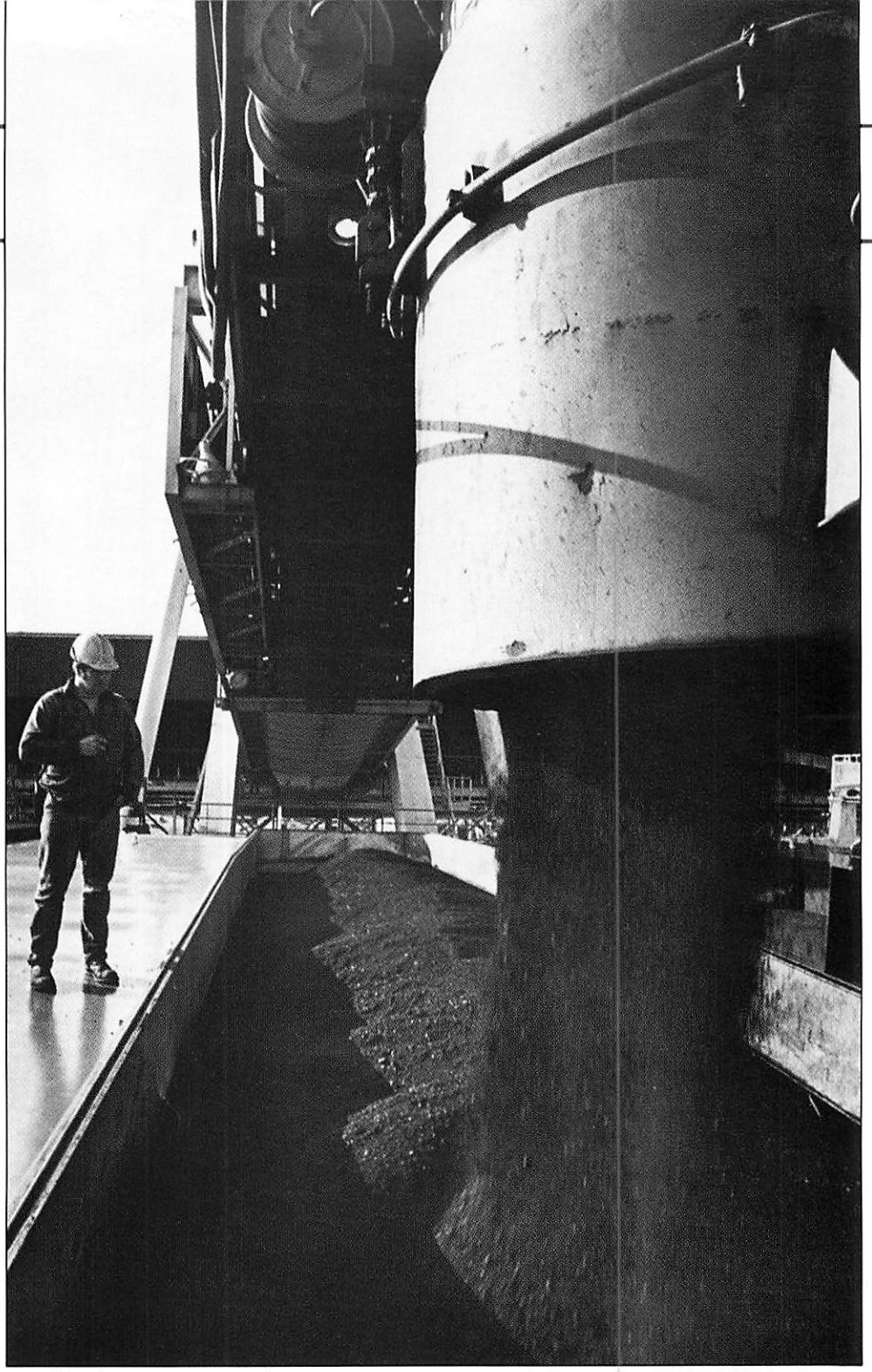
The two major limitations to increased exports of western coal are the current level of international demand and the physical restrictions of the Great Lakes ports and the St. Lawrence Seaway, Fruin said. He expects demand to increase and coal exports to at least double between 1985 and 2000.

Fruin projects that by 2000, the Duluth/Superior port's coal exports will increase because foreign demand will exceed the exporting capacity of eastern ports. "The Duluth/Superior port must be ready to handle the potential increased volume," Fruin said. "The harbor is now moving 5 million tons of coal a year but it could double that business."

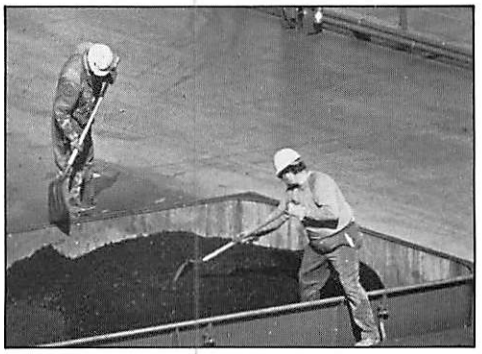
Fruin is comparing the costs of different shipping and loading options that could compensate for the harbor's physical limitations. The St. Lawrence Seaway and most of the Great Lakes harbors are too shallow for the deep ocean vessels that load at Atlantic and important foreign ports, Fruin said. He believes the best option for the Duluth/Superior harbor is to load coal onto lake vessels there and then transfer the coal onto 150,000 ton ocean vessels in the Lower Gulf of the St. Lawrence. This would increase the coal volume out of the Great Lakes ports and would help make shipping from those ports competitive.

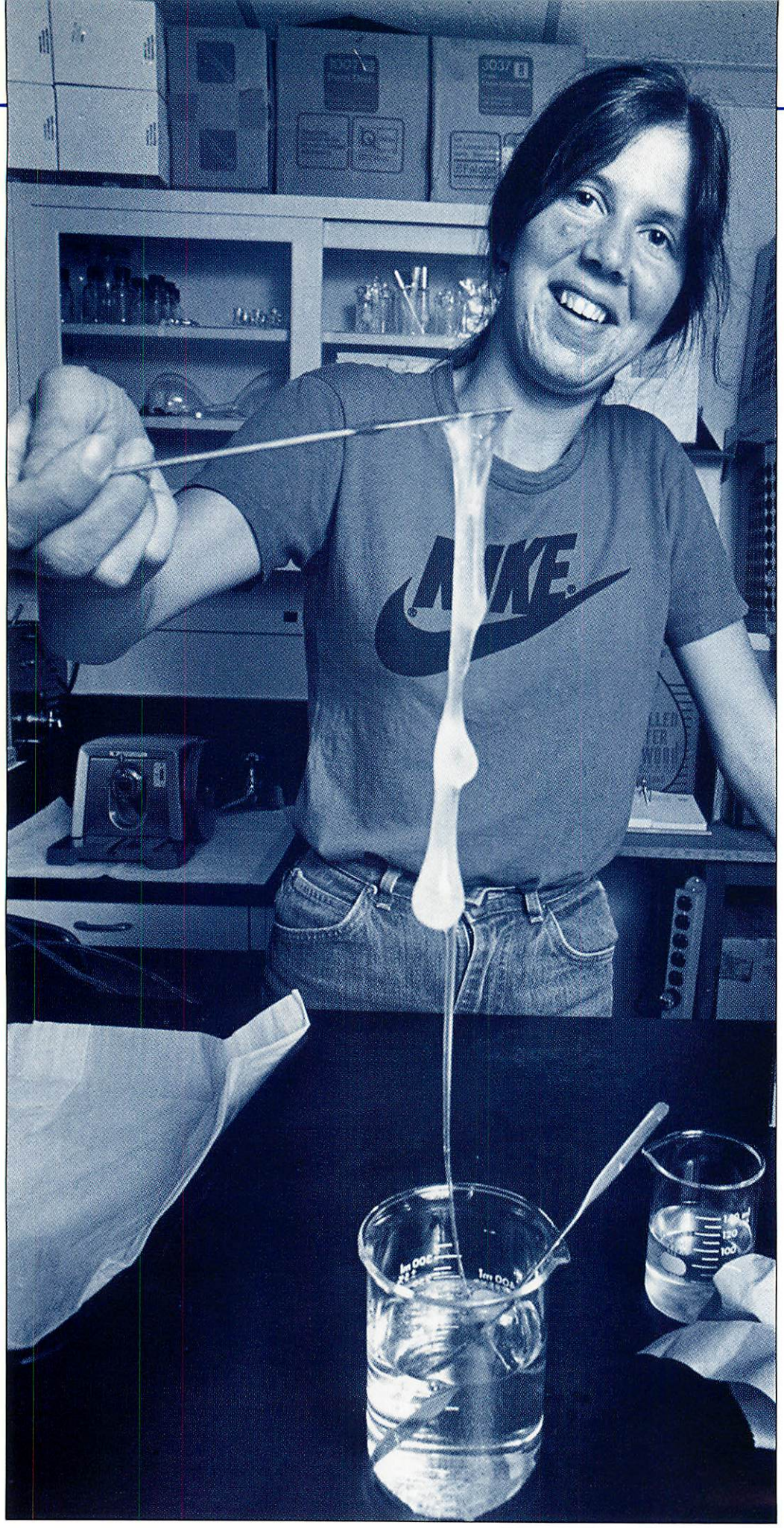
Fruin will complete his analysis of the international potential for western coal shipped from the Great Lakes next year. Then he will study the potential for serving selected midwestern and northeastern U.S. markets. He will analyze how Seaway tolls, user fees, and railroad regulations influence the price of western coal shipped on the Great Lakes compared to eastern and midwestern coal shipped to those same markets from Atlantic ports.

Jerry E. Fruin, Associate Professor
Dave Senf, Graduate Student, Sea Grant Trainee, Department of Agricultural and Applied Economics
University of Minnesota, Twin Cities



A coal loading operation at Midwest Energy Resources in the Duluth/Superior Port. The harbor moves 5 million tons of coal a year but has the potential to double that capacity by the year 2000.





EDUCATION

Mary Murphy never thought she would go to college. And she certainly never expected to spend several hours a day studying fish slime. Murphy is now a senior in chemistry and geography at the University of Minnesota-Duluth, thanks to Sea Grant's American Indians in Marine Sciences program (AIMS).

Murphy, a Chippewa Indian, was recruited for a Sea Grant scholarship from the tribe's lists of students interested in science. She had just completed a two-year vocational electronics program when she received the notice. "I never even dreamed I could be in college," Murphy said. "I never challenged myself in high school and college just wasn't an option."

"AIMS gets students into fields no Indian students have been in before," says Bob Diver, coordinator for the program. It gives Native American students beginning their third year of undergraduate study the opportunity to work in marine science. Each student is supervised by a Sea Grant researcher.

AIMS represents what one of the originators of the program, Ruth Myers, calls a "symbiotic relationship between Sea Grant and the Minnesota Chippewa Tribe." It is the only program of its kind in the country.

"The Sea Grant scholarship was the main reason I came back to school," Murphy said. "Sea Grant and AIMS offer great encouragement; they really want us to do

well and they give us a lot of help."

Murphy and the other three students in the program receive a monthly stipend and tuition from Sea Grant. They are required to maintain B averages and to supplement their studies with research. Murphy's research on hagfish slime is a perfect combination of her experience with electronic equipment and her interest in chemistry, she said. Hagfish produce copious amounts of slime, which contains thread cells with properties similar to those of silk and wool. Murphy is looking for a way to isolate the threads for use as a fiber.

In addition to training marine scientists, AIMS hopes to provide role models for other young Indians and to encourage them to continue their education. On Myer's door are these words: "Education is your most powerful weapon. With education, you are the white man's equal. Without it, you are his victim and so shall remain all your lives."

Murphy credits the Indian community and Sea Grant for encouraging her and other Indians to continue on to college. But she believes her success as a woman in science is also important. "I'm in a unique position as a woman in electronics and chemistry. My experience shows that people will support women in these fields and that we can do it. Others—whether they are Indian or not—can point to me and say, she made it. I'd like to see a lot more women get out there and learn they have choices."

Murphy is the fifth full-time student in the AIMS program. The first graduate, Lea Fairbanks is in medical school. The second, Mike Swan is an aquatic researcher for the Minnesota Chippewa Tribe.

Sea Grant trainee Pat Dalton at the Duluth harbor, a major tourist attraction. Dalton is providing survey data on a project to develop Northern Minnesota's tourism industry.

Sea Grant Educates Graduate Students...

When Pat Dalton found out her husband had a job in Duluth, she thought she would have to drop out of school at the Twin Cities campus. Luckily, her advisor Wilbur Maki, was working on Sea Grant research along the North Shore, just northeast of Duluth. Maki hired Dalton as a trainee to develop surveys on tourism facilities. She provides research support as well as the link between the North Shore and the Twin Cities, and between four researchers: three in Duluth and one in the Cities. The traineeship also allows Dalton to finish her master's degree in agricultural and applied economics.

Dalton—as far as she knows—is the only student doing research at one campus while receiving her degree at another. So far, the arrangement has worked very well. Dalton's proximity to the people she surveys gives her better familiarity with the area and its problems. Her results will provide data for a computer model to forecast investment options in North Shore tourism.

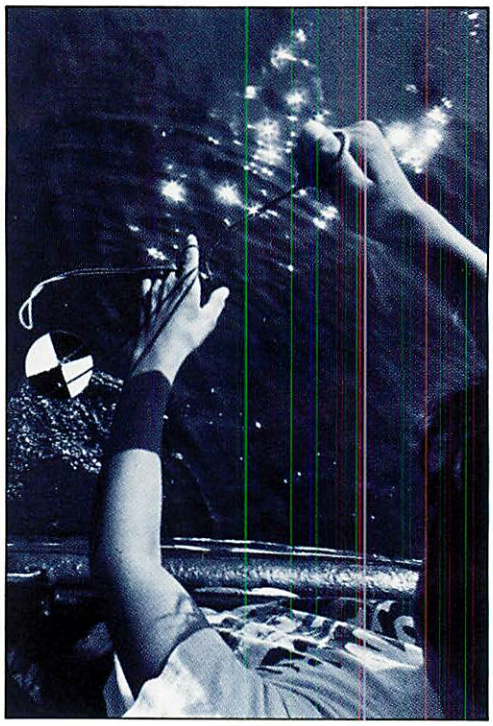
Dalton is one of ten graduate student trainees supported by Sea Grant this year. Each student receives a stipend of $6,200, tuition, and the opportunity to work closely with faculty on Sea Grant research. Research areas range from fisheries, to animal science, to physiology. Each trainee works with one researcher, gaining valuable experience in his or her field.

"Support for these young men and women costs only 11 percent of our federal budget, but they are certainly our most rewarding product," said Sea Grant Director Donald McNaught. "These students will go on to careers as diverse as aquaculture, resource management, teaching, and government. We hope they will be a testimony to the Sea Grant ethic: to promote the wise use of our marine resources."

...and Junior High Scientists

Thirteen-year-olds work hard at pretending they don't enjoy school work. But after a three-hour educational cruise on Lake Superior, these students had to admit, it was a "pretty cool" way to learn science.

The 27 sixth through ninth graders obviously enjoyed their day aboard the L.L. Smith, an educational cruise ship



Left, students review their test results after a three hour educational cruise on Lake Superior. Above, a student uses a secchi disc to measure light penetration through the water.

operated by the University of Wisconsin-Superior. Their outing was part of a four-week course, Jr. High Indians and Aquatic Science. It was developed and taught by Sea Grant agent Bruce Munson and funded by the Duluth Public Schools.

"We taught the course to stimulate interest among Indian students in the sciences and to encourage them to consider science as a career," Munson said.

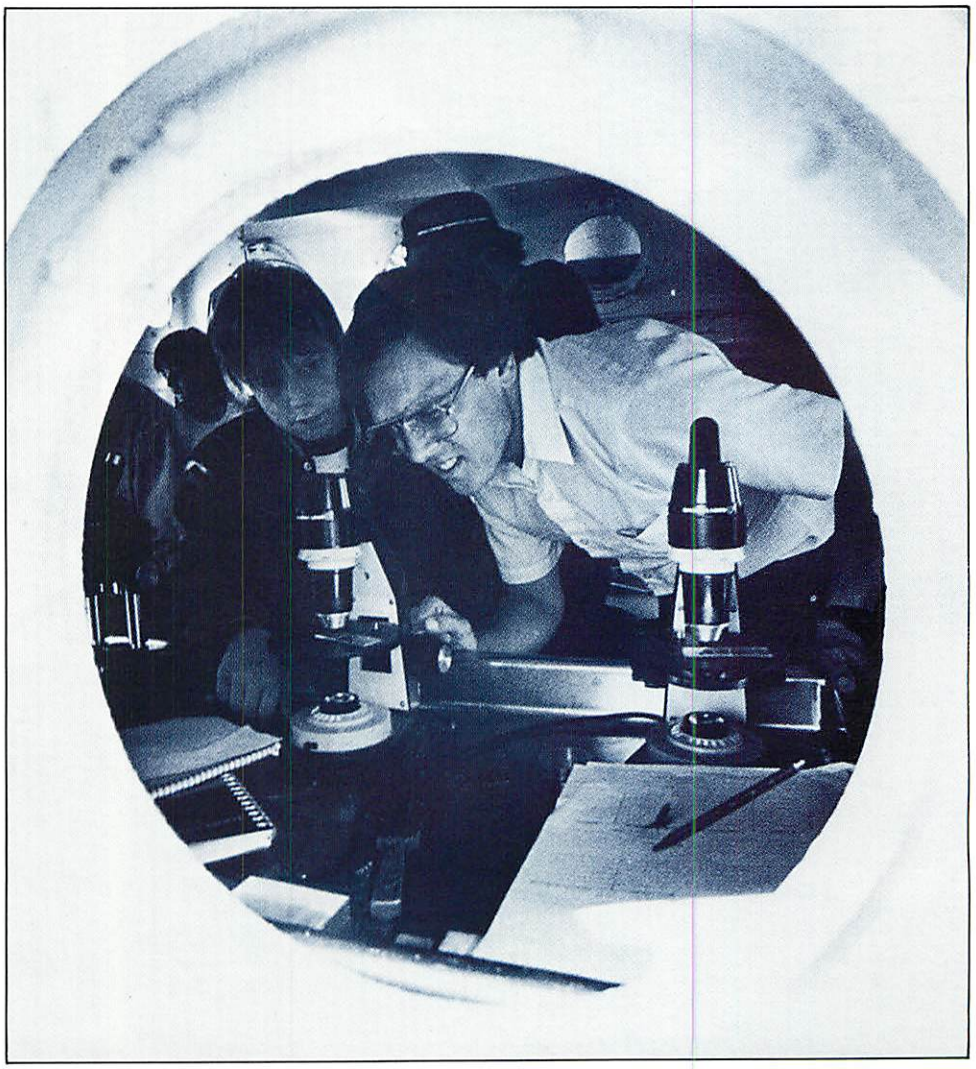
Northern Minnesota and the Duluth area have a large Indian population and many of the region's water resources are managed by the reservations. But there are very few Indians in the marine sciences, Munson said. "I couldn't find an Indian with science or education background to help teach this course."

Junior high is a crucial time to get students excited about science, Munson said. "At that level, science requirements are minimal and the coursework is textbook oriented. By the ninth grade, the majority of Indian kids don't take elective science courses because they aren't stimulated and they have no one encouraging them to take them."

To give the students a different view of science, Munson took them on field trips and laboratory visits. "We visit places that need employees trained in the sciences to show the kids the diversity of opportunity. We try to provide enough variety so that each kid finds something that appeals to him. We also show them that Indian tribes have a need and a reason to be concerned about water by bringing in Indian speakers to tell them what opportunities exist, that jobs are available, and that there are good reasons to be involved in science."

While teaching, Munson concentrated on plenty of hands-on experiences. "I tried

Above, students test the pH of the lake water. Right, Sea Grant education agent Bruce Munson helps a student get a microscopic view of lake plankton in the ship's lab.



to show them what science is firsthand, from the thinking end, rather than through memorization." His approach was obviously successful; the students were excited about learning. "I never had a teacher actually *do* the experiments with me," said one student. "Mr. Munson doesn't just stand up there and lecture. He does everything we do. He makes it fun."

Will the course affect these students' interest in science? "I only want to be a race car driver," said Bob, age 13. "...Or maybe a chemist."

WATER SAFETY

Tom Mack gingerly slipped into the tank of 50°F. water. Immediately, his body tensed, recoiling from the cold. The shock made his chest muscles contract and his regular breathing turned into gasps. He began to hyperventilate. Privately shivering in sympathy, we watched Mack's skin first pale then flush from the near-Lake Superior temperature.

Mack, a Sea Grant agent, has participated in the hypothermia experiment many times before. Today he was reenacting it for a regional television program.

Under the watchful eyes of Sea Grant researchers Drs. Bob Pozos and Larry Wittmers, Mack floated in the tank with only swim trunks, a life vest, and wires connected to machines measuring his vital signs. He remained in the tank for 30 minutes, half the usual time.

When the half-hour was up he stepped over to the hot tub. The warmth, however, was as painful to his cold body as the water was when he entered the tank. Within minutes his pink skin turned pale and clammy-looking and a remarkably fatigued look came over his face. His speech slowed and sounded lethargic. Yet it wasn't long—about 20 minutes—before Mack began to return to normal.

Hypothermia, the lowering of the body's temperature due to exposure to cold air or water, will if experienced long enough, bring the body

Dr. Lorentz Wittmers, center, monitors a volunteer's cardiovascular fitness before he is immersed in the hypothermia tank.

to the point of 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 can drown from heart failure, sucking in water while hyperventilating, or from unconsciousness caused by extended hyperventilation.

Is Tom Mack masochistic, you wonder, subjecting himself to this unusual stress? "I've gone through the experiments for two reasons," he said. "One is to give proof that one can survive an extended period of time in cold water, if prepared. I'm also out to destroy the myth and the fatalistic attitude that says,"If I fell in I'd die anyway, so why should I care about hypothermia prevention?"

"The other reason is to understand the information I pass on to others." Mack gives presentations on hypothermia to boaters, fishermen, scuba divers, service organizations, and sometimes to children.

When people learn they have a good chance of surviving if they fall into the lake, they'll be less inclined to panic and they'll be more prepared to survive, Mack said.

Staying Alive in Cold Water

If Tom Mack were floating in Lake Superior instead of in a laboratory tank, his thoughts would probably be much different. If he were in a boating accident, for instance, and fell into the lake a mile from shore, he would probably wonder: "Should I swim? How long can I last? Will I be dead soon?"

These questions and many others on how to survive in cold water have been researched for the past six years by Drs. Bob Pozos and Larry Wittmers in their hypothermia lab at the University of Minnesota-Duluth. Duluth is an appropriate location for the laboratory, given its proximity to Lake Superior, the largest and coldest Great Lake. Superior's summer temperature ranges from 40°F. to 60°F., posing a severe hypothermia danger year-round.

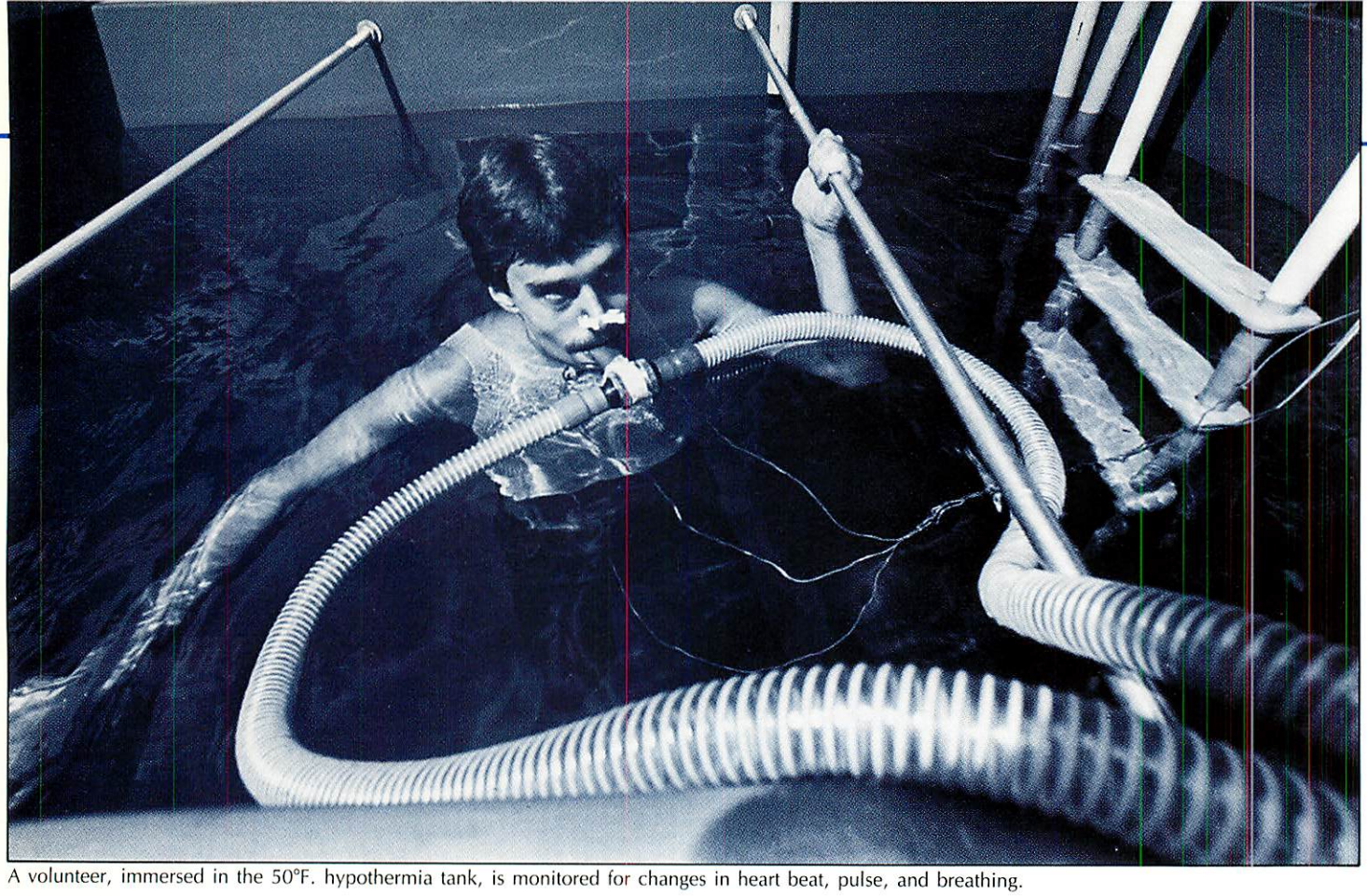
In the land of 10,000 lakes, hypothermia is a contributing cause in 50 percent of drowning fatalities. Although their research raises as many questions as it answers, Pozos and Wittmers have discovered new evidence that dispells many myths about the nature and treatment of immersion hypothermia.

"Will I be dead soon?" The greatest myth is that survival in cold water is unlikely. People assume that if you fall into Lake Superior, you will not come out alive. But Pozos and Wittmers have found that the body and mind do not give up so easily. The body uses two methods: the dive reflex and the shiver reflex to keep the body warm enough to survive.

In the dive reflex, heart rate drops, blood pressure rises, and blood vessels in the body's extremities constrict. As a result, blood flow is concentrated in the body core—the heart, lungs, and brain—organs essential for survival. By reducing blood flow to the extremities, heat loss is reduced and oxygen is conserved. The colder the water, the greater the reflex.

"We use the dive reflex as a tool to measure the cardiovascular response of an individual subjected to cold," said Wittmers. In some cases, immersing only the hands or face is enough to induce the reflex. The question is, are there types of people more susceptible than others to hypothermia? If so, can researchers predict how a person's body will react by simply immersing their hand in cold water?

The reflex in humans is a vestigial trait inherited from aquatic mammals like walrus and seals. The mechanism evolved as a way to stay under water for long periods of time in order to feed or escape harm. Children generally have a



A volunteer, immersed in the 50°F. hypothermia tank, is monitored for changes in heart beat, pulse, and breathing.

more pronounced reflex than adults. A Chicago boy who remained under water for 20 minutes after sledding into Lake Michigan in 1983, is alive today because his body shut down; oxygen was conserved and heat loss minimized.

Shivering is the second survival reflex. The involuntary contraction of muscles raises metabolism, thereby producing more body heat. Like the dive reflex, the shiver reflex varies among people.

"Some people don't shiver at all, and some shiver violently," Pozos said. The variation in shiver response among people cannot be linked to age or sex. Alcohol consumption can decrease one's ability to shiver and can, therefore, lower the body's resistance to hypothermia. Prolonged violent shivering can induce muscle cramps, sometimes painful enough to make a hypothermia victim lose hope and die.

"Should I swim?" Swimming produces three times more body heat than floating, but the extra heat is lost to the cold water due to greater circulation in the extremities. A person wearing a personal flotation device (PFD) who swims, cools 35 percent faster than a person floating. So even with a PFD, if the water is colder than 50°F. and the shore is a mile away, you'll most likely succumb to hypothermia before reaching shore.

Wearing a PFD can prolong survival time by insulating the body from cold, Pozos said. But many PFDs are designed for flotation, not insulation. The traditional advice has been to tell people to float and fold their legs up against the chest in a fetal position called H.E.L.P., a heat escape lessening posture. But the H.E.L.P. position is very difficult to maintain while wearing a typical PFD, Pozos said. They can also be death traps for handicapped people, he added.

"How long can I last?" Cold water survival can be a case of mind over matter. "Individual psychology is an important ingredient in survival," Pozos said. "The incredible powers of the mind, through the expression of the will to survive, can greatly influence heat production and heat loss."

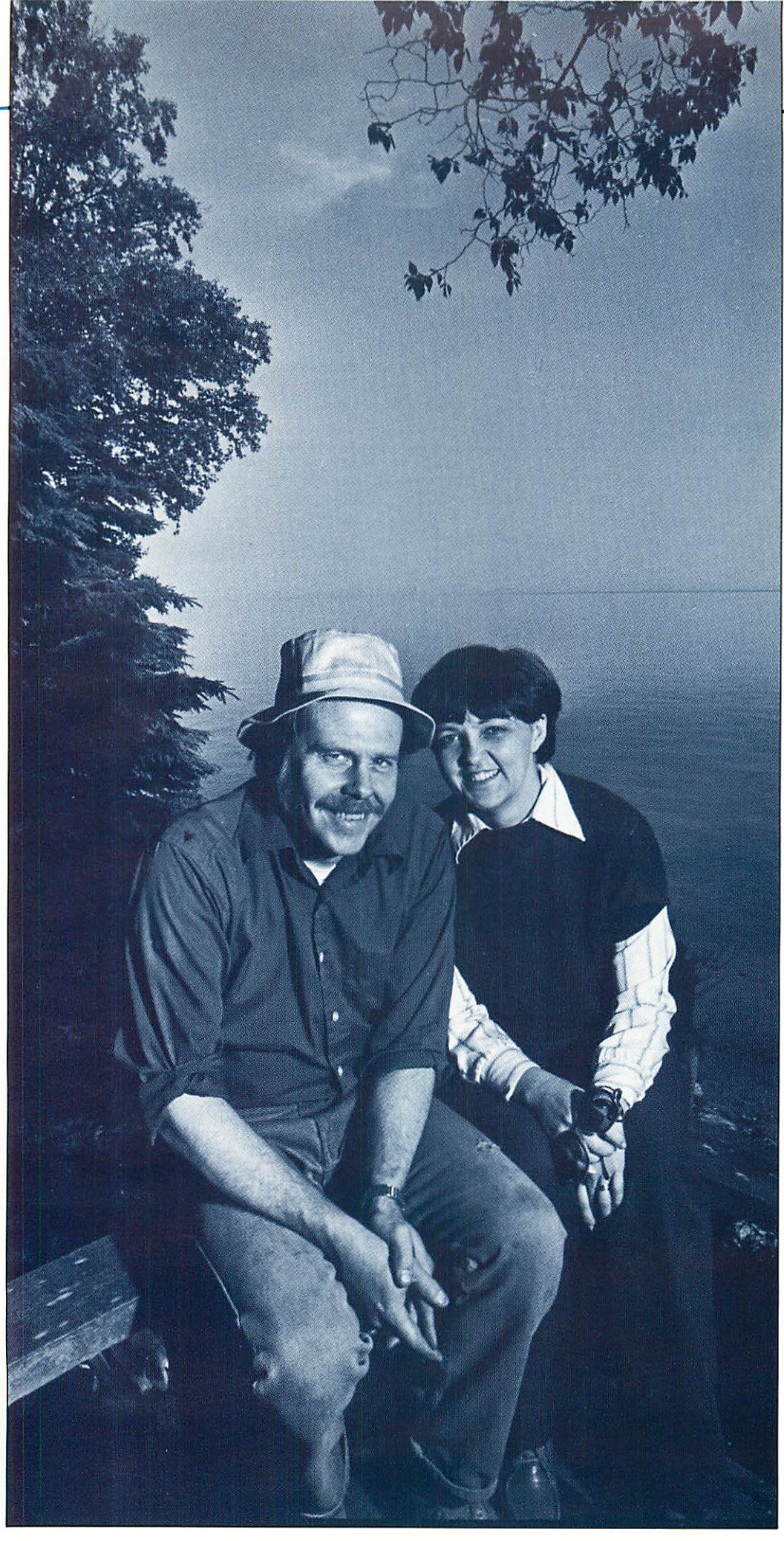
When a person does give up and lose conciousness in cold water, he may still be alive, even though there are no vital signs of breathing or heartbeat. In the past, such victims were given up for dead when they could have been revived with proper treatment. Researchers do not agree on how to treat these victims but administering cardiopulminary resuscitation could shock the heart into fibrillation, Pozos said. Like"a can of worms," the heart muscle fibers beat out of synch with one another, rendering the heart useless as a blood pump.

Contrary to popular belief, body massage, alcohol, hot showers, hot foods, and drinks do nothing to warm a victim and may speed up the rate of cooling. In fact, rewarming the body in this manner starts cold blood moving from the extremities to the body core, further lowering body temperature. Pozos and Wittmers recommend instead that rescuers call emergency medical help immediately, remove wet clothing, then wrap the victim in blankets and cover the head and neck.

During their six years of research, Pozos and Wittmers have received calls from hundreds of reporters, physicians, parents, and lawyers all over the country. "Alot of times, they want to know why a drowned child didn't survive," says Pozos. From Alaska to England, they have given hypothermia presentations to offshore drillers, the Coast Guard Auxiliary, firemen, fishing and boating clubs, the Red Cross, and the military.

In the area of cold water stress, Sea Grant has been invaluable, Pozos said. "Basically, we have become a national information source for hypothermia."

Robert S. Pozos, Associate Professor and Head
Lorentz E. Wittmers, Associate Professor
George Fall and **Dave Howard**, Graduate Students, Sea Grant Trainees
Department of Physiology
University of Minnesota, Duluth



EXTENSION

Beth and Bill Blank vacationed on the North Shore for years. On one of their trips to the area, they noticed Solbakken's resort was for sale. One month later, they quit their jobs, moved to Lutsen, Minnesota, and became full-time resort operators.

Ever since, they have worked to make the Lutsen area an increasingly successful tourist region. The Blanks, along with several other resort owners and managers, helped start the Lutsen-Tofte Tourism Association to draw more tourists to the area. The Association is made up of three towns with such varied members as real estate offices, resorts, and grocery stores.

The Association formed in 1981 to work on an extensive cross country ski network. The forest service had built the trails but they couldn't afford to groom them, Beth said. No single resort could afford it either, so the Association was formed to maintain,connect, and promote the trails. The result has been more skiers and a 20 percent increase in the Blank's winter business. "That's just our increase, but I'm guessing its up that much at most of the other resorts too," Bill said.

The trail system is now one of the longest in the Midwest and is starting to earn a national reputation for excellent skiing. The Association has continued to groom

trails, build new trails, produce maps, and to advertise the system.

Beth credits Sea Grant tourism agent Tom Mack for giving the Association needed direction and good advice during its first year. "Tom helped us by designing the brochures to publicize the trails and by holding several seminars on small business management," Beth said. "Both Tom and Chad Dawson (Mack's successor) have given us good advice along the way. "We've benefitted alot from their experience and expertise."

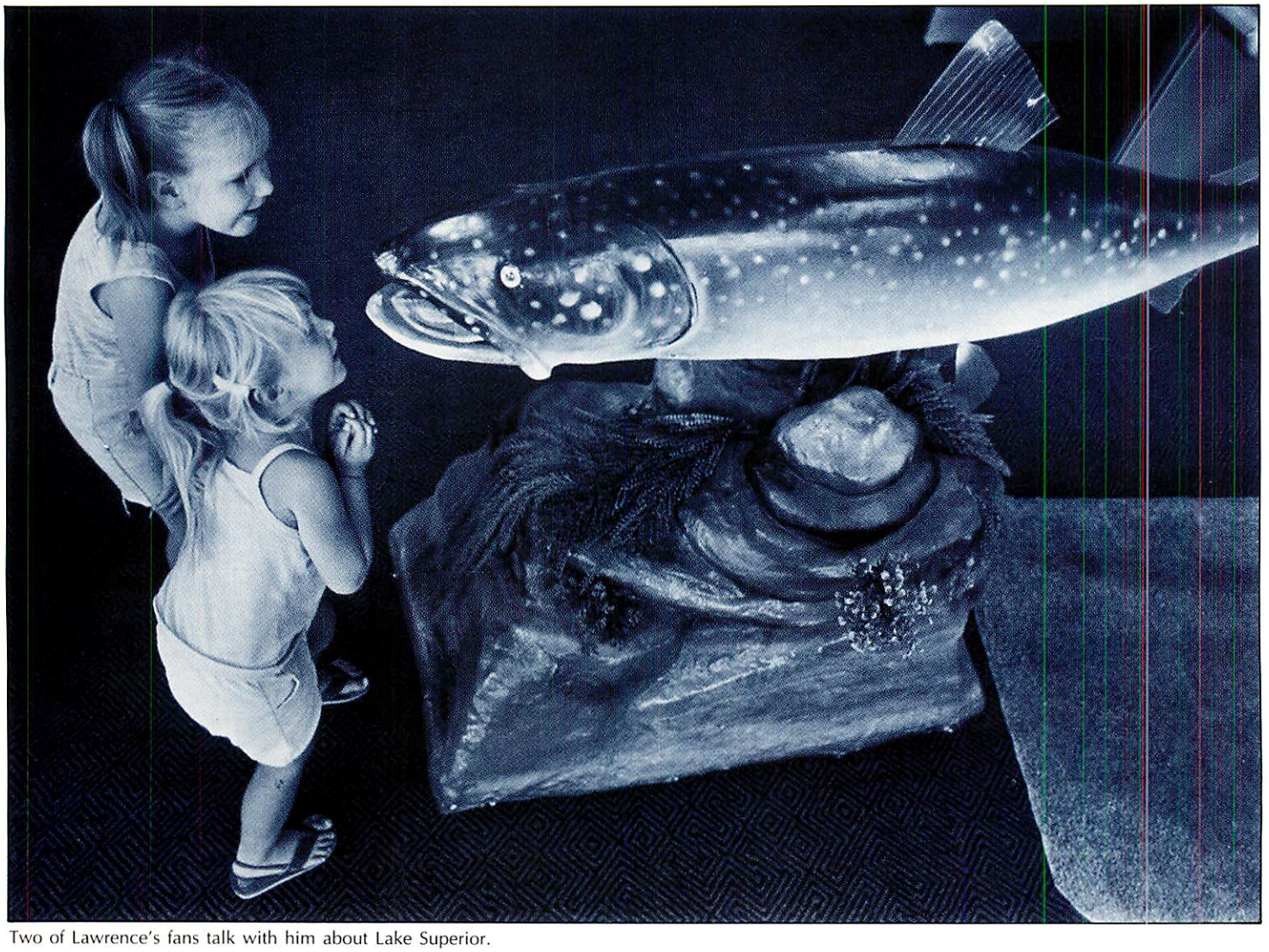
The Blanks hope the Tourism Association's success will encourage other areas on the shore to form their own tourism groups. "It's hard to keep these groups together, and its especially unusual to take three towns and make it work," Bill said. "We've shown there are many things a group can do that individuals cannot. We think it has proven its value to the area."

Lawrence Takes a Leave From Sea Grant

How can anyone become attached to a mechanical talking fish? Gimmicks come and go; all novelties have a short life span. Yet after being around for five years, Lawrence the talking lake trout's retirement in 1983 aroused strong feelings of disappointment.

The five-foot fiberglass replica of a lake trout may have first caught our attention because he was a clever idea or a silly idea or just an oddity. But it didn't take long for young and old to become enamored with him. Once we got past the incredulity, we were drawn into his watery world. Lawrence came to mean more than a gimmick; he became a symbol. Just as Smokey the Bear brings to mind the fragility of our forests, Lawrence represents the fragility of our waters.

"Before you can educate people, you have to first attract their attention," said Dale Baker, who helped create Lawrence. The Sea Grant Extension Director thought a talking fish would be a good teaching



Two of Lawrence's fans talk with him about Lake Superior.

tool for the program. A novelty like Lawrence educates subtly: who can be preachy talking through a fish's mouth?

"Children will listen and talk to Lawrence on topics they'd never talk about with an adult," said Baker. Through Lawrence, agents talked to thousands of people about Lake Superior and what Sea Grant is all about.

While the fish slowly swiveled on his pedestal of Lake Superior granite and moss, moving his gossamer fins and large tail, someone with a headset and microphone stood concealed nearby. When the speaker talked into the mike, Lawrence's mouth opened and closed in sync with the vocal vibrations.

"We never thought of Lawrence just as a fun thing; we took him seriously as an educational tool," Baker said. In fact, Sea Grant produced cue cards, tapes, and scripts for Lawrence so he could accurately answer questions about the Great Lakes and water resources. Bruce Munson, marine education agent, spoke for Lawrence most often. "You have to go through a sort of personality change and adopt the role of the fish as you perceive him to be," Munson said.

Lawrence spoke to people all over the country. In Minnesota, he made his State Fair debut in 1978 and was such a hit, he was voted the most popular display at the fair. He appeared on television at least 20 times, before Congress, and at sportsmen's festivals. Once, before 100,000 people at the Potomic River Awakening in Virginia, he went through a sex change and appeared as Lucretia the Lake Trout. Lawrence was so popular that during the two years before he retired from Sea Grant he was hardly ever at home in Minnesota, Baker said.

When Sea Grant decided to retire Lawrence, more than 30 groups requested him, including the Red Cross, several museums, and the National Advisory Fisheries Service. A committee decided to loan Lawrence to Silver Bay, Minnesota, a small city on the North Shore of Lake Superior.

Why Silver Bay? "Its a town that has gone through some serious ups and downs, and they were undergoing a major shift in emphasis from a declining taconite mining industry to tourism," Baker said. "As a community, they had made a commitment to tourism and Lawrence became the central theme of their campaign."

Lawrence lives in Silver Bay at the tourism center for nine months each year and at the Corps of Engineers Canal Park Museum in Duluth for three months.

"Lawrence started his career in education and he wanted to stay in that area," Baker said. He believes Lawrence is happy to have stayed in Minnesota, where he can continue to teach the public about the Great Lakes.

Lake Superior's Dangerous Weather

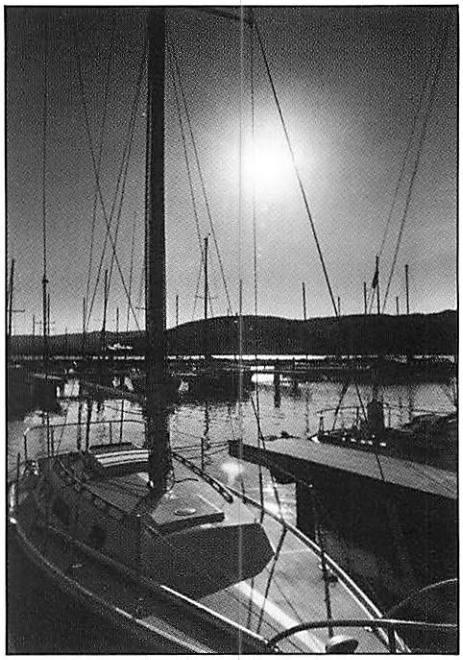
You decide to spend Saturday fishing on Lake Superior. It's a warm sunny day as you launch the boat, and the lake is glassy smooth. You let out your line, peel off your shirt and proceed to bask in the sun like a lazy reptile, as stringers of lake trout dance through your daydreams.

Within minutes, the wind is howling and waves are building. The radio reports: marine forecast still calm and sunny. But a wave just doused your trolling motor and the water in the bottom of the boat covers your feet. The adrenalin surges as you reel in and head for shore.

"Why didn't the #?@ *! weather report predict this," you wonder, as waves crest into the boat and you promise to go to church on Sunday if only you'd make it to shore alive.

As many will testify, Lake Superior creates its own microclimate. Wind speed and direction can be much different at the Duluth airport, where marine forecasts originate. The Marine Reporting Program (MAREPs) is a cooperative effort of the National Weather Service and Minnesota Sea Grant Extension, designed to provide more timely and accurate marine forecasts.

Ten volunteer boat operators radio weather data to the aerial lift bridge and cooperating marinas along the Lake Superior shore between Brule Point and Two Harbors. Reports are called in three times daily, then relayed instantly by computer to the National Weather Service at the Duluth Airport. The weather service includes the information on its marine weather forecasts.



It may be a calm day in the harbor even while a storm is brewing on the lake.

Dave Gould, charter fishing captain and MAREPs volunteer, believes MAREPs adds credibility to marine forecasts. Right now, "it's wrong two times out of three," according to Gould. "Most folks listening to the marine forecast don't pay any attention to it, 'cause they just know it isn't gonna be right."

Early morning reports are particularly helpful to recreational boaters. "Winds can pick up around sunrise," says Gould. "If trailer boats could get an accurate report of wind, they wouldn't bother launching."

Before MAREPS, the weather buoy 25 miles northeast of Outer Island provided the only continuous source of Lake Superior weather data. On such a large lake, the weather is often unpredictable. The cold temperatures and vastness of Lake Superior create a dome of high pressure that generates winds that differ in speed and direction from on-shore winds. Warm southwest wind can suddenly break through the cold dome, causing an increase in wind speed and, at times, a 180 degree shift in direction. A MAREPs observer off the shore provides information valuable to those farther out on the lake.

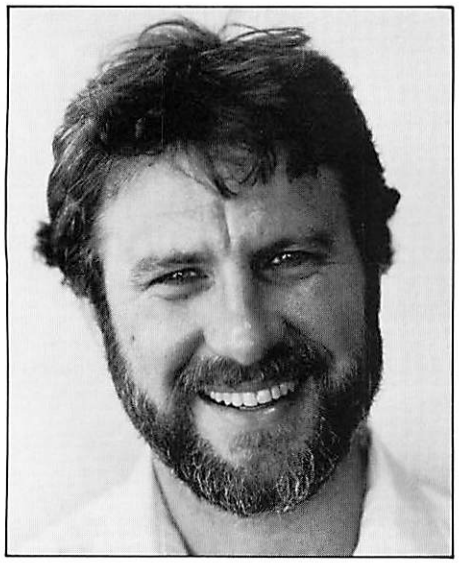
Whatever the cause, it's often impossible for the Weather Service to accurately predict sudden onslaughts of dangerous weather. MAREPs helps ensure that boaters on Superior won't end up cursing the #!?@*! weather report.

Taking Research to the Public

Sea Grant's extension program is based at the University's Duluth campus near the 206-mile North Shore of Lake Superior. This region is the primary focus for most of the extension programs, but like Sea Grant's research, extension efforts have practical applications statewide and beyond.
Following is an explanation of a few of the programs the extension agents worked on this year. Other programs are featured elsewhere in this report.

COASTAL ENGINEERING AND TRANSPORTATION

Dale Baker, Extension Director



International markets are growing and Great Lakes ports must take advantage of the potential to increase their business. Dale Baker (with Wisconsin Sea Grant and the Port Authorities of Duluth and Superior) organized a conference to bring together commodity handlers and government specialists to discuss how to diversify and promote international imports and exports in the Upper Great Lakes.

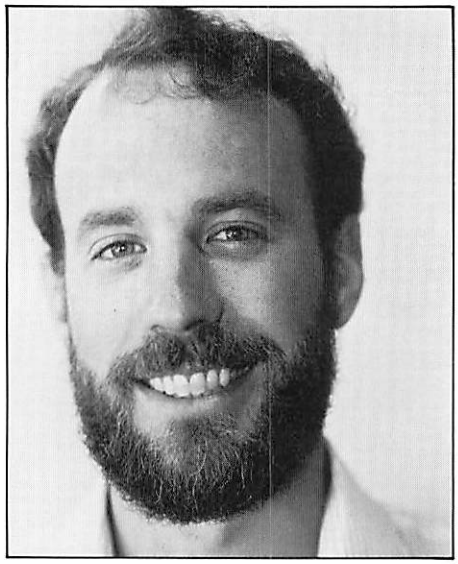
Participants discussed possible solutions for some of the port's ongoing problems and limitations, including season extension, how to stimulate international trade, educating the public about ports and shipping, and taking advantage of changing technology.

At least one idea discussed at the conference resulted in a new business and 500 new jobs since a Duluth facility is now being used for secondary processing of products for shipment to international markets.

As a result of the workshop, a closer relationship has developed between Sea Grant and the port community, and the governors and government officials of Wisconsin and Minnesota have become more aware of the problems and potential for the Lake Superior port.

FISHERIES

Jeff Gunderson

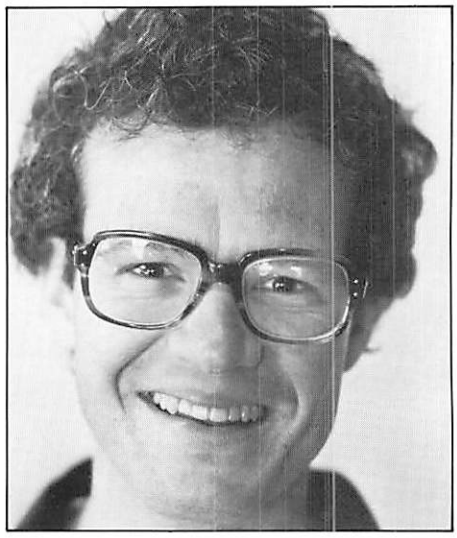


The ribbon leech is a very popular fish bait in Minnesota. But natural populations are declining and shortages occur in late summer. Jeff Gunderson held a seminar on Sea Grant's research results for 60 bait dealers, leech harvesters, and other businessmen. They learned how to price and market bait leeches, improve worker productivity, construct a leech culture facility, and methods to minimize mortality during handling.

As fishing on Lake Superior becomes more popular, fishermen want to know how and where to find the big ones. Gunderson helped organize a 10-week Fishing Lake Superior/Boating Safety class for sportfishermen and boaters. Coast Guard Auxiliary instructors gave presentations on boating rules. Fishermen, state fisheries managers, and Sea Grant agents from Minnesota and Wisconsin explained the equipment useful for fishing Lake Superior, preparing the catch, using temperatures and currents to find fish, sensory perception in fish, and fishing regulations.

EXTENSION COMMUNICATIONS

Howard Bell



The 500,000 visitors who tour the Duluth Canal Park Maritime Museum each year will now see a new display on Facts About Lake Superior. The Minnesota Sea Grant display answers the most common questions visitors have about the lake: its size, formation, volume of water, and temperature. Howard Bell provided materials and an artist donated watercolor graphics.

Sea Grant's Fishing Lake Superior class was so successful, Bell videotaped it for broadcast on Duluth's cable access channel. More people wanted to attend the class than could be handled and many who did attend wanted to review the materials. The program ran on television for six consecutive weeks.

More resorts, shops, and motels now carry Sea Grant publications, thanks to improved marketing efforts. Bell visited most tourist locations along the North Shore to describe and sell publications. The result was greater awareness of Sea Grant and increased use and sales of books and fact sheets.

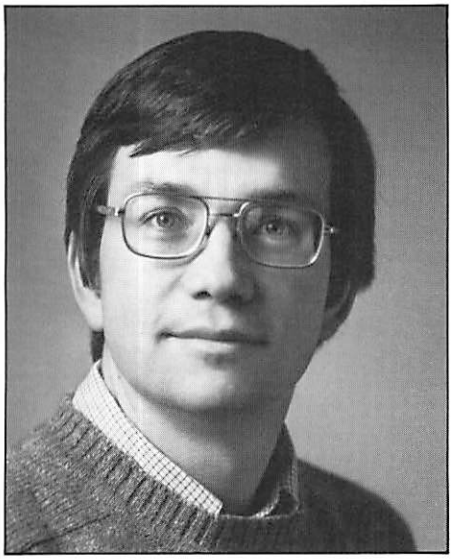
TOURISM/RECREATION

Chad Dawson

Sportfishing on Lake Superior has improved steadily for the past few years. And as more fishermen come to Lake Superior, more charterboat operators are starting businesses to serve them. To meet the demand for information on this growing industry, Chad Dawson and Wisconsin Sea Grant agent Karen Plass organized a charterboat fishing workshop. Marketing and financial planning

Sports fishermen benefit from Sea Grant's research and extension efforts. Above, fly fishing at the Lester River on Lake Superior.

specialists and Great Lakes fisheries experts advised charterboat operators and others interested in starting a charter business.



In 1982, northeastern Minnesota contributed 20 percent of the state's annual tourism expenditures, provided 22,700 jobs, and produced $43 million in state and local tax revenues. To keep tourists coming back, the area needs knowledgeable, courteous employees working in hotels, restaurants, and tourist attractions. Dawson organized a hospitality training workshop to help teach those skills. The 100 employees who attended left the workshop with a clear understanding of tourism's economic importance and their crucial role in leaving good impressions with customers.

EDUCATION

Bruce Munson

Forty million tons of cargo move through the Duluth/Superior harbor each year, making it an important source of jobs and community vitality. But many people don't realize how important the port is to the local economy. Bruce Munson led 60 sixth graders on a tour of the port as part of Harbor Awareness Week. They had the chance to walk through a coal storage facility and the insides of grain and cement elevators. Before the tour, five students in the University's Duluth College of Education helped Munson develop a curriculum unit and lesson plan on the harbor, ship types, and how the harbor links Duluth/Superior with the world.

Science teachers in Minnesota are becoming more interested in teaching marine sciences to their students. Munson helps those teachers develop lessons by holding Aquatic Workshops for Educators. The program includes 25 workshops in marine sciences. Munson has presented the workshops to educators throughout the state.

ADMINISTRATION

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Lydecker. 1976. Revised ed., 1982. A 60-page booklet describing the Minnesota coast of Lake Superior, its setting and history, its problems and potentials.

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Fixin' Fish: guide to handling, buying, preserving, and preparing fish.
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Warren Downs, UW Sea Grant Institute, 1982. Describes lamprey's history, life cycle, and steps taken to control them.

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Smooth Sailing Through Coastal Permits.
D. Baker. 1982.

Boat Batteries.
B. Whittier. 1983.

PERIODICALS

The Seiche.
A quarterly newsletter published by Sea Grant Extension for and 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.

North Shore Correspondence.
Quarterly; contains information and research results on tourism.

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	$14,735	$ 8,176	C
R/F-6	**The Relationship of Growth Rate Changes to Smoltification of Chinook Salmon**	Ira Adelman	12,621	7,285	C
R/F-9	**Nutrients, Productivity and Water Quality in Lake Superior: A Mechanistic Approach to an Oligotrophic Food Web**	G. David Tilman	16,920	7,495	C
R/F-10	**Population Dynamics and Yield Potential of Lake Superior Pink Salmon (Oncorhynchus gorbuscha)**	George Spangler	13,398	2,726	0
R/F-12	**Application of Gamete Preservation Techniques to Enhance Minnesota Aquaculture**	Edmund Graham	3,835	33,750	0
COASTAL AND ENVIRONMENTAL PROCESSES					
R/CL-6	**Sediment Mass Movement on the Tailings Fan in Lake Superior at Silver Bay, Minnesota**	W.H. Busch	13,380	3,130	C
R/CL-7	**Redistribution of Sediments by Turbidity Currents**	Gary Parker Heinz Stefan	19,069	10,486	0
R/CL-9	**Turbidity Storms in the Western Arm of Lake Superior**	Thomas Johnson David Darby	21,384	8,236	C
MARINE APPLIED ECONOMICS					
R/C-8	**Recreation Industry - Activity Cluster Assessments for Recre ation Resource Management**	Wilbur Maki	13,145	3,511	C
R/C-9	**Economic Analysis of the Com-Great Plains Coal Exported Through Great Lakes Ports**	Jerry Fruin	20,053	7,516	0
WATER SAFETY					
R/S-2	**Diving Reflex: Cardiovascular Adjustments to Cold and Water Stress**	Lorentz Wittmers	18,587	4,848	C
R/S-4	**Relationship Between Shiver, Metabolic Rate, and Glucogenic Hormones**	Robert Pozos	7,784	35,619	0
MARINE EDUCATION AND TRAINING					
E/T-3	**Sea Grant Traineeships**	Donald McNaught	62,000		0
E/T-4	**American Indians in Marine Sciences**	Bruce Munson Robert Diver	28,201	2,726	0
SEA GRANT EXTENSION PROGRAM					
A/SE-1	**Minnesota Sea Grant Extension Program**	Dale Baker Barbara Stuhler G. Edward Schuh	204,548	109,258	0

C = completed
0 = ongoing

PROJECT NUMBER	SECTION AND PROJECT TITLE	INVESTIGATOR(S)	NOAA SEA GRANT FUNDS	LEGISLATIVE & UNIVERSITY MATCH	STATUS
PROGRAM MANAGEMENT AND DEVELOPMENT					
M/P-1	**Program Management**	Donald McNaught	60,516	41,407	0
M/P-2	**Program Development**	Donald McNaught	15,208		0
M/P-3	**Ship Time**	Donald McNaught	10,000		0
M/C-1	**Communications**	Alice Tibbetts	19,616	8,635	0

Grant NA82AA-D-00039

BUDGET SUMMARY

Activity	NOAA Office of Sea Grant	State Match	University Match	Industrial Match	Federal Pass Through
Research	$219,735	$ 47,282	$ 94,131	$2,500	$37,430
Education	90,201		2,726		
Extension	204,548	78,603	30,655		
Program Management	60,516	29,789	11,618		
Totals	$575,000	$155,674	$139,130	$2,500	$37,430

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Lenore Johnson
Two Harbors - Lake County
(ex-officio member)
Renny Lovold
Two Harbors - Lake County
Lyle Northey
Two Harbors - Lake County
Andrea Peterson
Grand Portage - Cook County
James Schliep
Tofte - Lake County
Stanley Sivertson
Duluth - St. Louis County
(ex-officio member)
Dick Thorngren
Little Marais - Lake County

Sea Grant Administrative Staff

Donald C. McNaught
Director
Judy Goetzke
Executive Secretary
Kathy Larson
Accounts Specialist
Cynthia Osborn/Alice Tibbetts
Communicators

Sea Grant Extension Personnel

Dale R. Baker
Extension Director
Judy Zomerfelt
Principal Secretary
Gayle Stroup
Accounts Specialist
Nancy Berini/Howard Bell
Communicator
Jeff Gunderson
Fisheries Agent
Douglas Tave
Aquaculture Specialist
Tom Mack/Chad Dawson
Marine Recreation Agent
Bruce Munson
Marine Education Agent