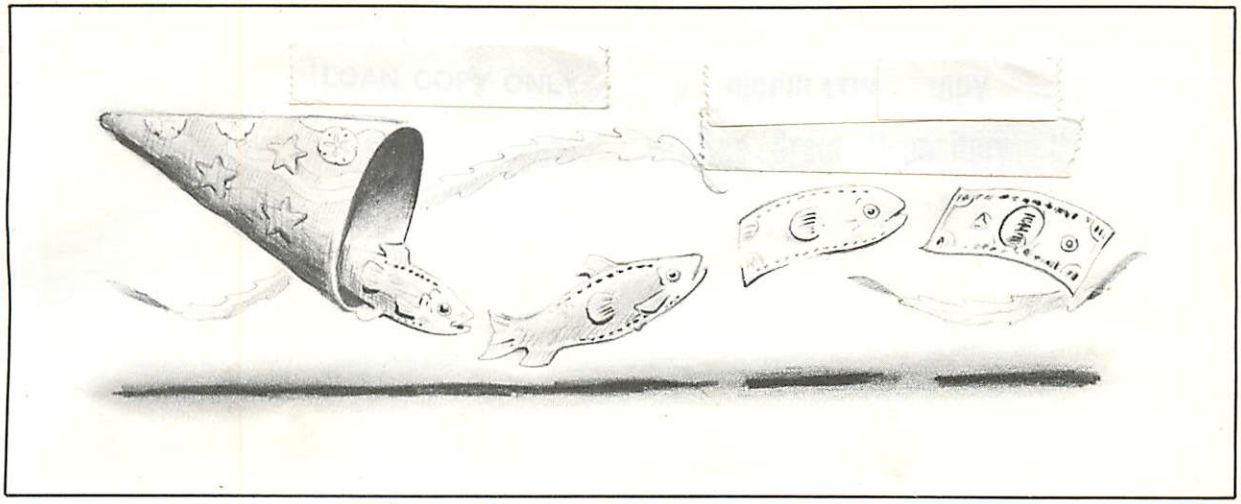
Alchemy for the 80s

Riches from our Coastal Resources



New York Sea Grant Institute
of State University of New York and Cornell University
411 State Street • Albany, New York • 12246

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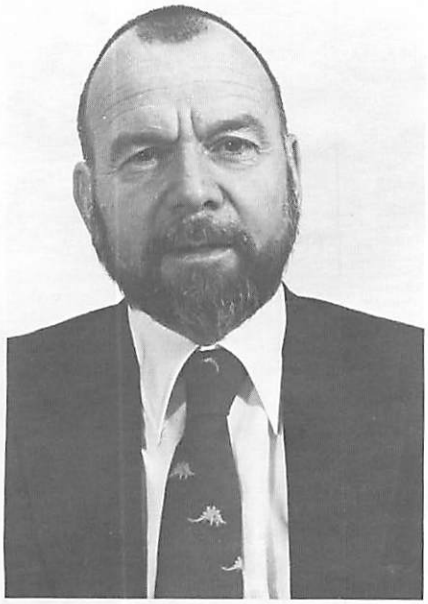


With coastlines on the Atlantic and Great Lakes, New York State abounds with coastal resources. Historically, New York has neglected these resources; but Sea Grant is helping to change that. Like the alchemists who turned metals to gold, Sea Grant helps people and industries of New York State to turn these coastal resources to economic benefits. Through its research, education, training, and extension programs, Sea Grant helps develop and manage these resources wisely and realize their potentials.

Over the past few years, New York Sea Grant has focused on the state's fin and shellfish stocks, coastal recreation and tourism, the seafood industry, mineral deposits, and energy.

- In the process, Sea Grant has helped to build campus research strengths in selected subjects: seafood science and utilization and aquatic veterinary medicine at Cornell; coastal law and policy at SUNY at Buffalo; marine science at SUNY at Stony Brook; and Great Lakes studies at SUNY at Oswego.

- New York's Sea Grant extension program, nationally recognized for imagination and productivity, has developed a broad capability to meet the needs of citizens, industry, and business on New York's marine and Great Lakes coasts. Working in tandem with the Cooperative Extension Service of Cornell has proved a great asset.

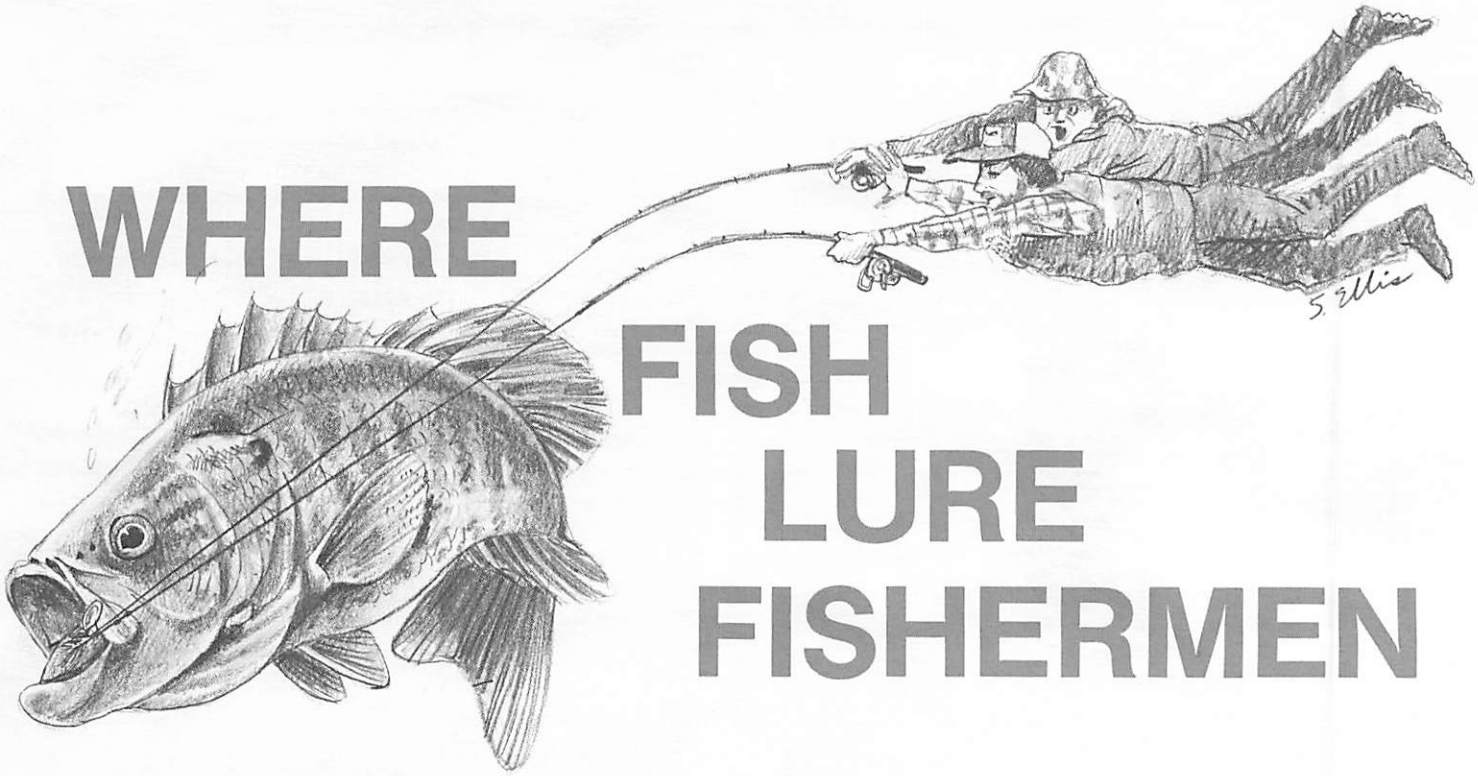
- Through its staff in Albany, the Sea Grant Institute keeps in touch with the state legislature, government agencies, and others whose decisions affect the way we use our coasts.

Because Sea Grant is university based—in New York, a cooperative activity of the State University of New York and Cornell University—it can carry out these activities with flexibility and expertise. By reaching out to campuses besides SUNY or Cornell, as it does, Sea Grant broadens its experience and competence.

The National Sea Grant College Program as measured in economic terms is regarded as a success; as a major factor in the training of a new generation of marine engineers and scientists; and as a successful change agent in the way we treat our coastal resources. New York Sea Grant is a successful part of that network linking the university, industrial, and business communities.

This report covers the tenth and eleventh years of institutional support under the National Sea Grant College Program Act for the State University of New York and Cornell University, and the seventh and eighth years of these institutions as a Sea Grant College.

Donald F. Squires, director
New York Sea Grant Institute



WHERE FISH LURE FISHERMEN

Fish have long lured fishermen to northern New York. Along with the fishermen comes a tourist industry worth several million dollars annually to upstate communities. But the sport fishing and tourism business, according to many, still hasn't approached its potential.

Now communities are fishing for ways to boost fishing and tourism business—by lengthening the season, expanding the territory, and promoting more species. Sea Grant has helped them with such approaches as surveying and tracking the fish and teaching the public how to get the most from their fisheries—on Lake Ontario, Lake Erie, and the St. Lawrence.

THE FISH STORY

Fish is the region's main attraction, according to Joe Swift, charterboat operator from Sodus Bay, Lake Ontario, and member of a regional Sea Grant advisory committee.

These inland waters support diverse fisheries—warm, cool, and cold water species—species that favor different habitats and hold different attractions for anglers. The warm water fish live in the rivers, bays, and areas near shore. They thrive in waters warmer than 70° F and include largemouth bass, carp, northern pike, and muskellunge. The cool water fish—smallmouth bass, yellow perch, and walleye—prefer waters from 60° to 70° F. And waters below 60° F are home for the ever-popular cold water species: those fish in the trout and salmon families called the salmonids.

Of all the upstate waters, Lake Ontario is considered best suited for the salmonids. It is oligotrophic—deep, cold, and well oxygenated—the kind of lake salmon and trout prefer.

But populations of native Atlantic salmon and lake trout have declined. By damming and polluting the streams where Atlantic salmon spawn, man brought about the salmon's extinction in the region by the 1890s. And since the 1950s lake trout have been overfished by the fishermen and decimated by the voracious sea lamprey, inadvertently introduced from the Atlantic into Lake Ontario when the St. Lawrence Seaway opened.

Recognizing their loss, New York State's Department of Environmental Conservation, following Michigan's lead, began restocking the lake with salmonids in 1968. The idea is to grow salmonids in hatcheries and restock the lake with fish big and hardy enough to survive. In an attempt to develop a year-round fishery, department managers have been introducing non-native species, as well, that proved successful in Lake Michigan. New York has stocked the lake with not only native lake trout, but European brown trout, Pacific coho and chinook salmon, and west coast rainbow trout. In this way, it is hoped, the state can build up sport fishing even before the two traditional Great Lakes fish—Atlantic salmon and lake trout—can be brought back to normal levels. Ultimately, managers hope the native species can keep up their own populations without man's help.

PROMOTING OUR ACADEMIC RESOURCES

New York State—its people, government, and academic institutions—had long neglected its fisheries resources. Few in the state had the academic expertise to carry out the complex population dynamics studies on which to base a management program.

To fill this void, Sea Grant has created a professorship for one of the upstate campuses. The Sea Grant professor will provide competency in population studies of Lake Ontario's resources and train graduate students to deal with fisheries management topics. Other Sea Grant professors have filled similar roles in shellfish biology and economics.

THE APPEAL OF THE SALMONID

Non-fishermen may ask, why salmonids? Fishermen like Joe Swift point out the virtues that make trout and salmon the most prized fish among anglers. The salmonids have mystique. They are sought for their beauty, fight, and flavor.

Of the salmonids, the chinook salmon is considered the true "glamour fish." They grow largest—up to 30 pounds in three years—and fight back most fiercely.

Because the salmonids are so attractive to fishermen, they are attractive to managers at New York State Department of Environmental Conservation. They have found salmonids easy to manage: most can be grown in hatcheries and added to the lake to augment the wild population.

The salmonids' elusive quality, too, adds to their allure. Local anglers have noticed salmonids are scarce every year during tourist season—June, July, and August.

When they can't catch salmonids, charterboat captains like Swift promote whatever other fish is around. They know enough about the other fish, their habits and habitats, to choose a more predictable species and pursue it. But captains claim their customers are most satisfied when they're catching salmonids. Charterboat captains and sportfishermen ask, where are the salmonids in the summer?

Jimmy Winter, fishery biologist at State University College at Fredonia, knows where they're not. Dr. Winter and his colleague, James Haynes at SUC at Brockport, have seen them nearshore in the spring where they've been released from hatcheries and then again in the fall when they return to spawn; but not in between. Winter assumes that during these times they are out far and deep in colder water. But since no one has ever tracked them before, these are only assumptions.

STALKING THE ELUSIVE SALMONID

The state's effort to attract tourists to the lake by stocking salmonids will have little impact if no one can catch them during tourist season. Presently, only a small fraction of stocked salmonids are caught by fishermen. Natural mortality and predators claim most of them.

To help fishermen catch more salmonids, Sea Grant planned an investigation to find their summer depths and locations. Winter had already tracked Lake Erie fish for an earlier Sea Grant study. Now he teamed up with Dr. Haynes to extend the tracking into Lake Ontario.

The salmonids have mystique. They are sought for their beauty, fight, and flavor.

In spring when salmonids swim nearer to shore, Haynes and Winter caught them, attached thumb-sized radio transmitters, then released them. By following the radio signals, they traced the movements of the fish. The unique frequency of each transmitter allowed them to follow the course of individual fish.

This approach, called radio-telemetry, offers a unique window through which to study fish habitat preference and behavior. It is a powerful tool which permits continuous monitoring of unseen animals. And it does not require sacrificing the fish or altering their behavior.

Some of the transmitters are also equipped with pressure gauges that show depth. Because the deeper the fish swim the harder it is to detect

"New York State has been blessed with Sea Grant. Numerous fishery-related studies funded by Sea Grant have provided valuable data on the needs of the fishery programs and their economic results. New York State's salmonid fishery program might best be compared to the story of the tortoise and the hare: we may eventually enjoy the peculiar distinction of starting out last and ending up first. Lake Ontario is becoming a fishermen's Mecca."

—Devvie Schleyer, vice president-treasurer of the Empire State/Lake Ontario Trout & Salmon Derby and member of the New York Sea Grant Recreational Advisory Committee, Rochester, NY.

their radio signals, Haynes and Winter are supplementing radio-telemetry information with vertical gill net surveys. These long nets snag the fish as they swim. By measuring how far down the net fish are ensnared, the scientists can determine how deeply they were swimming when caught.

Already, Haynes and Winter have traced an eastern migration in the spring and then a movement out toward deeper, colder waters as the summer sun warms waters. Already fishermen are following this pattern to find success with salmonids.

Haynes and Winter expect these techniques will tell them still more about where the salmonids go when the tourists come. A better understanding of salmonid movements would help anglers to predict when, where, and how to catch them. Michael Voiland, Sea Grant extension specialist in Brockport, says this information can boost fishing in the region and represent a substantial influx of tourist dollars.

Vertical gill nets, used together with radiotelemetry, help track salmonids' swimming depths and migration patterns.

LIFE AT THE BOTTOM

Salmonids aren't the only gamefish in town. Warm and cool water fish are significant sport fish, too. But a perennial problem for those who fish for them has been access. Terrain, facilities, and riparian rights often bar fishermen from the best fishing grounds.

Since many of these non-salmonid species are attracted to reefs, wrecks, and other natural bottom features, fishermen believe building artificial reefs can solve their access problem. If anglers can't get to the rich fishing grounds, they reason, an artificial reef can bring the fishing grounds to them.

Radio-telemetry offers a unique window through which to study fish habitat and behavior.

The west end of Lake Ontario has a nearly flat, sandy bottom. Fishermen there believe such a reef would enhance fishing. Ronald Scrudato and John Gannon from the State University College at Oswego are studying the lake's bottom to see which features attract sport fish and why. Knowing which kinds of natural reefs support the richest fisheries can tell us much of what we need to know to evaluate artificial reefs.

They confirmed that fish congregate at these reefs. They began by examining the lake's bottom to select experimental sites—on and off reefs. Then they surveyed which species lived at these sites. Their hypothesis: more fish gather around features like bedrock outcroppings, cobble-gravel shoals, and man-made breakwaters, than at sandy "control" sites. They surveyed fish on and off reefs at two depths. As they expected, they counted more fish—particularly smallmouth bass and white perch—around the reefs.

In studying Lake Ontario's reef communities, Dr. Gannon has also found that reefs with a greater variety of rock sizes support a greater variety of life. More nooks and crannies offer homes for the various plants and animals that feed a more diverse community of larger fish—and one that can support more anglers. Put simply, fish find more to eat around these reefs, so fishermen can find more fish there.

Drs. Scrudato and Gannon followed the reef food chain with their experiments. They looked specifically at bottom-dwelling plants and animals found on and off reefs. A ubiquitous, large, green plant, *Cladophora*, flourishes on shallow water reefs with firm substrates. Many bottom animals, including crustaceans called "crawfish," feed on this plant. Analyzing stomach contents of reef-dwelling smallmouth bass and white perch, the investigators found "crawfish" an important staple.

In addition to food, reefs also offer protection from predators. This seems particularly important during spawning for some species—for example, smallmouth bass.

If anglers can't get to the rich fishing grounds, an artificial reef can bring the fishing grounds to them.

The smallmouth bass can be an important sport fishery if anglers learn how and where to catch them, according to Voiland. Some fishing techniques are particularly effective in catching bass, but with the "disappearance" of the fish, these techniques have been forgotten. Voiland has been reintroducing these fishing methods, and anglers who adopt them report good catches.

ARTIFICIAL REEFS FROM COAL WASTE

The Lake Ontario region, like much of the rest of the nation, is returning to coal as an energy source. New York State Electric and Gas is building a coal-fired power plant on the lake at Somerset, NY. If environmentally safe, New York State and Canadian groups have suggested, reefs made from the plant's coal waste blocks might solve the plant's disposal problem and improve Lake Ontario's sport fishing at the same time. Sea Grant's involvement was a natural, given its history of using residuals from one area to solve a problem in another.

Sea Grant's Coastal Law Center at SUNY at Buffalo studied the legal aspects of using coal waste blocks, particularly as they relate to the Federal Ocean Dumping Act of 1972. Because coal waste blocks are "manufactured," they contend, they should not be considered waste. Therefore, building a reef with them would probably not be considered "dumping."

Artificial reefs had already been successfully built from coal waste blocks in the marine environment of the Atlantic. But before building any artificial reefs on the Great Lakes, sport fishing groups want to better understand how they would affect the environment, fish populations, and sport fishing in general. Scrudato and Gannon studied the environmental questions in the lab and in the field.

Whether coal wastes are toxic to organisms in the lab was their first concern. Their answer: probably not. They pulverized coal waste blocks to simulate worst-possible conditions and observed organisms living amid the material in the lab. Mortalities, they found, were not significant. This led them to believe that leaching of any harmful materials from the coal blocks was minimal and no threat to lab animals.

Their next investigation was in the field: they made a small reef of coal blocks and sent divers down to collect algae. They compared kinds of algae and their heavy metal contents that grew there with samples from a control reef made from cement blocks.

To turn this question from the theoretical to the practical, Scrudato and Gannon will build a pilot-scale reef from construction corings from the new lakeside coal-fired power plant. They will study colonization around the reef and try to match conditions from the most productive natural reefs. From this study, they hope to determine whether the plant, when functional, can use its coal waste blocks to build an artificial reef safe and suitable for fishing.

THE ST. LAWRENCE MUSKIE

The muskellunge had always been a popular St. Lawrence sport fish. But the hydroelectric dam built at Massena as part of the St. Lawrence Seaway Project in the 1950s changed the river, its ecosystem, and the abundance of muskie.

The dam destroyed 30 miles of rapids and turned thousands of acres of lowlands into quiet backwaters. Different plants and animals inhabit these changed waters. Fishermen say

A bigger, stronger river-dwelling muskie developed in the St. Lawrence and became the best muskie fishery in North America.

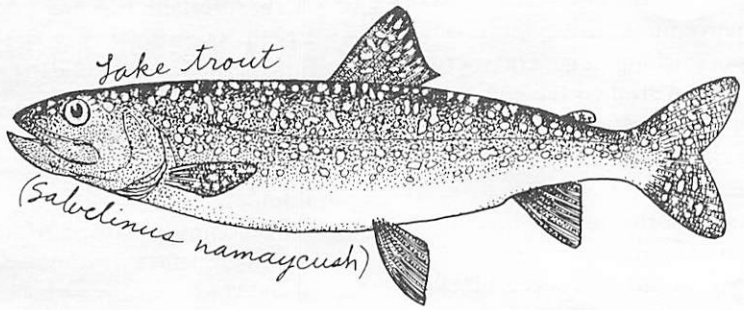
the muskie count in the river is down; northern pike is up.

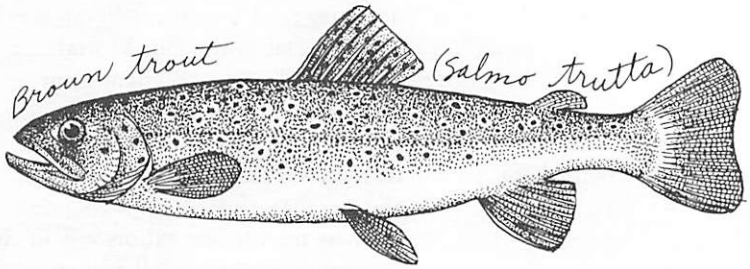
Local chambers of commerce have noted a decline in tourism and attributed this in part to decreased muskie fishing. To check whether this was so, New York Sea Grant Institute asked Fred Menz, economist from Clarkson College, to study the economic impacts of the St. Lawrence muskie. His study confirmed the importance of this fishery to the region and confirmed that the fishery was in trouble.

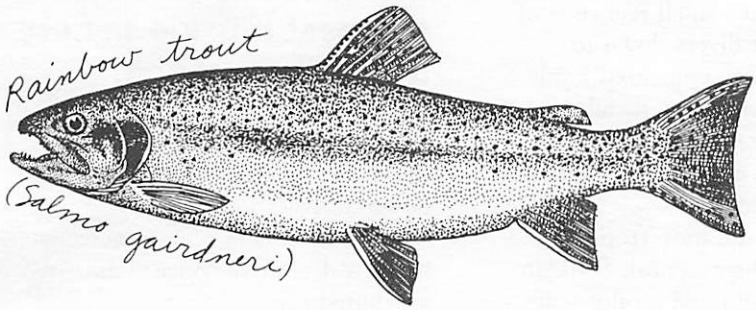
While all suspect that the power

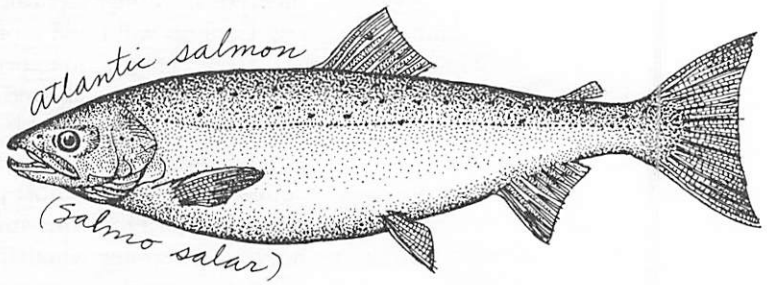
Biologists believe an artificial reef made from coal waste blocks will attract fish.

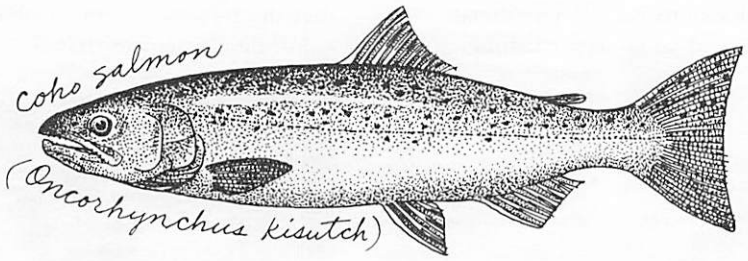
SALMONIDS
(Cold water fish)

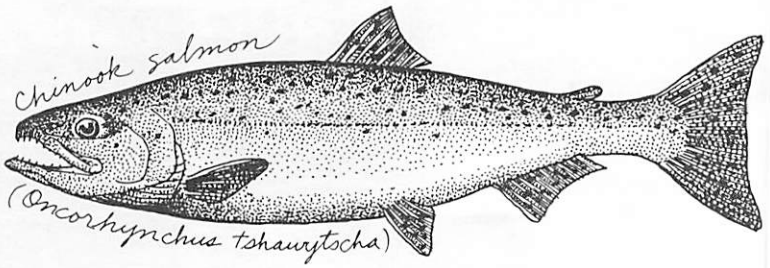




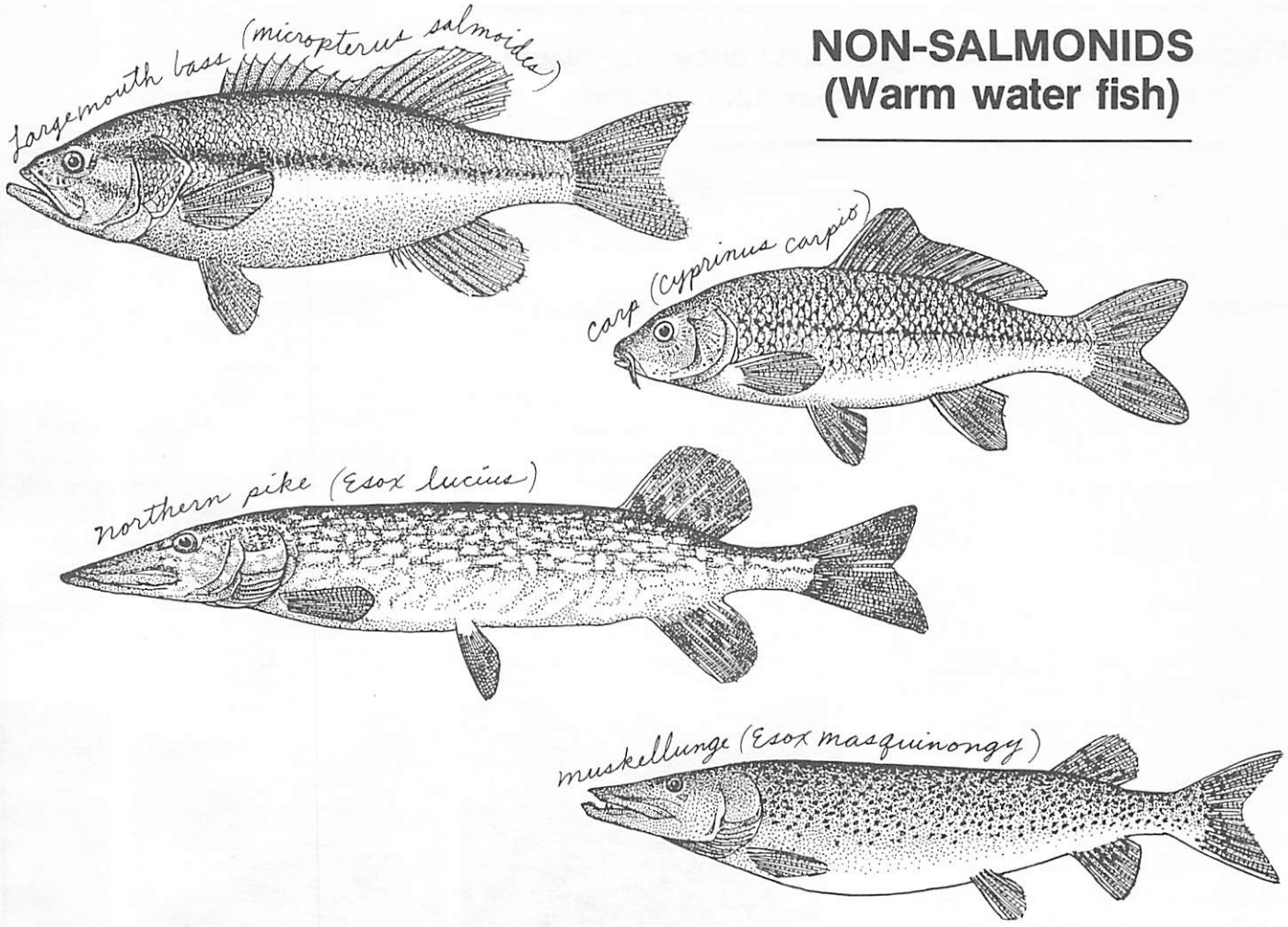




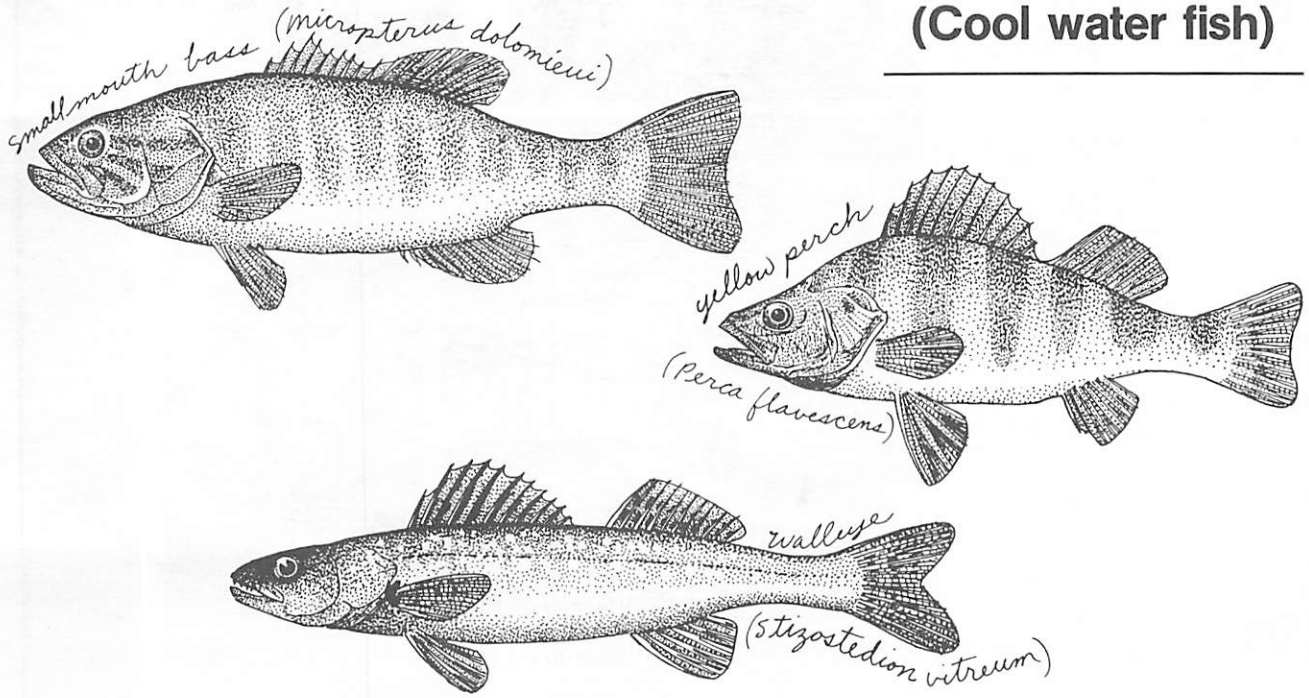




NON-SALMONIDS (Warm water fish)



NON-SALMONIDS (Cool water fish)



When dams cut the raging St. Lawrence into placid tracts, the muskies lost their spawning grounds.

projects disrupted the fishery, the extent of that disruption cannot be determined without baseline figures. To compile the figures necessary to manage the resource, Donald Osterberg from State University College at Potsdam surveyed the muskellunge in the St. Lawrence and studied their life history, movement, and spawning behavior.

Muskies generally live in lakes. But a bigger, stronger, river-dwelling subspecies developed in the St. Lawrence and became the best muskie fishery in North America, according to Dr. Osterberg. To adapt to its riverine environment, the St. Lawrence muskie developed different spawning behavior than its lake-dwelling brethren. But when dams cut the raging St. Lawrence into placid tracts—more like lakes—the muskies lost their spawning grounds.

Pike, on the other hand, spawn and thrive in these backwaters. Now even in the moving waters, Osterberg has found pike not muskies. Muskies have never competed successfully with pike, he points out. One reason is that the carnivorous pike hatch several weeks earlier and eat the muskies as soon as they're hatched.

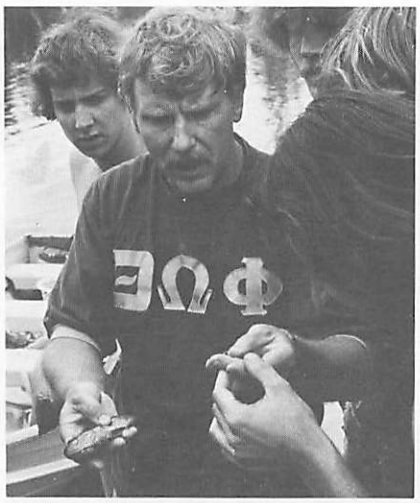
Osterberg will find out more about the muskie and its spawning behavior by locating existing spawning grounds and identifying the biological, chemical, and geophysical appeal to muskies; and by watching the fish at their natural spawning sites and again in captivity. From these investigations, he will better understand how spawning patterns have changed in the lower-river fish as a result of changes in the habitat.

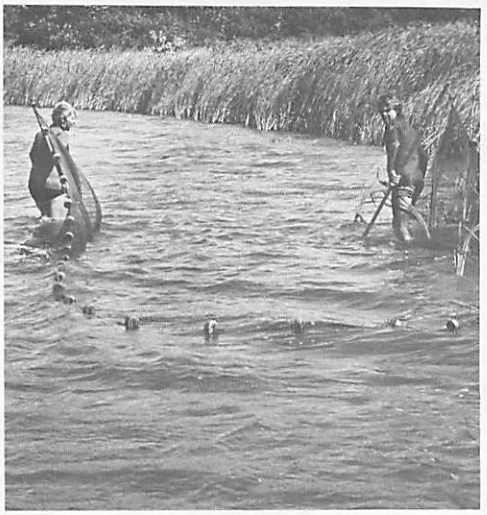
The next step will be gathering data on adult muskies by radio tracking. If he succeeds in collecting a full year's observations on the muskie, this will be a first. But his observations are not limited to the muskie. Osterberg has watched the young pike population, too, to better understand the muskies' chief competitor.

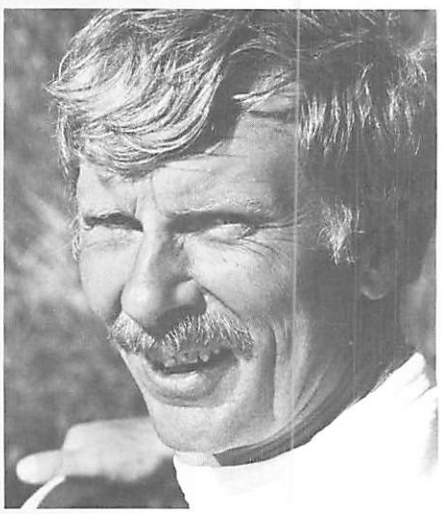
This study would not be as thorough, though, without help from the anglers. Osterberg has set up a hotline and has asked anglers to report the location, date, and size of muskies they've caught and then return the fish to the water unharmed. To help them to distinguish between the muskie and its cousin, the northern pike, he has run a public education program through the local press.

It may still be possible to keep the muskie fishery alive. New York State's Department of Environmental Conservation is considering a muskellunge management program that would include restocking muskies upstream from the power dam near Massena. Managers at the department are awaiting Dr. Osterberg's conclusions to determine whether there is still hope for the river muskie and how they can help it to survive.

Although New York has long neglected its fisheries, Sea Grant is helping the state make up for lost time. These Sea Grant-supported fishery experts on Lake Erie, Lake Ontario, and the St. Lawrence will continue to provide data and guidance to safeguard the relationship between the region's fish and fishermen—a relationship important to the region's environment and economy.







Donald Osterberg and his graduate students study the St. Lawrence muskellunge.

Related Sea Grant Projects

A. ARBEL, P. GRIER, A. VENKATESH. An Energy Impact Model for New York Water-Related Recreation Activities. The researchers are investigating the impact of decreasing energy availability and increasing energy costs in the tourism industry in New York's coastal zone. A model depicts the impact of increasing energy costs on prices, demand, capacity, use, and profit. Such information will be useful to government and businessmen who seek advice on adjusting recreational systems because of increased energy cost.

T.L. BROWN. Assessment of Great Lakes Nonsalmonid Sport Fishing Demand. While state and national efforts have been devoted to promoting salmonid sport fishing in the Great Lakes, far less attention has been paid to nonsalmonid species. This study is deriving regional demand curves and estimates of recreational fishing benefits for major nonsalmonid species; comparing harvest and catch rates of major species by region along the Great Lakes coast; and determining a priority list for species and regions which could be more heavily promoted, given specific policy objectives.

T.L. BROWN, H.B. BRUMSTEAD. Factors Affecting Tourism Potential on the Great Lakes Coast. By developing a methodology for assessing tourism development potential and applying it to regions along New York's Great Lakes coast, Brown hopes to provide coastal counties with insight into tourism as a primary and secondary industry important to the general economic development of the area.

J. CONRAD. Management Economics of New York's Marine Industries. Conrad is studying small businesses that constitute the bulk of the state's coastal commerce. This research should result in the development of programs that will assist the more effective conduct of the small businesses. The results should also provide Advisory Service staff with additional competency for carrying out effective educational programs for small businesses in shell and finfish wholesaling and retailing and with recreational industries.

D. COOK. An Assessment of Seven Waterfront Public Access Sites to Anticipate Their Potential for Development.

D. COOK. Public Access to the Urban Waterfront: A Behavioral Study to Establish Criteria for Development, Planning, and Design. As part of New York City's ambitious waterfront development program, Cook is investigating the use of public access areas through observation and interviews. Emphasis is on patterns of use and visitor evaluation of different kinds of waterfront sites. The results will provide behavioral information needed to establish criteria for the development of sites and determine appropriate design.

J.M. HAYNES, J.D. WINTER. Determination of Lake Ontario Salmonid Movement Patterns, Distribution, and Habitat Preferences Using Radio Telemetry. Haynes and Winter are examining summer movements of salmonids in Lake Ontario. They are determining seasonal and daily patterns of depth distribution, summer temperature preferences, and investigating local concentrations of salmonids by season. Such information will lead to greater understanding by fishery managers and anglers of the movements of salmonids stocked in the lake.

J. NICKUM. Intensive Culture of the Walleye Percidae: *Stizostedion Vitreum*. Nickum is developing diets and techniques for the intensive culture of the walleye and for evaluating the effects of various diets and rearing techniques on the growth, survival, and efficiency of using food of walleye fry and fingerlings. The research examines the effects of incubation and temperatures and uniform lighting in rearing units.

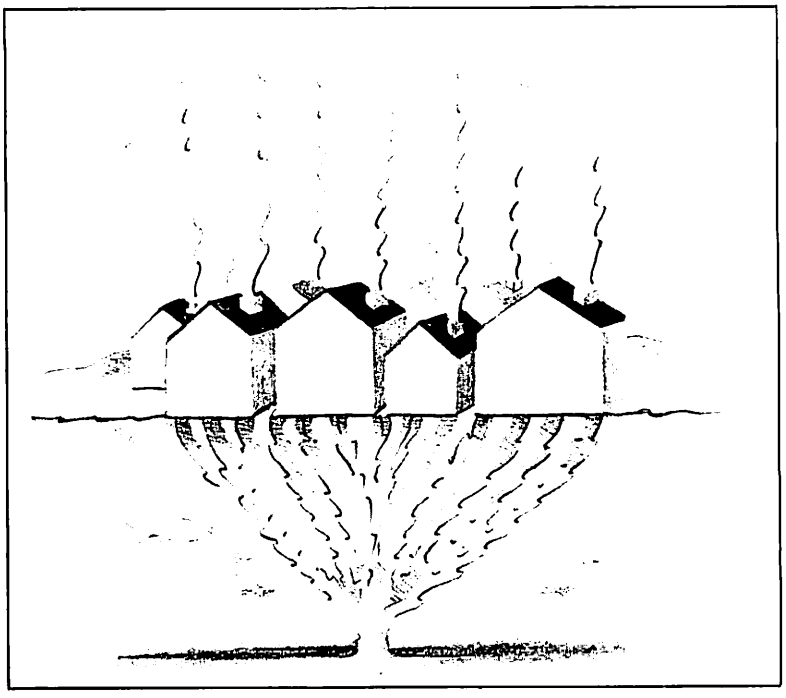
D.M. OSTERBERG. Characterization of Spawning Sites, Spawning and Post-Spawning Behavior of the Muskellunge in the International Portion of the St. Lawrence River. The "muskie" is one of the most sought-after, yet one of the least common gamefish in the fresh waters of New York. This study investigates the location and nature of the spawning sites for the species, determines spawning behavior, and reveals movements of larvae and juveniles. This study is in direct support of proposed management schemes for restoring the muskellunge to historic population levels.

R.J. SCRUDATO, J.E. GANNON. Assessment of Suitability of Coal Waste Blocks for Artificial Reefs in Lake Ontario. The researchers are studying the environmental suitability of wastes generated by coal-fired generating stations for construction of artificial reefs and other subaqueous structures in freshwater environments. This information will be useful to managers concerned with sportfishery development activities in the Great Lakes.

R.J. SCRUDATO, J.E. GANNON, R.A. ENGEL. Lake Ontario Bottom Features and Sportfishing Potential. Another warm water recreational fishery project, this study attempts to identify natural features and characteristics of known productive sportfishing sites along New York's Lake Ontario shoreline. The study is assessing the extent to which manmade breakwaters, cobble-gravel shoals, and bedrock outcroppings attract fish. Data generated will assess the potential for artificial reefs in New York's Great Lakes waters and be useful to the Department of Environmental Conservation.

D.F. SQUIRES. Population Dynamics of Lake Ontario Fishes. This project involves the selection of a qualified fisheries biologist to serve as a Sea Grant Professor in the population dynamics of Lake Ontario fisheries. Such an academic capability/interest in the state will be of direct support to state programs to enhance the sportfishing potential of the lake, and will provide needed campus support to extension activities related to the sportfisheries of the area.

Turning Green to Gold: Energy from Seaweed



It may sound like old-time alchemy, but scientists at State University of New York at Stony Brook can turn seaweed into methane, one of the cleanest, most efficient energy forms known. According to some predictions, by the 1990s the green stuff New York State uses to pay its heating bills may be seaweed.

As oil and gas supplies dwindled in the 1970s, the nation began looking for an alternative to petroleum for energy. Now one possibility is converting biomass—plant materials or animal wastes—into methane through bacterial digestion. And seaweed may be a suitable raw material for making methane.

Unlike drilled natural gas, biomass is renewable; seaweed grows readily in coastal waters worldwide. One east coast seaweed, *Laminaria*, can grow about an inch a day.

If we can cultivate seaweed successfully—and that's still a big question—the ocean offers low-cost space near most major cities and low-cost transportation. According to projections, Long Island Lighting Company could get methane equivalent to half the natural gas it needs from a farm 10 miles wide and 38 miles long, even with conservative production estimates.

SEAWEED LOVES NEW YORK

Marine biomass projects are under way on the east coast, west coast, and Gulf coast. New York Sea Grant has been collaborating—with Gas Research Institute, New York State Energy Research Development Authority, and the New York State Gas Group, including all seven investor-owned state gas utilities—on the east coast venture, where conditions look promising. The broad, shallow continental shelf along the east coast makes the Atlantic ideal for growing seaweed. The waters are rich with nutrients and turbulent enough to mix up nutrients to fertilize the crop.

In addition, the Atlantic waters of the northeast US are close to where needs are greatest. People of the heavily populated northeast have grown dependent on imported energy. Currently, New York State imports almost all of its petroleum from other states and nations, and pipes 87 percent of its natural gas from Texas and Louisiana.

This tract of the Atlantic has drawbacks, though. It is among the busiest waterways in the world, used heavily for commerce, recreation, fishing, and shipping. Its climate, too, poses challenges for would-be seaweed farmers: temperatures fluctuate widely and storms are frequent and violent.

FINDING THE BEST CANDIDATE

Whether seaweed can be successfully cultivated at all has been a first concern. If so, the group involved wants to find the best seaweed and learn how it can be grown and converted in a way that makes economic sense.

Sea Grant and General Electric collaborated on a study plan that included setting up criteria to choose a seaweed, calculating gas yields, studying chemical compositions, and comparing growth rates.

Sea Grant then put together a team of biologists to tackle problems of plant selection and growth. According to Boudewijn Brinkhuis, head of that team from Marine Sciences Research Center at SUNY at Stony Brook, the best approach would be a multiple species approach: a winter crop of *Laminaria* and a summer crop of *Gracilaria* or *Codium*.

By the 1990s, the green stuff New York State uses to pay its heating bills may be seaweed.

This plan was based on more than a year's experiments at the team's Flax Pond greenhouse—built for the purpose. There Dr. Brinkhuis and his colleagues compared about a dozen species of seaweed found in northeast waters—those they felt had the greatest potential for growth and methane conversion.

By culturing different species under different nutrient and water conditions in the greenhouse, the biologists got better acquainted with each biomass candidate:

Laminaria saccharina. Proposed as the winter crop, this plant is the only local species that grows well through the winter. It is the common kelp found and harvested commercially along the rocky coasts of New England and Canada, and a common source of polysaccharides used in foods and pharmaceuticals.

Gracilaria tikvahiae. The best candidate for summer crop, *Gracilaria* grows well from May through October and yields much methane. Biologists are concerned, however, that this seaweed might not grow well on the ropes they envision in their farm design and may prefer calmer waters.

Codium fragile. Another summer choice, this plant seeds itself and is easy to culture. But it is a porous plant that traps a good deal of water—93 percent by weight. This may pose a problem in converting it to methane. After removing the water, though, *Codium* produces much methane for its weight.

Other contenders useful as secondary crops are *Fucus vesiculosus* and *Agardhiella tenera. Fucus* has an unimpressive growth rate in the lab, but grows better in the field. Its chemistry is ideal for digestion, but its life cycle is not well suited for cultivation. *Agardhiella* is comparable to *Gracilaria.*

Fertilizing seaweed, the biologists found, would be unnecessary in the nearshore waters off New York—another plus for the region. When they added nutrients to different seaweed cultures in the greenhouse, they found all grew at about the same rates. When they measured nutrient levels in nearshore waters, they found them high enough to sustain this growth naturally without the added expense of fertilizing.

That different species produced different amounts of methane was no surprise. But the biologists found that different plants within the same species can differ in methane yield as well. By selecting the most gas-yielding strains within each chosen species, they think they can improve the already impressive production rates.

Still searching, the biology team will continue isolating, refining, and cultivating the best strains of the best candidates in the field. Their objective is to find the best combination of fastest growth and

In a "digester," bacteria break down the seaweed into methane and other inert gasses.

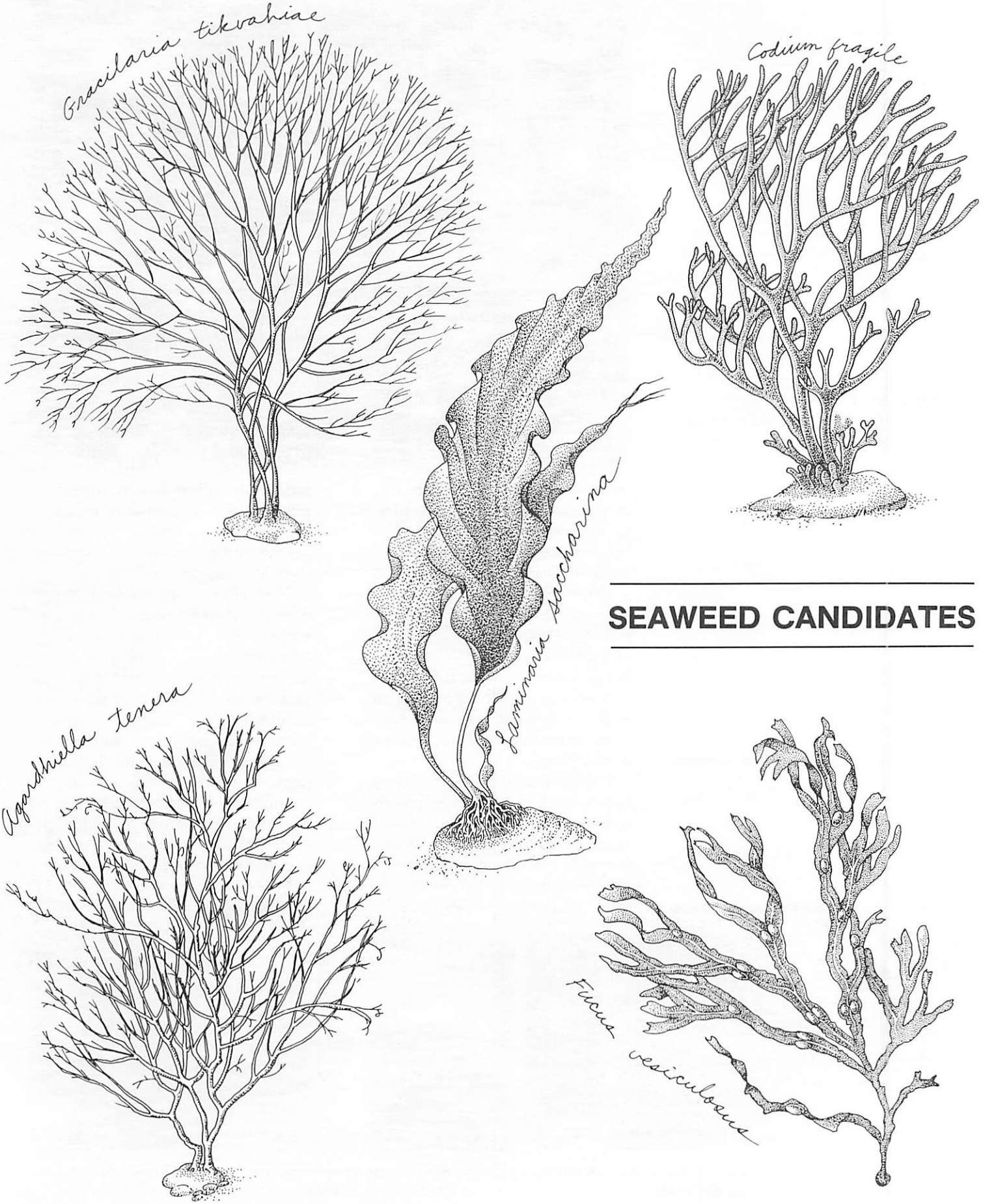
"In the marine biomass project, Sea Grant has shown itself to be a unique organization with the ability to pull in a large number of professionals with unique skills in marine engineering and science.

"Sea Grant's vast experience in marine research eliminated costly paper reviews and provided an integration of knowledge.

"Sea Grant has funneled information about past biomass efforts to the biologists, produced marine engineers capable of coming up with new engineering concepts in farm designs, and provided overall project integration for the marine biomass project in New York."

Kimon Bird, project manager, Gas Research Institute, Chicago, IL.

Researchers Bart Baca (left) and Dennis Hanisak (center) examine greenhouse specimens; biologist Boudewijn Brinkhuis (right) proposes a winter crop of Laminaria and a summer crop of Gracilaria or Codium.



SEAWEED CANDIDATES

greatest methane yields.

In a "digester," bacteria break down the seaweed into methane and other inert gases. To upgrade the mixture to "pipeline quality," the methane must be separated; it can then be piped to wherever it is needed.

ON THE FARM

At the conceptual other end of the pipeline, we need the right kind of farm. Engineers Herbert Herman and Ray Zatorski, also from SUNY at Stony Brook, have designed test farms to take the concept from lab to field. These designs were not firsts. For centuries, on simple, low-cost farms, the Chinese have grown seaweed for food. Project staff plan to import Chinese experts and adapt their designs to northern Atlantic conditions.

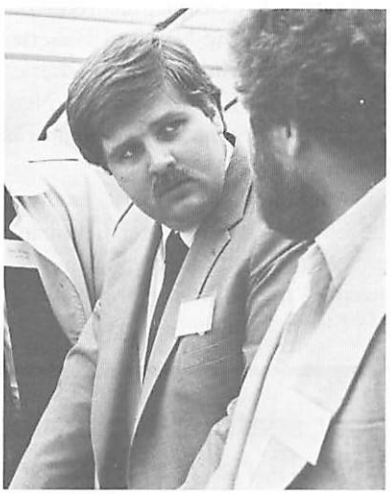
Herman and Zatorski's requirements for the next round of field tests are rigorous. They need a structure chemically and physically compatible with the plants, fixed fast to stay in place, and durable enough to survive the region's winds and storms. They must also consider how boats can get to their structure for harvest and maintenance. They want a design, too, that can put winds and waves to work circulating nutrients through the farm.

According to projections, a test structure meeting these requirements will be afloat in New York waters by 1983 to answer many of the biological questions. If successful, the next step will be a larger prototype structure to answer questions of design, energy efficiency, and economics of a seaweed farm.

Planners envision future seaweed farms as modular, floating structures, easy and inexpensive to build and maintain.

The collaborating groups have been thinking of farms on several scales: the utilities are interested in large farms—hundreds of square miles—that might be run by firms or public utilities and could supply enough energy for urban centers; another possibility would be smaller, privately owned farms closer to shore that could make enough methane for local commerce or industry. At any scale, planners envision future farms as modular, floating structures, easy and inexpensive to build and maintain.

Sea Grant project coordinators have also envisioned that such a structure could double as a farm for growing shellfish or finfish. Clearly, if the same farm can grow several marketable crops in the same space, it becomes more cost effective.



Turning seaweed into energy depends on the work of biologists and engineers. Boudewijn Brinkhuis (left), biologist, shows seaweed samples to New York Sea Grant Director Donald Squires; Ray Zatorski (right), project engineer, explains farm design requirements.

A MULTIDISCIPLINARY PROBLEM

While biology, chemistry, and engineering are major considerations, they are not the only ones. The social and political problems must still be addressed—questions of allocation of resources, underwater land ownership, and surface rights.

Robert Reis and Milton Kaplan, professors of law from SUNY at Buffalo, researched underwater land ownership, rights, and regulations starting with the web of colonial patents that govern nearshore waters.

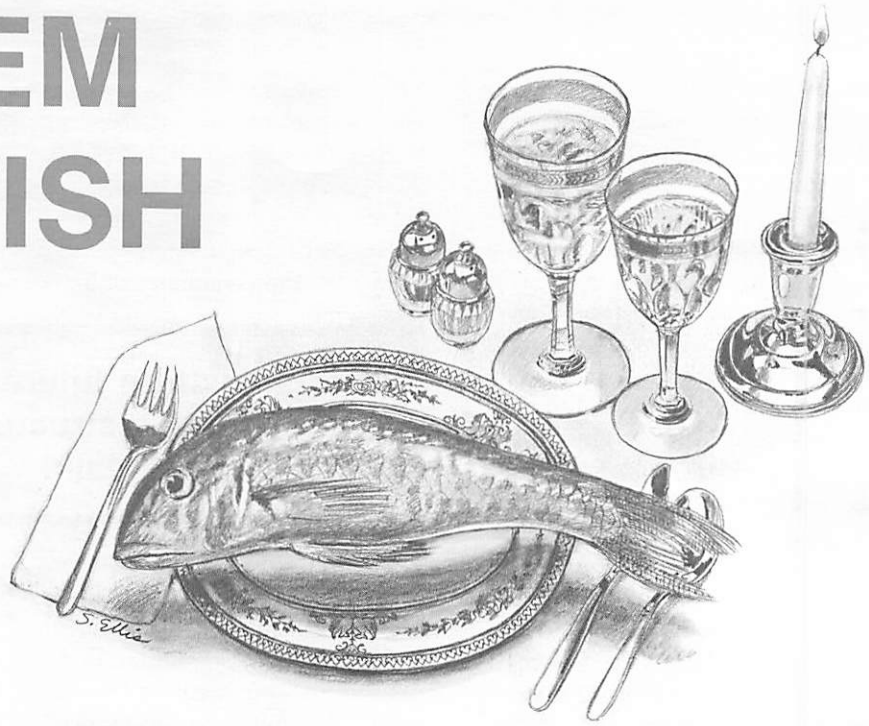
At the request of the Sea Grant Institute, DeWitt Davies, senior marine planner from the Long Island Regional Planning Board, looked more specifically at biological field test sites. By interviewing fishermen, boaters, and others, he mapped coastal water uses adjacent to Long Island and proposed locations.

Laura McKay, assistant project manager from Sea Grant, describes the biomass project as a multi-disciplinary problem in which many more questions remain—scientific questions; practical and economic questions; legal, social, and policy questions.

Depending on whom you talk to, McKay observes, they'll tell you the next round of research is in *their* field. Much work remains in all these fields before we can commercially turn seaweed into energy. We'll need to know how to grow and harvest the crop, how to store it after harvest, how to digest it, and where to grow it safely with least competition from other water uses.

McKay and others involved with the Sea Grant project are heartened, though, by the progress of the past few years—progress that suggests that heating our cities with methane from seaweed is more than a pipedream.

LET THEM EAT FISH



Wastes and shortages may seem like opposite problems, yet they coexist in the food industry. But new seafood technologies at Cornell University can cut down on both wastes and shortages by making fish more versatile, hence more marketable. These processing technologies can mean more food for consumers and more income for fishermen, processors, and retailers.

Imagine keeping fresh fish fresh—whole, dressed, or ground like hamburger—for three weeks or longer. This is the vision food scientist Joe Regenstein has had since he became involved in seafood research funded by Sea Grant—a vision that draws closer to reality.

Since 1974 Dr. Regenstein has been one of the team of Sea Grant-supported food science researchers at Cornell helping to develop what is fast becoming a major center for seafood technology in the northeast. The group specializes in applied research on the use of fish ranging from new product development, market testing, and shelf-life extension to waste recovery and treatment.

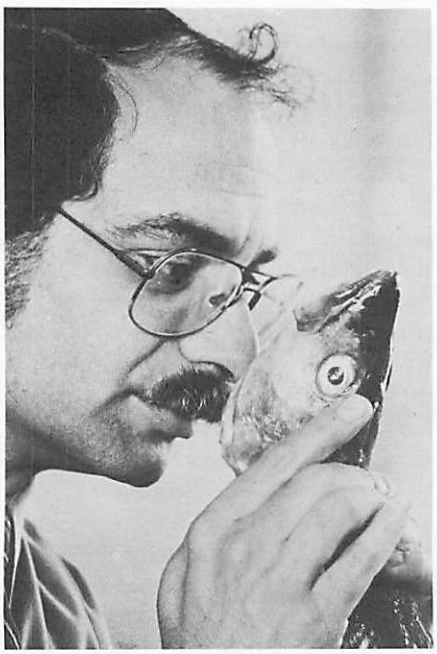


Photo: Herb Swanson, *Daily Democrat*, Dover, N.H.

Joe Regenstein is studying ways to extend the shelf-life of fresh fish.

Before Sea Grant turned scientists toward fish products, few university food scientists worked with fish. Now, however, through Sea Grant's effort to engage university scientists in ocean-oriented research, seafood technology centers such as Cornell's are emerging on both the east and west coasts. Private nonprofit organizations and industry are beginning to take notice. Cornell's program, for example, has received backing from the National Fisheries Institute, the Mid-Atlantic Fisheries Development Foundation, the New England Fisheries Development Task Force, Monsanto Industrial Chemicals, Sea-Land Services, Inc., the Shelter Island Oyster Company, and Airbox Ltd. in Stockholm, Sweden, in addition to the New York Sea Grant Institute.

At Cornell, the Sea Grant-sponsored team got its start under the leadership of Robert Baker, chairman of the Department of Poultry and Avian Sciences. Key members include Regenstein, Robert Zall, and John Kinsella, all from Food Science; Dana Goodrich from the Department of Agricultural Economics; and Glenna Kophen, nutrition specialist. With each engaged in a different specialization, the team has a broad base of expertise.

The newest advance being investigated at Cornell—which, if proved feasible for commercial use, would change the entire fish packaging industry—is Regenstein's work on keeping fish fresh for three weeks or longer.

Working with fish transported from Long Island to Cornell in upstate New York, Regenstein has grown keenly aware of the need to extend the freshness, or "shelf-life," of fish products. A few years ago

New seafood technologies cut down on both wastes and shortages...This can mean more food for consumers and more income for fishermen, processors, and retailers.

with the help of Michael Fey, a Cornell graduate student, Regenstein studied storing fish in a "modified atmosphere," that is, an atmosphere containing a special mixture of gases such as carbon dioxide, oxygen, and nitrogen. In these first attempts, he used relatively simple gas-impermeable bags and containers. The study also tested the combined effects of a modified atmosphere and potassium sorbate-treated ice. In this method, melting ice, containing potassium sorbate, bathes the fish continuously, thereby suppressing any buildup of bacteria missed by the modified atmosphere.

Since then, Regenstein has further refined this technique. Last year he continued his work at the Torry Fish Research Laboratory in Aberdeen, Scotland, learning from European experience with fish-evaluation methods and packaging materials. Now, back at Cornell, he is working out the technical details of using rigid-sided containers for individual portions of fish and larger boxes for shipping bulk quantities of fish.

The impact of this technology is far-reaching. According to Regenstein's predictions, these methods will make it possible for supermarkets throughout the country to carry fresh fish, which most consumers prefer. They will also make it possible to ship fresh fish in bulk to both domestic processors and foreigh markets. In the long run, they might eliminate the need to freeze fish. Clearly, this would result in significant savings in cost, energy, and labor.

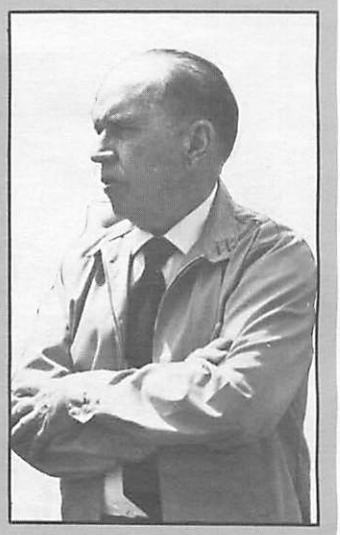
Imagine keeping fish fresh for three weeks or longer.

Best-known of the group for his work on new fish products is Robert Baker. Originally engaged in developing new poultry products, Dr. Baker shifted some of his attention to fish in the early 1970's. Backed by Sea Grant funds, Baker, with Regenstein's help, researched deboning, a process that separates the fish meat from fish bones—considered undesirable by most consumers. This process yields a minced, boneless product much like hamburger. From this minced fish, Baker and Regenstein have gone on to develop chowders, breaded fish crispies, and frozen and canned minced fish from underused species like red hake, whiting, white sucker, sea robin, and porgy. Some of these products have been further test marketed by Dana Goodrich of Cornell's Department of Agricultural Economics.

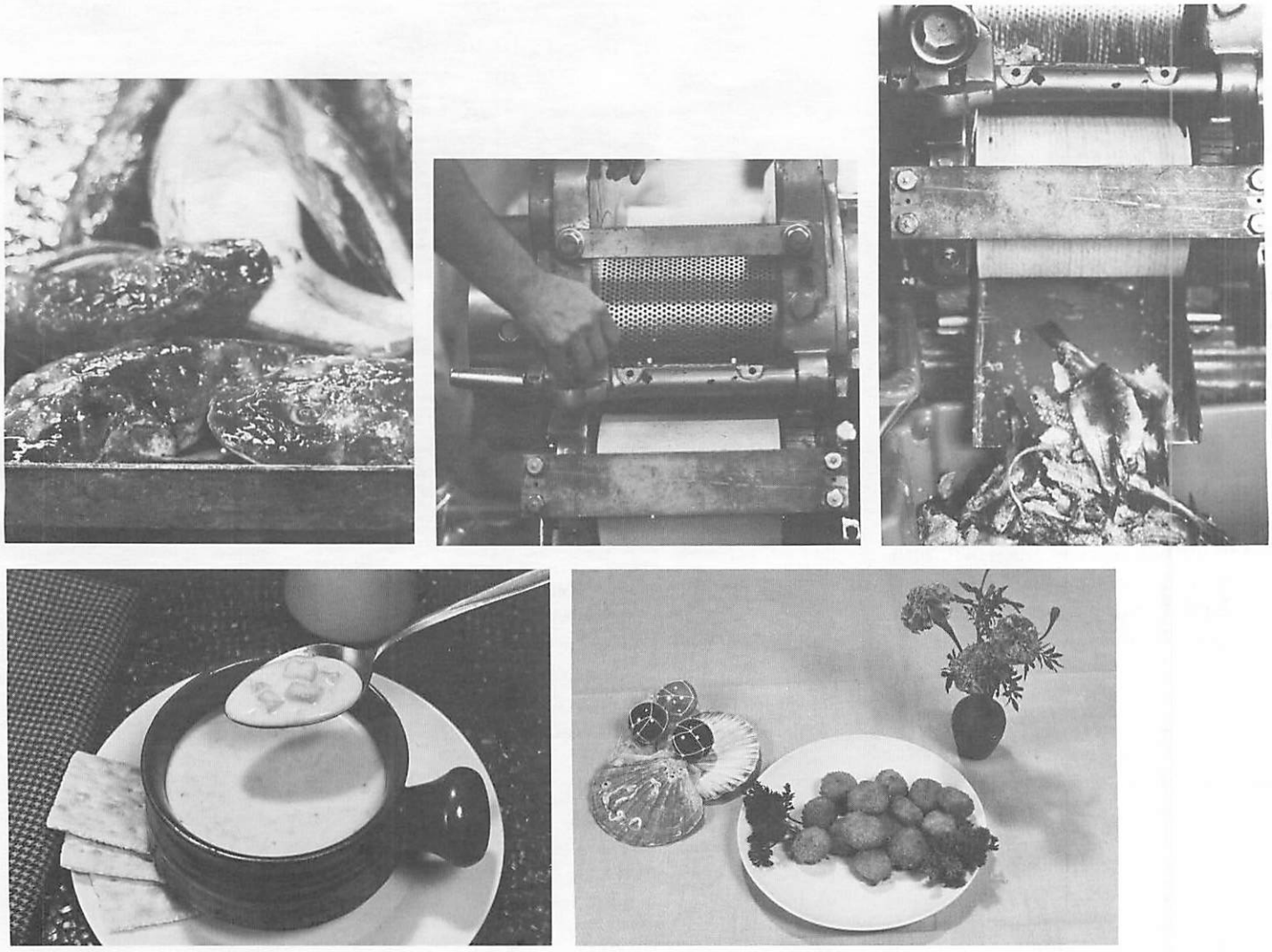
Presently, Baker and Regenstein are working with representatives of a fish processing firm on Long Island and a canning company in Connecticut to develop a canned tomato-fish sauce that can be used in tacos, spaghetti, pizza, lasagna, chili, and sloppy jonahs, a fish version of sloppy joes. Their goal is to have the sauce produced with a commercial label, tested in supermarkets in upstate New York, and, if successful, produced and marketed thereafter by the two companies. Baker and Regenstein are working out research,

"Sea Grant helped us to develop a clam juice from the clam wash water. This has saved us a considerable amount on labor and energy. Now we can produce clam juice without having to cook the clams. Reclamation is something most companies are looking at now. When you're in a business like ours—where the margin of profit is so small—these kinds of savings are very important."

John Plock, Sr., president
Shelter Island Oyster Company
Greenport, NY.



Robert Zall (far left), Lamartine Hood (far right), and their research team have developed edible seafood products from processing by-products.



A deboning machine can turn underused fish into tasty soups and other seafood products.

testing, canning, and labeling the new product with funding from the Mid-Atlantic Fisheries Development Foundation.

Baker has also researched the effect of heat on fish muscle and the use of retort pouches as an alternative to traditional canning methods. Regenstein has studied cold storage changes in frozen fish and the use of fish in kosher foods. With his wife Carrie, he has coauthored a Sea Grant publication entitled *Old Laws in a New Market: The Kosher Dietary Laws for Seafood Processors*. A second publication on kosher minced fish cooking is in preparation.

Robert Zall and Lamartine Hood have been engaged in the recovery of meat from oyster shells after shucking, and in the production of broth from the protein-rich wash water that rinses minced clams. One Long Island firm, Shelter Island Oyster Company, now uses their method to make a commercially successful clam broth. Other research by Zall concerns extending shelf-life by quickly dipping the fish in hot water.

University scientists have been "transferring technology" to the seafood industry.

John Kinsella's work deals with the biochemistry of fish. He is examining the effect of deep fat frying on the lipids in fish and the oxidation of their polyunsaturated lipids. These compounds have been of health concern, as some studies suggest they have cardiovascular effects. Some consumer groups favor more complete nutritional labeling of foods; these studies would be useful for more complete labeling of fish products.

In addition to conducting research and working with students, the five seafood scientists maintain close ties with Sea Grant's extension staff. These activities include participating in seafood nutrition workshops and meetings for fishermen. Members have also been working with Donald

Squires, director of the New York Sea Grant Institute, in planning a seafood laboratory at Kingsborough Community College in Brooklyn as a cooperative activity of the City University of New York, Cornell University, and New York Sea Grant. If funding for the lab is passed by the New York State legislature, the seafood technology team will share responsibility in making it a center for seafood research, extension, equipment demonstrations, and training of seafood workers for the northeast. The waterfront location and docking facilities at the proposed site offer the team direct access to a continuous supply of freshly caught fish of many species.

Regenstein expects that in the future the team will be involved with new, economical products from minced fish; improved packaging and extended shelf-life; greater cooperation in developing new products with the commercial seafood industry; better use of processing wastes; and increased ties with the seafood laboratory in Gloucester, Massachusetts.

Through Sea Grant's support, university scientists have been "transferring technology" to the seafood industry. This work will benefit American consumers, along with fishermen, processors, and retailers.

A few years ago, turning boney fish into a bone-free product was just an idea. Now it's a reality. Fish that stays fresh for three weeks may be the next development. In an age where substantial wastes coexist with food shortages, such breakthroughs can't come too soon.

Related Sea Grant Projects

R.C. BAKER, J.M. REGENSTEIN. Development of Convenience Products from Underutilized Fish. Baker and Regenstein are working to convert underutilized or waste products and possible pollutants into nutritious and economic human food. They are developing the food from mechanically deboned (minced) fish, developing recipes, and market testing the products. By salvaging these underutilized species of fish, Baker and Regenstein hope to provide another source of valuable high quality protein, reduce wastes and contaminants, and offer marine and Great Lakes fishermen an opportunity for added income.

R.C. BAKER, J.M. REGENSTEIN. The Shelf-Life Extension of Underutilized Fish. The researchers are converting fish that are underutilized or generally wasted into nutritious, palatable, and economical food products. The factors affecting the water-holding capacity of fish flesh are under study as are the composition and effect of bones in fish on functionality, flavor, and texture of processed fish products.

D.C. GOODRICH. Market Structure and New Product Potential for New York Finfish and Shellfish Industries. In an effort to increase the economic data base relating to New York State fisheries, Goodrich is gathering economic information for a description of the present finfish and shellfish marketing sectors of New York State. Goodrich is determining retail and institutional sales responses to new seafood products manufactured from low value fishery by-products and underutilized species developed at Cornell. This information will provide the data necessary for recommendations to improve the fishing industry.

L.F. HOOD, R. ZALL. Recovery and Utilization of Protein and Other Nutrients from Seafood Processing Wastes. Shellfish and finfish processors face increasing problems of waste handling and disposal, plant sanitation, raw material availability and cost, and production efficiency. Hood and Zall are investigating and developing methods for recovering protein, other nutrients, and flavor materials from fish processing wastes and are attempting to convert them to food ingredients or marketable food products.

J.E. KINSELLA, R.C. BAKER. Lipids in Fish Products: Effects on Quality and Flavor. Lipids affect fish product quality. In order to provide new techniques for improving the stability and ultimate quality of market fish and fish products, Kinsella is studying the changes in lipids during processing and storage and investigating the nature of the interactions between off-flavor compounds and proteins. The information on lipid composition will be a key element in the successful development of stable, high quality products from aquaculture.

J.E. KINSELLA. Nutrients, Nutritional Value, and Quality of Fish and Seafoods. Kinsella is studying the fatty acid, sterol, amino acid, and mineral composition of fish fillets and processed products. He is also investigating the role of lipids in off-flavor development and binding of carbonyls to fish. Such information is necessary for the effective promotion of seafood as a high quality, nutritious food source.

J.M. REGENSTEIN. The Shelf-Life Extension of Underutilized Fish. Regenstein is seeking methods of improving the shelf-life of fish through use of modified atmosphere, low temperature, and/or additives. Development of such technologies will allow long-distance shipment of fish in a variety of forms, helping to meet the large export demand for this product.

P.J. VANDEMARK, E.A. DELWICHE. Detection of Microbial Growth and Activity in Seafood and Seafood Products. Because of the high perishability of seafoods and the necessity to move fresh fish and shellfish rapidly to market, quality control in this industry is dependent on the availability of rapid and precise measurements of microbial quality which are practical for use during harvesting, processing, and marketing. VenDemark and Delwiche are investigating the use of electrical impedance and other techniques for the rapid determination of the microbial and sanitary quality of seafoods and seafood products. They are also investigating the development and effect of procedures to repair or resuscitate indicator organisms.

R. WARNER. Evaluation of Fish Protein in Milk Replacers for Calves.

Of Holes and Spoils:

Two-for-One in New York Harbor

One solution for one problem is ordinarily a good ratio. But in a project now under way in the Lower Bay of New York Harbor, scientists are trying to do twice as well as that.

If they succeed, they'll have taken a major step toward eliminating difficulties caused by mined holes on the floor of the Lower Bay and, potentially, many other bays. At the same time, they'll have found a way to dispose of contaminated spoils from harbor dredging.

MINED HOLES: THE FIRST PROBLEM

Traditionally, sand and gravel—used for basic construction material like aggregate and fill—has been mined onshore. But in recent decades, zoning restrictions and the high costs of overland transport have made the terrestrial supply more and more problematic.

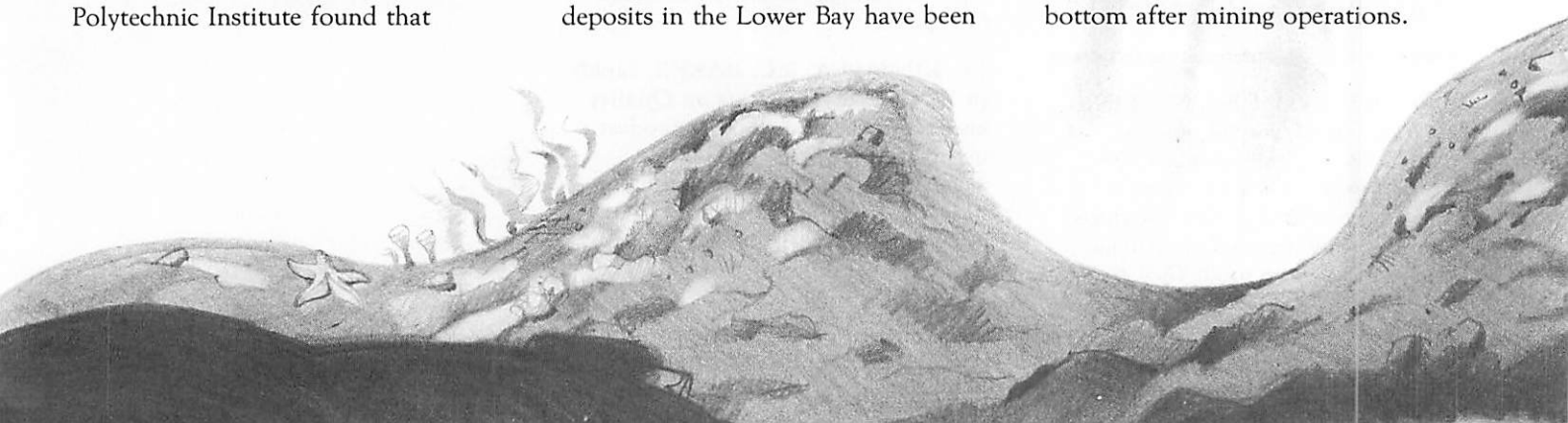
It followed naturally to look to offshore sources. Fortunately, the nearshore and offshore areas of the mid-Atlantic region are lined with a deep layer of sand and gravel.

New York Sea Grant has led the way in defining the economic advantages of the offshore option. In research supported by Sea Grant, Dr. William A. Wallace of Rensselaer Polytechnic Institute found that offshore mining methods are more efficient—hence the product cheaper—than for onshore sand and gravel mining. Also, the nearness of offshore deposits to cities and the comparative efficiency of barge loading make transport more convenient and affordable.

The New York State Department of Transportation has set standards for grain size and homogeneity that differentiate between material used for fill or for building. For some time, the Lower Bay of New York Harbor has been exploited for fill material, but not for building material (known as aggregate). In fact, New York City has added about 64 square miles of land to its five boroughs since 1963, and sand deposits in the Lower Bay have been the main source of fill for that expansion.

Yet additional Sea Grant-supported work has found that the Lower Bay is also a great potential source of aggregate. On the supply side, Dr. David Carlisle of RPI has reported high volumes of aggregate-level material in the bay; on the demand side, Dr. Wallace has projected continuing, long-range needs for aggregate in the Greater New York Metropolitan Area—with demand ranging from 8.5 million to 10.7 million tons annually in the 1980s and 1990s.

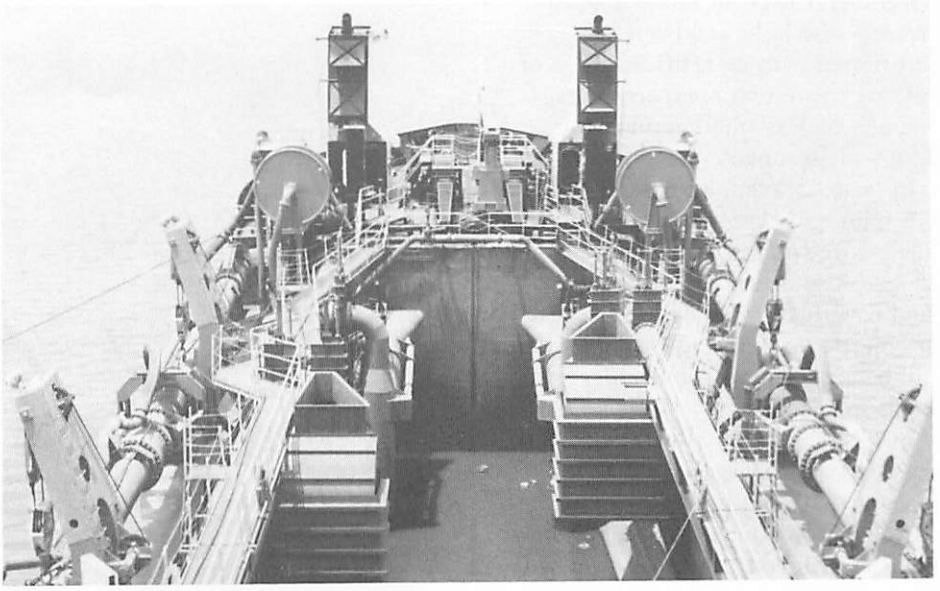
Offshore mining, however, has been associated with some environmental problems. These essentially begin with the holes left on the bottom after mining operations.



Mined holes alter a water body's bathymetry—its bottom configuration; and altered bathymetry is thought to lead to impacts on water circulation, wave action, water quality, and aquatic life.

In 1973, when sand mining in the Lower Bay was restricted, the New York State Office of General Services (OGS) called New York Sea Grant's attention to the problem of mined holes and the bay environment. Sea Grant, in turn, presented the problem to scientists at the Marine Sciences Research Center, SUNY at Stony Brook; over the next several years, Sea Grant and the OGS supported MSRC faculty in a wide range of research on mined holes and their effects:

- Dr. Boudewijn Brinkhuis found that mined holes accumulate organic matter which uses up the oxygen supply in the water—meaning less oxygen for aquatic life, and, possibly, lowered species abundances.
- Drs. Kuo-Chuin Wong and R.E. Wilson found that mined holes alter tidal range, possibly worsening coastal erosion.
- Dr. Blair Kinsman, MSCR Director J.R. Schubel, and others found that they also affect the direction of waves, thereby also possibly aggravating erosion.



The Hopper dredge is primarily used for maintaining large federal navigation waterways such as Ambrose Channel in New York Harbor.

DREDGE SPOILS: THE SECOND PROBLEM

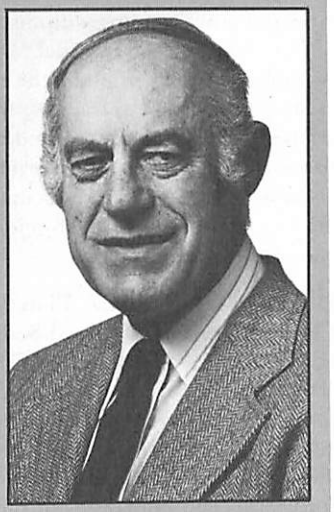
The US Army Corps of Engineers must dredge federal waterways in New York City to keep them open for shipping. The mud displaced during dredging is known as dredge spoils. Some dredge spoils from New York Harbor (about 20 percent) are regarded as contaminated because they do not meet federal criteria for ocean dumping. According to the Environmental Protection Agency, these spoils cannot be dumped in the ocean. But if channels are to be dredged and cargo ships crucial to the city's economy are to get through, dredge spoils will have to go somewhere.

A WAY OUT OF THE MORASS

One idea for solving the mined-holes problem has been to fill them in. And one idea for solving the dredge-spoils problem has been to bury them in mined holes. In other words, it may be possible to solve both problems at once.

A research team lead by Dr. Henry Bokuniewicz, an expert on spoil and waste disposal at MSRC, and sponsored cooperatively by New York Sea Grant and the US Army Corps of Engineers as part of the Corps's Dredged Material Incremental Management Plan, is working with this two-in-one methodology in the Lower Bay. A mined hole of about 4 to 5 million cubic yards has been chosen for the honors. As of

"I was told back in 1974 that the sand mining program would be terminated because of environmental concerns. But based on Sea Grant's published studies, the EPA rescinded the prohibition and authorized the DEC to continue its sand mining. As our economy improves, suppliers will be looking for an offshore source of sand and gravel. We have it in the Lower Harbor.



"The disposal project went hand-in-hand with sand mining. Sea Grant and the NYS Office of General Services started this study. Now the Corps has picked up the idea. This project offers relief for some serious needs: a place to bury dredged materials, a way to restore the bottom contour, and a source of income for the state."

James Marotta, dredging and operations specialist, New York State Office of General Services, Albany, NY.

December 1981—in Phase 1 of the project—the hole had been partitioned with an artificial ridge of sand to create two compartments, one of which is small enough for pilot-scale testing.

In Phase 2, planned for fall 1982, this pilot-scale compartment is to be filled with dredged mud. Although plans to use officially contaminated mud have had to be altered because of objections, this load of mud will still be representative of dredge spoils in general.

In Phase 3, the goal will be to cap the deposited dredge spoils with a layer of sand that would prevent escape of contaminated particles into the water. In addition, this layer will be slightly depressed to create a topography attractive to fish populations—a possible fringe benefit of this procedure that has only recently been suggested.

After Phase 3, the surrounding bay environment will be monitored for effects on water, plants, and animals.

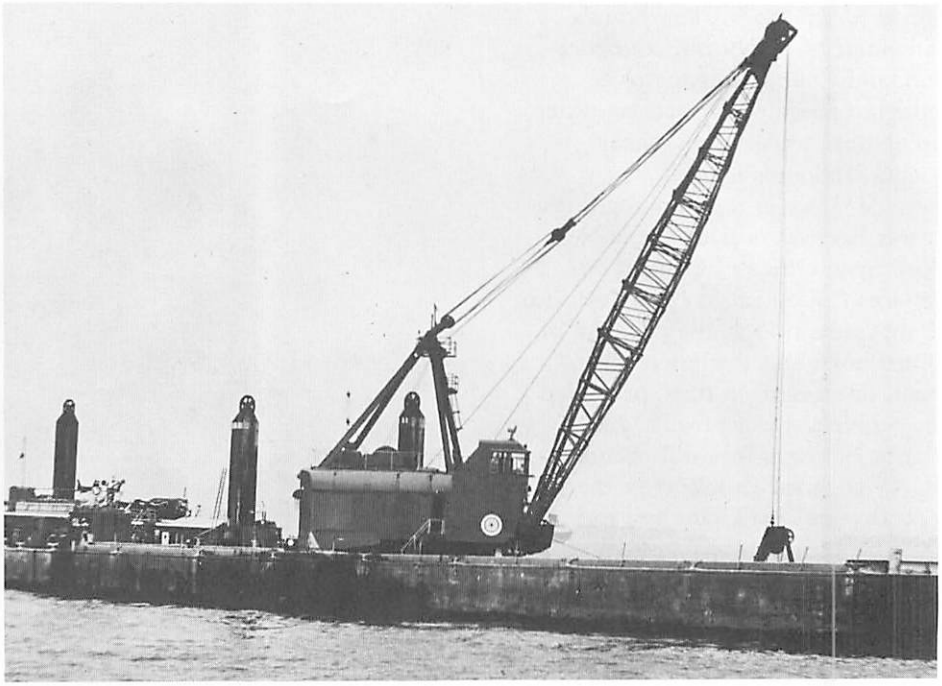
THE OUTLOOK

If mined holes can be filled and covered effectively, then it may be possible to minimize environmental impacts.

If dredge spoils can be buried beneath the water rather than dispersed throughout it, then channels could be dredged and ocean commerce could proceed—unhampered by the dredge-spoils problem.

Contaminated spoils from harbor dredging and holes from offshore mining are two problems facing scientists. Now it may be possible to solve both problems at once.

Mined holes and dredge spoils are problems not only for New York City but for other ports as well. Thus it is no surprise that this project has received both regional and national attention.



Clamshell dredge: disposal of dredged materials in an environmentally safe manner remains a critical challenge.

Related Sea Grant Projects

H.J. BOKUNIEWICZ. Physical Processes Influencing the Containment of Dredged Sediment in Mined Pits in New York Harbor. The project examines the potential for combining sand and gravel mining with disposal of fine-grained dredged material. Bokuniewicz is determining the role of existing mined pits in trapping fine-grained material and associated contaminants and, in a series of experimental disposal operations, he is documenting the fate of dredged material released over one of these areas.

H.J. BOKUNIEWICZ. Plan for the Containment of Dredged Sediments in Submarine Borrow Pits. This project involves formulation of a plan to control the disposal of dredged sediment into submarine borrow pits, including the scheduling of disposal operations, the constraints and limitations of the procedures, and the monitoring scheme necessary to evaluate the environmental effects of the disposals.

H.J. BOKUNIEWICZ, J.R. SCHUBEL. Containment of Dredged Sediment under the Floor of the Lower Bay of New York Harbor. The investigators are determining the physical fate of dredged material deposited in subaqueous pits, the feasibility of capping such deposits with coarser grained material, and short- and long-term environmental effects of this disposal method. This project is being done in conjunction with the dredged material management plan for the Port of New York sponsored by the US Army Corps of Engineers.

B.H. BRINKHUIS. Site-Specific Faunal Surveys of Potential Sand and Gravel Mining Beds in the Lower Bay, New York Harbor. Brinkhuis is carrying out detailed investigations of benthic invertebrate and fish assemblages in potential sites for offshore mining in the Lower Bay. He is estimating the commercial value of these resources as well as the impact mining operations may have.

B. KINSMAN. Evaluation of Changes in Wave Regime on Shore Erosion, Particularly on Staten Island, New York. Kinsman is identifying wave energy distribution along the coastline of New York's Lower Bay, determining how this would be affected by changes in bathymetry produced by sand mining, and investigating whether serious shore erosion problems could be alleviated through dredging and/or filling. The data will be used by the Office of General Services

and the Department of Environmental Conservation in developing a sand mining program in the New York metropolitan area.

W.A. WALLACE. The Impact of Offshore Sand and Gravel Mining on the Availability and Costs of Construction Minerals in Greater New York Metropolitan Area. The objective of this on-going project is to determine the economic impact on mineral aggregate production and distribution of offshore mining and the effect on consumer expenditures, particularly in the New York metropolitan area.

W.M. WISE. Computer Simulation Studies on the Lower Bay, New York Harbor. This project applies predictive environmental models (one for tidal-elevation/currents and one for wave refraction) to hypothetical mining strategies in the Lower Bay of New York Harbor. These models are useful planning tools for state and local officials in answering critical questions about the nature, size, and location of offshore mining in the Lower Bay.

Additional Projects

H.J. BOKUNIEWICZ. Episodic Bluff Erosion on the North Shore of Long Island. This research studies the effects of catastrophic bluff erosion on the north shore of Long Island in order to determine the frequency of occurrence, extent and persistence of intermittent erosional features, and the capacity of these features to supply sediment into the coastal sedimentary system. The information gathered will help land-use planners to make more accurate "worst-case" estimates of bluff recession on the north shore.

H. HERMAN. The Construction and Repair of Seawater Structures through Mineral Accretion. Herman is developing a seawater structures repair system using mineral accretion by causing an electric current to flow between two electrodes immersed in sea water. Such a system may provide a relatively low-cost method for preserving and restoring failed structures.

F.H. KULHAWY, P.L.-F. LIU. Development of a Coastal Structures Construction Manual. When complete, the *Coastal Structures Construction Manual* will give technical and practical information for waterfront contractors, consultant and municipal engineers, and planning and regulatory agencies. Including construction procedures for docks, wharves, sea walls, breakwaters, and other coastal structures, the manual will provide consistent sound design, use of standard materials and supplies, and inspection guidelines.

P.L.-F. LIU. Coastal Currents and Sediment Transport on Great Lakes Shoreline. This study is providing information to better understand the complex shoreline processes of New York's Great Lakes coast. Liu is developing numerical models to calculate coastal currents and sediment transports, examining the impact of manmade coastal structures on coastal processes, and investigating water movement in harbors along the Great Lakes shoreline. The research will result in estimates of how the water mass moves and where sediment is transported, basic requirements for answering questions pertaining to many coastal processes.

P.L.-F. LIU. Wave Refraction and Diffraction. Using a parabolic approximation technique to investigate the combined refraction and diffraction of water waves, Liu is working on a procedure for more accurate measurement of wave climates in coastal waters.

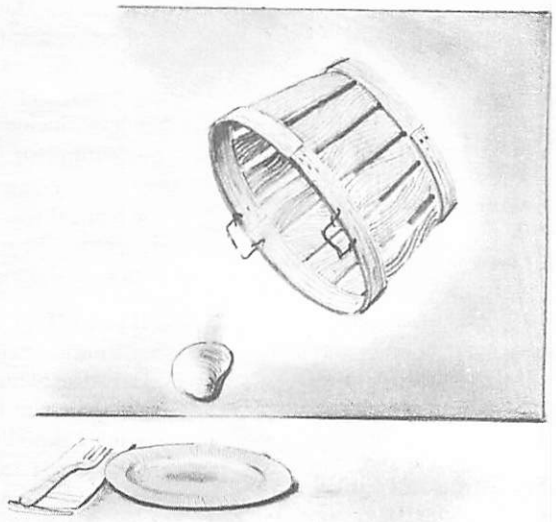
R. PIERCE, P. KNUTH, A. LEWIS. Engineering Studies on the Use of Floating Tire Breakwaters in Severe Wave Climates. This study involves engineering studies of prototype floating tire breakwaters (FTBs) to determine the optimum tire-binding material and design for severe waves as well as the most efficient mooring system. Follow-up includes construction of a large FTB and a field study of its operation in the relatively unprotected waters of Lake Erie.

P.K. RAY. An Evaluation of the Relative Importance of Mass Wasting Processes as a Mechanism of Lake Ontario Bluff Recession. This project seeks to identify the importance of various mass wasting processes in recession of Lake Ontario bluffs. Assessment of the importance of these processes vis-a-vis wave-induced erosion will assist lakeshore property owners in the development of effective control techniques.

H.T. SHEN. Formation of Hanging Ice Dams in the Upper St. Lawrence River. Formation of hanging ice dams in the St. Lawrence River restricts river flow, causing a loss of head to the Moses-Saunders Power Dam, the fifth largest hydropower facility in the United States. This project is developing a mathematical model to simulate time-dependent profiles of such hanging ice dams, leading to a better understanding of the processes involved in formation of hanging ice dams.

New York's Gold Mine for Clams—

Great South Bay: Has It Bottomed Out?



Great South Bay—the shallow lagoon along the south shore of Long Island—has excelled at growing clams over the past 40 years. The bay once accounted for more than half of the hard clams—littlenecks, cherrystones, and chowders—sold in the United States.

Lately, though, the bay's success has been waning. Six years ago, one clammer remembers, he could dig up about a bushel an hour. Now, with the bay's reduced productivity, he's lucky if he can get two bushels a day. In 1976 baymen dug 680,000 bushels of clams from the bay; by 1981 the harvest had fallen below 300,000 bushels. Clam license sales have dropped by 2,500 since 1976. But even in the depth of the slump—in 1981—clams were a significant crop valued at $18 million.

Some critics hold baymen responsible for overharvesting clams. Others point to interference with the clams' habitat through population and inlet dredging. Likely, all these and others are factors. The big question is what can be done to improve the situation.

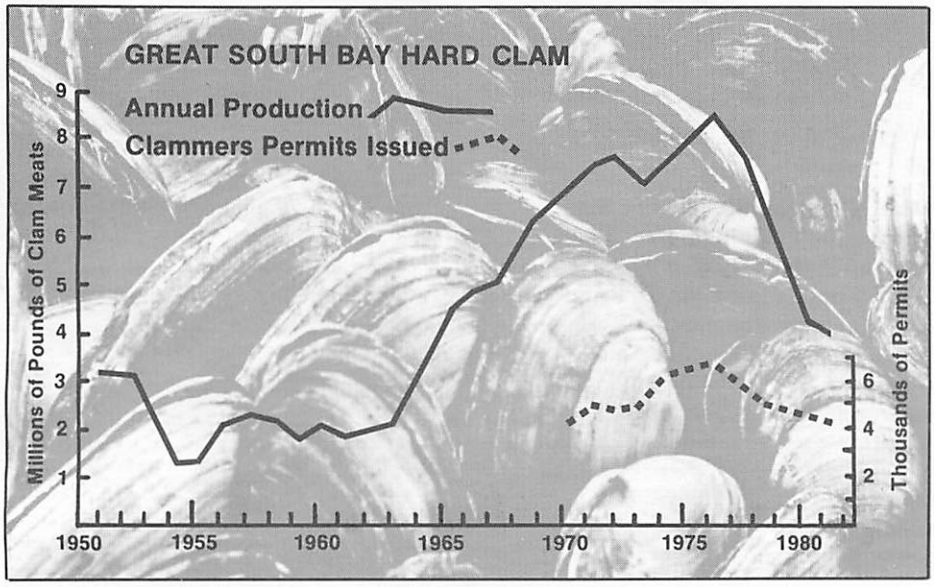
Some say to do nothing. Overharvest, they claim, need not lead to the end of clamming in Great South Bay. Many fisheries and other resources have followed cycles of boom and bust. As yields dwindle, they believe, clammers will stop clamming and leave remaining clams at peace to procreate.

Others believe we must manage the resource before it's too late. The conventional wisdom suggests that seeding can help restore the clam population in the bay. The Long Island towns have already begun programs to "plant" clam seed out in the bay.

John L. McHugh, an eminent fisheries biologist from Marine Sciences Research Center (MSRC), State University of New York at Stony Brook, concurs with baymen and managers who believe that the majority of the small seed clams are eaten by crabs, whelks, and other predators as soon as they're planted. But no one had ever studied seeding in Great South Bay scientifically to confirm this and to determine under which conditions seeding might be most effective.

Not, that is, until 1976—even before the bay's slump began—when Sea Grant and the New York State Department of Environmental Conservation set out to learn more about the hard clam and its ecosystem in Great South Bay.

To get started, Sea Grant set up a series of workshops for state, county, and town officials, representatives from private consulting firms, and members of the academic



Six years ago, a clammer could dig up about a bushel an hour. Now he's lucky if he can get two bushels a day.

community to find out what they knew about the hard clam in Great South Bay and what more they needed to know to manage resources and grapple with policy issues.

This led to a one-million-dollar Sea Grant study at MSRC to better understand the bay, its productivity, and recent failings. The study has focused on clam biology and nutrition, water circulation, sediment distribution, and circulation of nutrients. From this multidisciplinary approach, resource managers and hatchery owners are learning from scientists ways that they can protect Great South Bay's clams and keep them healthy and abundant.

CLAM BIOLOGY

At the heart of the study is the biological investigation, headed by Robert Malouf, shellfish biologist at SUNY at Stony Brook. As Sea Grant professor, Dr. Malouf was brought into New York State to provide the needed expertise in shellfish biology and to train others in this area.

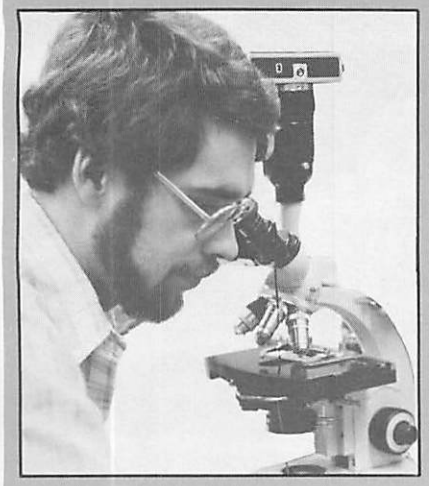
Malouf has directed field and lab studies that show that while some seeding approaches have worked in Virginia and the Carolinas, large-scale, unprotected plantings are unlikely to contribute significantly in Great South Bay. Instead, Malouf suggests that private entrepreneurs can effectively employ what he calls the "intensive effort" of planting larger, older seed—from three to five millimeters—in protected, carefully selected sites. Towns, he suggests, might use the "extensive effort" of establishing sanctuaries where larger clams can spawn and where their spawn will set in the right places at the right times.

These conclusions are based on a recently completed two-year study of seed planting in which Malouf compared combinations of seed size, bottom type, location, and time of planting to see which factors resulted in the least clam mortality.

Size. Of the three different seed sizes planted—3, 8, and 25 millimeters—there was never a question, says Malouf, that more of the largest seed would survive. The bigger the clams are when they're planted in the bay, the greater their chances for survival. But the biological answer is not necessarily the best answer. Economics must be considered as well. In general, growing clams to 25 millimeters is too expensive for the hatcheries or the towns. The medium-size clams are probably best for planting: they're cheaper to grow than larger ones, and less vulnerable than smaller ones.

Robert Malouf, shellfish biologist at SUNY at Stony Brook, heads the team investigating clam biology.

Substrates. Assuming that gravel protects the young clams from predators, some who plant clams dump a bed of gravel overboard first. Malouf experimentally tested this assumption. Planting seed in seven types of bottom sediment, he found that larger gravel is less



"Sea Grant has filled the gap for us — between what the state, the county, and the towns can do. Sea Grant sponsors nearly all of the research going on in Great South Bay. No one else — certainly not the towns — has the capability to do this research. And Sea Grant looks at the bay as a whole system. The towns stop looking where their own boundaries end. Sea Grant gives us information and assistance as we need it, too: we get the reports, even before they're published; we have access to the scientists doing the work. Sea Grant has given us an increased awareness of the complexity of Great South Bay. Understanding that complexity makes our management programs more realistic."

Jeffrey Kassner, Bay management specialist, Town of Brookhaven, NY.

We can give clams the edge over their predators by planting them in the right place at the right time in the right bottom material.

effective than believed; in fact, it protects the clam's predators from their predators more than it helps the clams. One-half inch gravel proved best for protecting small clams without harboring their predators. But gravel in general, he points out, is not a predictable substrate. It can only work at some sites against some predators. At some locations, for example, 95 percent of the clams survived in a certain gravel size; at others, none survived in this same gravel.

Locations. Malouf planted clams at several sites, including Shinnecock Bay and Napeague Harbor. While one cannot generalize about where clams grow best, location seems to be a key factor, since the assemblage of predators varies from site to site.

Predators. Using a combination of lab and field experiments, Malouf's team studied predators, particularly crabs—the greatest consumers of small clams in Great South Bay. During cold weather, he found, crabs consume fewer clams. Planting clams when the weather is colder, then, gives them a head start before the crabs grow more active.

Mud and hermit crabs, the team found in the lab, are voracious predators. A hermit crab can eat hundreds of three- to eight-millimeter seed clams each day—the size traditionally planted. At these rates, says Malouf, crabs can eat all the planted seed in days.

Grass shrimp, too, were found to eat the very small clams—those one-half millimeter or smaller. No one had ever recognized shrimp as predators before, but clams that size, says Malouf, are vulnerable to predators we don't even think of as predators. This, too, resists generalization: at the Napeague Harbor site, whelks consumed primarily the larger clams—those 20 millimeters or larger—instead of the more vulnerable, smaller clams.

Another facet of the biological study identified a less likely predator—adult clams. Adults often filter out their own larvae from the water column. This phenomenon, according to Malouf, had been suspected but never before conclusively demonstrated.

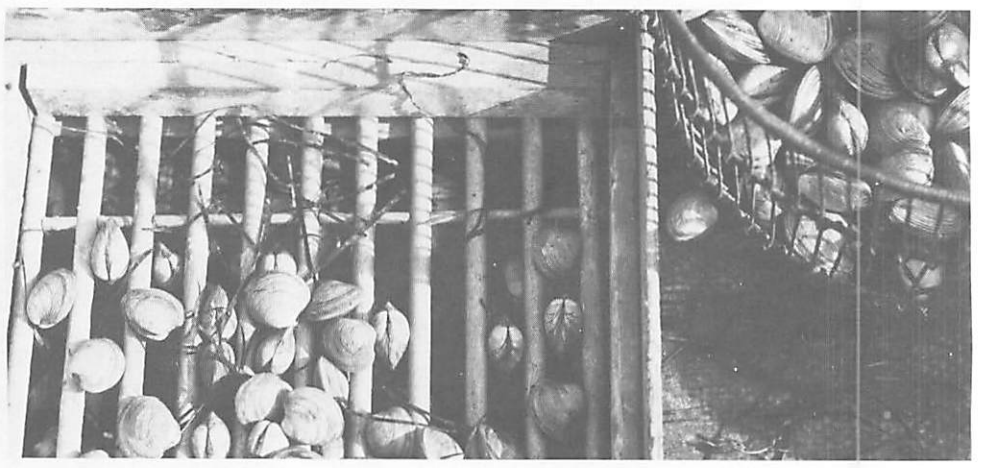
Several approaches, according to Malouf, can give clams the edge over their predators: holding them longer at the hatcheries until they grow larger; physically protecting them until they are about 25 millimeters long; planting them in colder water; and planting them in the right locations at the right time in the right kind of substrate. Bluepoints Oyster Company has recently begun protecting the seed it plants with screens. Others are considering protecting the animals on rafts, in gravel nurseries, or in protected ponds.

BIOLOGICAL INSIGHTS CHALLENGE OLD WAYS

From these biological inquiries, the hatcheries and the towns have learned new approaches to protecting their clams or learned that traditional practices were ineffective.

Since temperature changes can induce spawning, many towns believed that transplanting clams from colder waters into Great South Bay would lengthen the time that clam larvae are present in the bay, increasing the chance for a good set. This approach, it was believed, would augment the bay's natural production. But another facet of the study proved that this was not so effective, because the time of spawning varies greatly from season to season. Often, the biologists found, clams transplanted from Long Island Sound to Great South Bay spawn at about the same time as the native clams. On the basis of these results, the Town of Brookhaven may discontinue its spawner transplant program.

Another part of Sea Grant's Great



Clammer Greg Greene boards his boat with a bushel of clams. The grid is used to sort clams: those falling between the bars are undersized and must be thrown back.

South Bay study considered man as a predator and challenged New York State law. The law prohibits harvesting clams smaller than one-inch. This is intended to protect clams from clammers until the animals have had a chance to reproduce. Reproduction studies, though, suggest that protecting the *larger* clams is more important for protecting populations: Malouf found that as clams age, they grow larger and more fecund.

- Chowders—the largest, oldest clams—produce the most offspring—7 to 8 million;
- littlenecks—the smallest size that can be harvested—produce only about 1.5 million;
- smaller clams—the ones we protect—don't reproduce significantly.

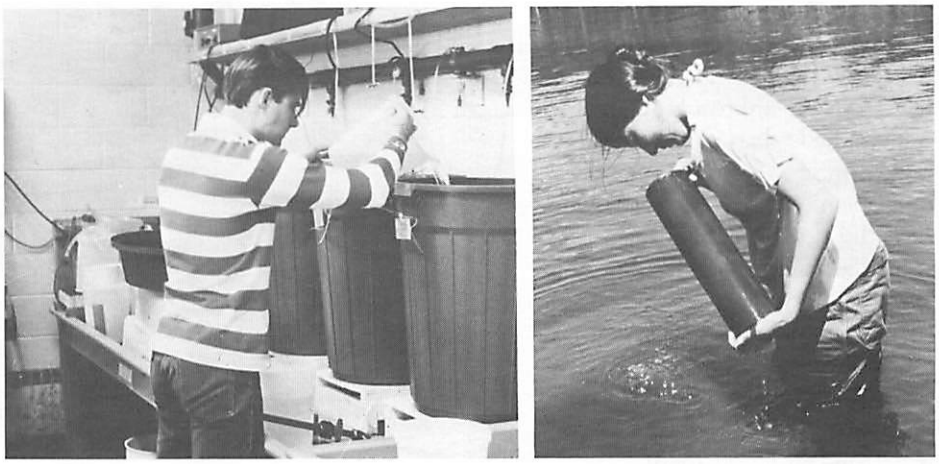
CIRCULATION AND OTHER FACETS OF THE SYSTEM

Malouf also favors protected spawner sanctuaries. These tracts could be planted with chowders, protected, and situated so that larvae drift into unpolluted areas where their chances of survival are favorable.

Clam larvae float freely for their first 10 to 18 days. In another

New York State law prohibits harvesting clams smaller than one inch. But new studies suggest the need to protect the larger, more fertile clams.

SUNY at Stony Brook inquiry, Harry Carter and Robert Wilson are studying where the larvae drift and set. Dr. Carter has designed a computer model that allows for water velocity and seed dispersement. Given seed planted anywhere in the bay, the model can predict where the larvae will set. The model can work backwards, as well, to tell managers where to plant seed so that the larvae will be statistically likely to set in specific locations.



Ken Kurkowski (left) has noted that adult clams often ingest their own larvae as they filter feed. Mary Gibbons (right) compared reproduction rates and found larger, older clams more fertile.

Towns are not using this model in their seeding programs. Before this study, seeding proceeded by intuition. One town, for example, planted spawners in their waters; a dye study told them that their larvae had drifted into the next town's waters. Results of Carter's investigation will allow for more informed management and help determine where seed planting can make the greatest impact.

Besides biology and circulation, other SUNY at Stony Brook faculty are studying other facets of the Great South Bay.

- **Nutrients and phytoplankton.** Clams eat phytoplankton, and for the process of photosynthesis that gives them life, phytoplankton need nutrients—the inorganic compounds of nitrogen and phosphorus. To manage clams effectively, therefore, requires an understanding of the nutrient cycle in Great South Bay. Sea Grant-supported scientists are studying how nutrients enter and circulate in the bay.

The phytoplankton in Great South Bay, they found, blooms in the summer when clams are most active. This is unusual for the region, and may be one the bay's chief assets in growing clams.

Eelgrass, duck wastes, and clammers have been proposed as factors that may influence the way the bay cycles nutrients. Each may affect the kinds of phytoplankton that grow in the bay and serve as food for clams.

Eelgrass, scientists have long believed, acts as a conduit for the exchange of nutrients between water and sediment. Boudewijn Brinkhuis has investigated the process. His preliminary results suggest that eelgrass absorbs nitrogen from surrounding waters and releases it into the sediments. If this is the case, it may be the plants' way of storing nitrogen for the long, nutrient-poor winter.

Duck wastes from the many farms that once bred ducks line many of the streams that flow into Great South Bay. These wastes add to the bay nutrients that fertilize the bay's plants; smaller forms of plant life—primarily phytoplankton—flourish. Malouf found that these small phytoplankton are unsuitable as clam food. In fact, clams fed small forms grew at about the same rate as clams not fed at all.

Clammers, too, it has been proposed, affect the exchange of nutrients in the bay by stirring up the sediment with their rakes or tongs. Edward Carpenter and Douglas Capone have studied how clammers affect the cycling of nutrients.

To see if these factors did indeed affect the cycling of nutrients, Drs. Brinkhuis and Carpenter compared levels of nutrients and phyto-

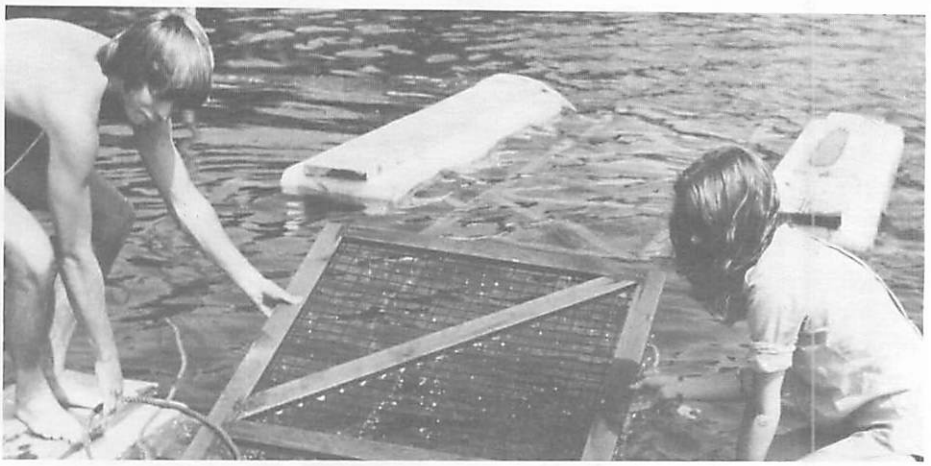
plankton over eelgrass beds, in clammed and unclammed areas, and over duck wastes. They found that fewer phytoplankton grew over eelgrass beds than at control areas. Furthermore, the nutrients and phytoplankton over active clamming beds did not differ significantly from the control sites. While this suggests that the mixing up of sediments from clamming is less important for exchanging nutrients, the nutrients stirred up by clammers may spread faster than the phytoplankton can ingest them.

Primary phytoplankton production over eelgrass beds was lower than at other sites. Scientists explain that most of these beds are on the bay's south side, where they are exposed to the influx of less fertile ocean water.

Douglas Capone has studied the release of nutrients from bay sediments. He has found that nutrient release from the sediments to the water column varies according to sediment type: sandy sediments show the greatest release and silty areas the lowest. These findings suggest that the sediment naturally releases as much as 30% of the nutrients the phytoplankton need during their peak summer bloom.

Investigators found that Great South Bay's phytoplankton are most likely to derive their nitrogen from urea in the water, rather than from ammonium, the generally preferred source. While urea is abundant in the bay, phytoplankton using it for photosynthesis must first convert it to nitrates. Investigators are still trying to understand why phytoplankton prefer ureas to the ready-to-use nitrates that are out there.

Good research raises more questions than it answers. But we can go a long way toward increasing and sustaining the existing stock of hard clams in the bay.



Paul Flagg (left) and Monica Bricelj (right) study the survival, growth, and fertility rates of clams under different environmental conditions.

- **Metals.** Since clams are filter feeders, they may ingest metals along with nutrients from bottom sediments. These metals—lead, iron, copper, and chromium—may become concentrated in clam tissues. David Hirschberg is studying how metals enter the Great South Bay by comparing the two major sources—atmospheric fallout and groundwater runoff.
- **Coliform bacteria.** When coliform bacteria levels rise, the New York State Department of Environmental Conservation closes waters to clammers. From Peter Weyl's studies of coliform bacteria in Great South Bay, the regulatory agency has learned that it can reopen clamming waters if there has been no rain in two weeks. Dr. Weyl's study documents that at that point no new bacteria have entered the bay and that the bacteria there have died.
- **Groundwater seepage.** The bay's salinity affects clam populations and the populations of their predators. This process must be better understood before managers know where to plant or transplant clams. Fresh water seeping up across the bay bottom is second only to stream flows as freshwater source for the bay. Henry Bokuniewicz has studied direct groundwater seepage.

TOWARD BETTER MANAGEMENT

Jerry Schubel, director of MSRC, SUNY at Stony Brook, says that any good research raises more questions than it answers. But with this research, we can go a long way toward making suggestions to increase and sustain the existing stock of hard clams in the bay.

With this improved understanding of the bay's processes and how they affect the hard clam resources, says William Wise, assistant director for the New York Sea Grant Institute, one can examine management problems in a broader context.

Clearly, new insights in the science of the bay are already resulting in new approaches to the bay's management. But moving from science to implementation, the situation grows more complex.

Adopting any approach on the large scale requires more than science: it requires meeting social and economic demands, as well. And sometimes these are the hardest to meet.

Related Sea Grant Projects

B.H. BRINKHUIS, A.C. CHURCHILL. **Analysis of Eelgrass Distribution and Growth Characteristics in Great South Bay by Multi-Spectral Scanning.** This project involves determining the utility of remote sensing by multispectral scanner of the distribution, abundance, and growth characteristics of eelgrass, a dominant submerged aquatic species in

Great South Bay. It is thought that this species plays a pivotal role in the nutrient cycle of the bay.

E. CARPENTER, D. CAPONE, B.H. BRINKHUIS. Sediment Effects on the Nitrogen Cycle in Great South Bay, New York. The investigators are studying the role of the sediments in nutrient cycling in Great South Bay, the flux of nitrogenous nutrients from the sediments as well as the extent of nitrogen fixation and denitrification in the sediments. Also, under study is how eelgrass buffers the flux of nutrients in sediments. Determining the nutrient cycle is fundamental to understanding phytoplankton dynamics, which greatly affects the food supply available to hard clams.

H. CARTER, R. WILSON, H.J. BOKUNIEWICZ. A Study of the Circulation and Ground-Water Flows in Great South Bay, New York. The Great South Bay Study plan is a multidisciplinary research plan to develop environmental data, a resource for forming a management plan for the hard clam resource of Great South Bay. This project addresses the relationship between local wind-forcing and nontidal currents in the bay as well as the influx of groundwater to the bay and its impact on circulation patterns and salinity distribution.

J.M. CONRAD. Management of a Multiple Cohort Fishery: The Hard Clam Resource in Great South Bay. Conrad, Sea Grant professor in management economics, is working on a bioeconomic model of the hard clam resource and the application of the model to determine optimum harvest levels and age structure of the stock. Comparing these with current landings and age structure in the fishery will permit recommendations to be made as to effective management strategies to move the fishery toward optimum sustainable yield management.

R. ELSTON, L. LEIBOVITZ. Development of a Program of Health Certification Criteria for Transfer of Molluscan Stocks into and out of New York State. The objective of this work is the development of a reliable methodology to assess the health of shellfish shipped across the state line. This will ensure that New York's disease-free native shellfish stocks remain that way. State natural resource agency personnel will find use for such a methodology as part of the permitting process for interstate shipment of molluscan larvae and juveniles.

R. ELSTON, L. LEIBOVITZ. Investigation of the Role of Larval American Oysters *Crassostrea virginica* as Carriers of Oyster Diseases. Elston and Leibovitz are investigating selected disease agents of oysters in terms of their importance as pathogens for larval oysters and the significance of larval infections in dissemination of the agents. This research will generate information necessary to evaluate the safety of commercial shipments of oyster larvae from an area of endemic disease to other areas and provide a basis for criteria needed to design necessary federal regulations.

J.M. GOODMAN. The Socio-economic Impact of Depuration on the Great South Bay Watermen. This study assesses the socioeconomic impact of technical alternatives to improving shellfish production in the Great South Bay. The base case involves depuration operations and their impact on the baymen. Impact is measured in terms of net income, employment, and life style.

E.P. GREENBERG. Luminous Bacteria as Indicators of Shellfish Contamination by Pathogenic *Vibrios*. This project assesses the potential for using luminescent bacteria to indicate *Vibrios* contamination. The presence of luminous bacteria can be detected quickly and inexpensively, offering shellfish managers and public health officials a potentially useful tool for microbiological certification of shellfish.

D.H. HIRSHBERG, J.R. SCHUBEL. Extent and Origin of Anthropogenic Contamination of Fine-Grained Great South Bay Sediments. This study measures levels of selected metals, chlorinated hydrocarbons, and biocides in the fine-grained sediments of the bay, and determines the relative importance of terrestrial runoff and atmospheric fallout as sources of these contaminants. Such knowledge is necessary if pollution control measures are to be effective.

L. LEIBOVITZ. Pathologic and Immunologic Responses of Commercially Important Species of Long Island Shellfish.

R.E. MALOUF. Population Dynamics of the Great South Bay Shellfishery. Great South Bay is the single most important producer of the hard clam, *Mercenaria mercenaria*, in the world. Rational efforts to manage the resource have only recently begun. Malouf is building a foundation of essential biological information, particularly reproductive biology, about the hard clam in Great South Bay. The study is expected to contribute to the development of an overall management plan for Great South Bay's hard clam resource by providing the data needed for adequate evaluation of important management techniques.

R.E. MALOUF. A Study of Factors Influencing the Growth and Survival of Juvenile Hard Clams, *Mercenaria mercenaria*, in Great South Bay. Malouf is studying the role of particulate organic matter in the nutrition of hard clams, assessing the interaction of temperature and food quality/quantity on growth of hard clams, and determining the importance of suspended particulates in the turbid bottom layer to hard clam energetics. This information is much needed by private and public shellfish managers.

R.E. MALOUF, P. FLAGG. An Evaluation of Seed Clam Planting on Long Island: A Cooperative Approach. This study evaluates the effects of size, time of release, and location on the survival of hatchery-reared seed clams released into the bay. This information will help maximize the production of marketable adult clams from seed.

J.F. TIMONEY. Antibacterial Mechanisms in Clams and Oysters: The Contributions of the Water Stream to Bacterial Clearance.

P.K. WEYL. Coliform Analysis of Great South Bay. Weyl is continuing a previous study to determine the variability of water quality data obtained by the New York State Department of Environmental Conservation as part of its shellfish management program. Discernible relationships between these data and various environmental factors (tide, rainfall, ground-water runoff) will assist in assessing the potential effectiveness of point and nonpoint source pollution control measures.

ADDITIONAL SEA GRANT PROJECTS

Ports & Harbors

V. HARMS. Development of Design Criteria for Floating Tire Breakwaters. Harms is establishing engineering design criteria for floating tire breakwaters (FTBs). These design criteria will enable future users to design FTBs that are optimal economic-technical solutions for wave attenuation at a specific site.

C.A. HEATWOLE, N. WEST. The Potential for Small-Boat Marina Development in New York City. Heatwole and West are undertaking an extensive survey of New York City boat owners and marine operators to ultimately design marina facilities and fee structures so as to attract sufficient numbers of users and to make marinas beneficial esthetic and commercial components of the urban waterfront.

R.E. PAASWELL, W. RECKER. Strategies to Maximize Benefits to Development at Port of Buffalo. To complement a number of studies of the possibility of importing and transshipping coal through the Port of Buffalo, Paaswell and Recker are seeking information on specific land use and ownership in the entire port area: commodity flows, problems of coal gasification at the port, data on grain shipment through the port, and bulk commodity handling needs at the port. This information will have an impact on port development and its associated sustenance of the regional economy.

The Finfishery

J.M. CONRAD. Cost and Returns in the Otter Trawl Fleet on Long Island, New York. By identifying fixed and variable costs of fishing associated with various boat/gear combinations and by determining expected catch functions for important finfish species, this project hopes to provide comparable estimates on the profitability of a select set of vessel/gear/species combinations. This information will be of direct assistance to ongoing educational efforts by extension personnel.

C.A. HEATWOLE, N.C. WEST. Recreational Fishing in New York City. This project, jointly funded with MESA's Hudson-Raritan Estuary Program (HREP), is investigating the magnitude of the shore-based recreational fishery in New York City and is gathering data on the socio-economic profile of participants. Such information will be of use to city and state agencies with recreation management and public health responsibilities.

F.C. HOPPENSTEADT, I. SOHN. A Multiple Species Fishery Model: An Output-Input Approach (Pilot Study). The researchers are developing a methodology for analyzing simultaneously the biological structure of a multi-species fishery and the economic structure of its exploitation. It is hoped this will provide objective and systematic answers to long unanswered questions about fishery management.

J.L. McHUGH. Is Extended Jurisdiction Working? McHugh is examining the history and performance of institutions and individuals during the three years following the implementation of the Fishery Conservation and Management Act of 1976. Performance is being evaluated and recommendations made for improvements in research, administration, coordination, management, and legislation.

E. SMITH. The New England Regional Fisheries Management Council—Year II.

B.T. WILKINS, C.P. DAWSON. Constraining Marine Recreational Harvests in the Mid-Atlantic Fisheries Conservation Zone. This project is estimating the impact on recreational harvests of selected finfish created by several management constraints. It is also investigating the correlations between angling activity and angler characteristics, and the responses of anglers to these constraints. This information will be useful to the Mid-Atlantic Fishery Management Council in its attempts to define and regulate recreational fisheries in the Mid-Atlantic Fisheries Conservation Zone.

B.T. WILKINS, W.H. EVERHART. Application of Management Strategies to the Mid-Atlantic Extended Jurisdiction Recreational Fisheries. Through an extensive literature review, Wilkins and Everhart are gathering information on social and economic aspects of the Mid-Atlantic extended jurisdiction recreational fisheries. The research will enable regional Fishery Councils and federal and state marine fishery agencies to identify applicable, but typically untried approaches to regulations in the marine fisheries. In addition it would provide those subject to regulations opportunity to identify problems and possible resolutions with the seemingly promising approaches.

P.M.J. WOODHEAD. Basic Population and Biological Data for Spiny Dogfish, *Squalus acanthias*. This project is collecting and analyzing data essential for management to develop biologically sound principles for rational exploitation of a steady long-term fishery for the spiny dogfish. It may also provide the data for management to reduce predation upon commercially more desirable food-fish stocks. Under investigation are reproduction potential, size distributions, age determinations, and dogfish liver measurements.

Contaminants

J. CLARDY. Halogenated Hydrocarbon and Other Metabolites from *Bangia atropurpurea*.

K.H. MARTIN. Reproduction and Tissue Response in Prairie Voles Fed Mirex and Lake Ontario Coho Salmon. This study is intended to document the effects of a diet of Lake Ontario fish on mammalian (prairie vole) tissues and systems and then determine whether the observed effects are due in fact to the presence of Mirex in the fish. This information may provide more information on the Mirex dilemma and establish the need for further studies on other contaminants.

J. OMOHUNARO. Preparing the Public for Hazardous Substance Spills.

R.J. SCRUDATO, A. DELPRETE. Lake Ontario Bottom Sediment-Mirex Relationships. The principal objective of this study is to determine the relationship between sediment type and Mirex concentrations in Lake Ontario bottom sediments. Results of the study will provide a basic understanding of the relationships between

sediment size, organic carbon, and Mirex concentrations in Lake Ontario bottom sediments—the necessary data for state and federal regulatory agencies involved in establishing policies and procedures for future management of the Lake Ontario system.

C. WURSTER, H. O'CONNOR. **The Behavior and Biological Effects of PCB in Aquatic and Estuarine Environments.**

Education & Outreach Activities

R.D. ABRAMS. **Developing a Model K-12 Marine Education Curriculum Concomitant Annotated Bibliography.** With a model K-12 marine education curriculum and annotated bibliography, Abrams plans to assist educators, unify individual programs throughout the country, and use the marine environment as an effective resource tool.

I. DUEDALL, L. CHUECAS. **Strengthening Marine Science Capabilities and Programs at the University of Concepcion, Chile.**

M. DUTTWEILER. **Lake Erie Recreational Climate Project.**

M. DUTTWEILER, B. WILKINS. **Advisory Service: New York Sea Grant Institute.** Each office of the Advisory Service continues its responsibilities to transfer information to coastal users, including fishermen, marina operators, coastal contractors, county planning boards, and others; stimulate those users to apply the information to problem-solving; and work with researchers to produce information needed to solve problems. Continued from 1980.

H. HERMAN. **Student Engineering Projects—Underseas Systems.**

B. KANTROWITZ. **Communications: New York Sea Grant Institute.** This program makes readily available new and useful information arising from the Sea Grant program and its research activities. A major intent of the communications program is to increase awareness, understanding, and support for Sea Grant among those who use New York's waters, and to make its broad range of activities and information accessible to the public.

F.H. KULHAWY, D.A. SANGREY. **Development of a Coastal Structures Construction Manual.**

P.L.-F. LIU. **A Marine Engineering Research and Education Program.** Liu is developing a marine engineering research and education program to provide support for engineering students to undertake research in marine engineering and technology as well as to establish an integrated engineering research-advisory service program.

G. PONTECORVO, M. WILKINSON. **The Aggregate Income and Product of the Oceans, Phase II.**

R.I. REIS, M. KAPLAN. **Coastal Law Scholars.** This program is similar in scope to the Sea Grant Scholar Program, but awarded to law students for research on advanced topics relating to critical coastal issues.

R. REIS, M. KAPLAN. **Problems in Coastal Law.** Concentrating on the Great Lakes area, Reis and Kaplan are identifying specific legal issues of coastal regulation involving shipping, recreation, and consistent management policies. Other research includes the development of teaching materials and methods for courses in coastal management legal problems, sponsorship of conferences for other interested law schools, and recommendations for coastal law reform.

C. RICKARD, D. ABT. **Aquavet: A Training Program for Aquatic Veterinarians.** An intensive four-week summer course held at the Marine Biological Laboratory in Woods Hole, MA, for students enrolled in veterinary school, AQUAVET is a graduate course providing research experience in aquatic veterinary medicine. Greater interaction between the veterinarian and marine biologist will enable both to apply their skills to the problems of aquatic animals.

L. SIEGEL. **Development and Implementation of Marine Related Infusion Materials for Secondary School Curriculum: Second Year—American History.** After initial work to infuse marine related materials into the New York State biology curriculum, Siegel is now integrating marine related materials into American History courses. Social Studies instructors will have marine related resources for their teaching that comprehensively portrays the role of the oceans in the social, economic, legal, recreational, and scientific life of our nation and the world community.

G.O. SOLOMON. **Development of a Comprehensive K-12 Marine Education Program for New York State.** Solomon is developing a curriculum for grades K-12 on the marine and lacustrine environment on a state-wide basis. In the first three years, the project emphasizes grades K-6, not so much to teach youngsters marine science as to use the field of marine science to teach the normal skills and concepts of the K-6 curriculum.

D. SQUIRES, L. O'DIERNO. **Marine Youth Education Project, Ecology Village, Gateway National Recreation Area.**

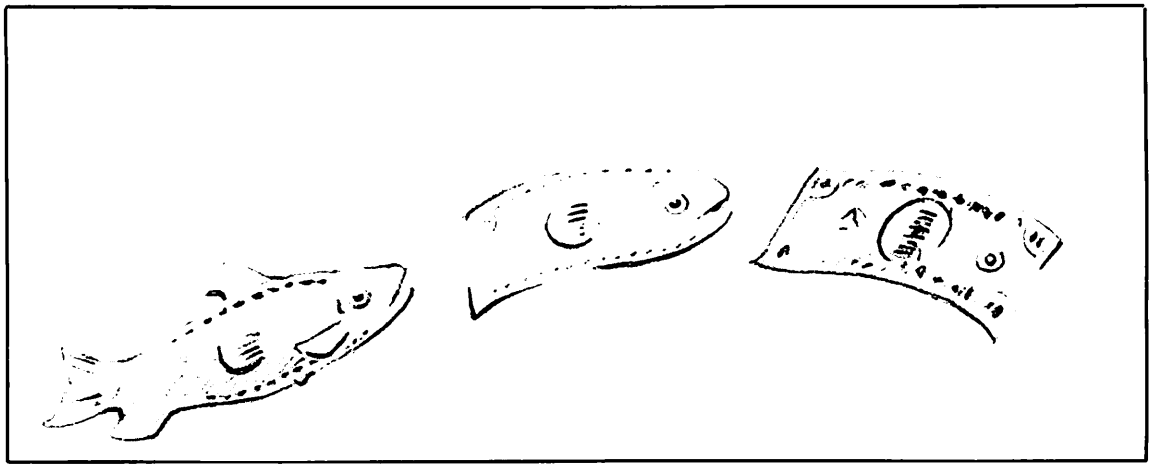
B.T. WILKINS. **Advisory Service Efforts on Critical Issues of the New York Bight.**

W.M. WISE, E.F. BOLLINGER. **Sea Grant Scholars: New York Sea Grant Institute.** This program supports graduate students who carry out a program of training and research related to the goals and objectives of the New York Sea Grant Institute while completing degrees in marine fields.

W. WISE, L. O'DIERNO. **Development of a Comprehensive K-12 Marine Education Program for New York State.** A marine education program is underway to utilize marine education in a transdisciplinary mode to create student-teacher involvement in the learning process, while at the same time developing basic concepts relevant to the world of water. Materials are being developed for both a K-6 marine education program and a junior/senior high school program.

Resources and Finances

New York Sea Grant Institute



SEA GRANT COLLEGES, INSTITUTIONS & COHERENT PROJECTS

Sea Grant Colleges (in order of establishment)

University of Rhode Island
Texas A&M University
University of Washington
Oregon State University
University of Wisconsin
University of Hawaii
University of California
State University of New York/Cornell
Massachusetts Institute of Technology
University of North Carolina
State University of Florida
University of Delaware
Louisiana State University
Universities of New Hampshire and Maine
University of Georgia
University of Alaska

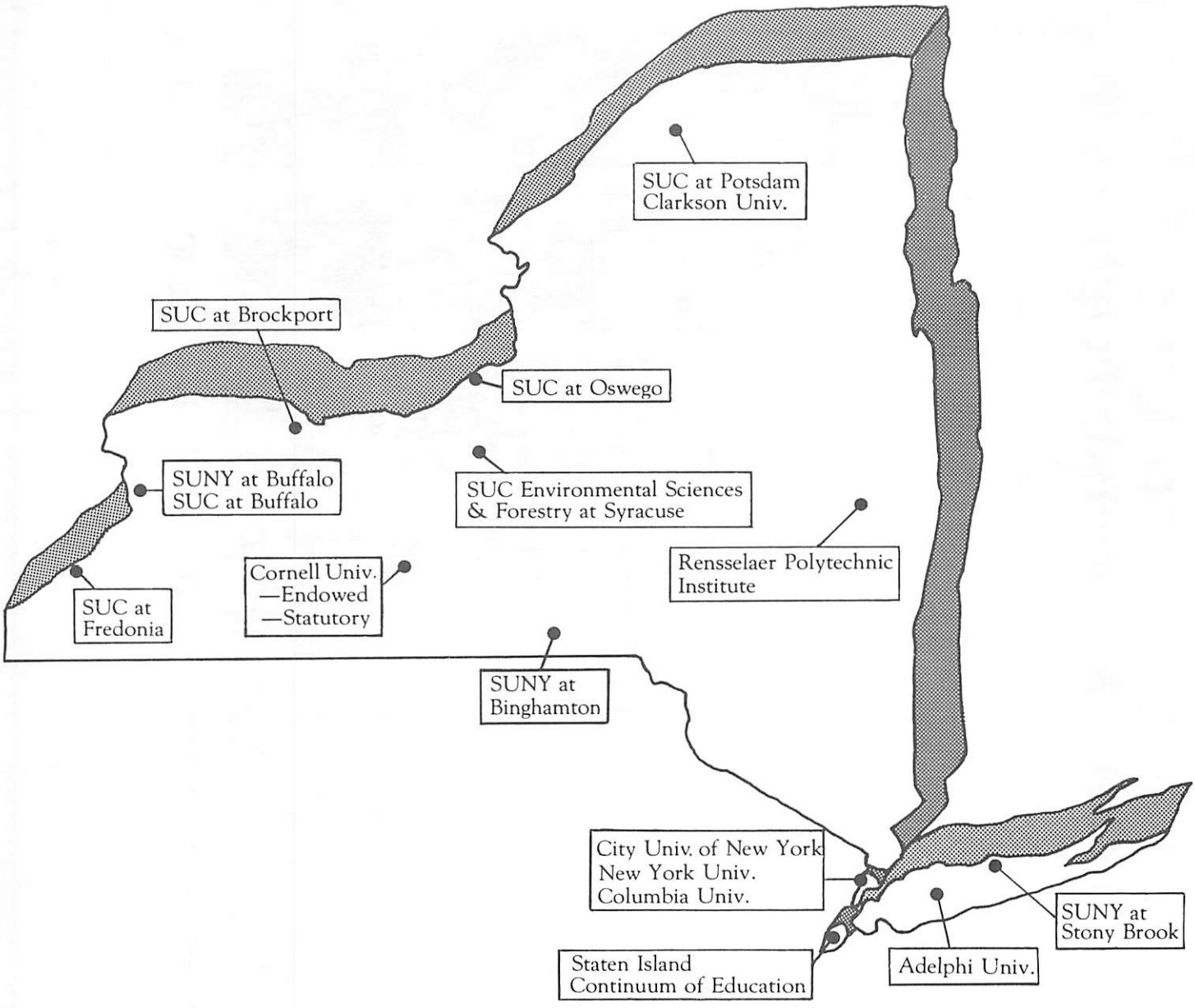
Institutional Programs

University of Maryland
University of Michigan
University of Southern California
South Carolina Sea Grant Consortium
Virginia Graduate Marine Science Consortium
Mississippi-Alabama Sea Grant Consortium

Coherent Projects

University of Minnesota
New Jersey Marine Sciences Consortium
Ohio State University
Woods Hole Oceanographic Institute
University of Puerto Rico, Mayaguez

New York Sea Grant
PARTICIPATING CAMPUSES
1980-81



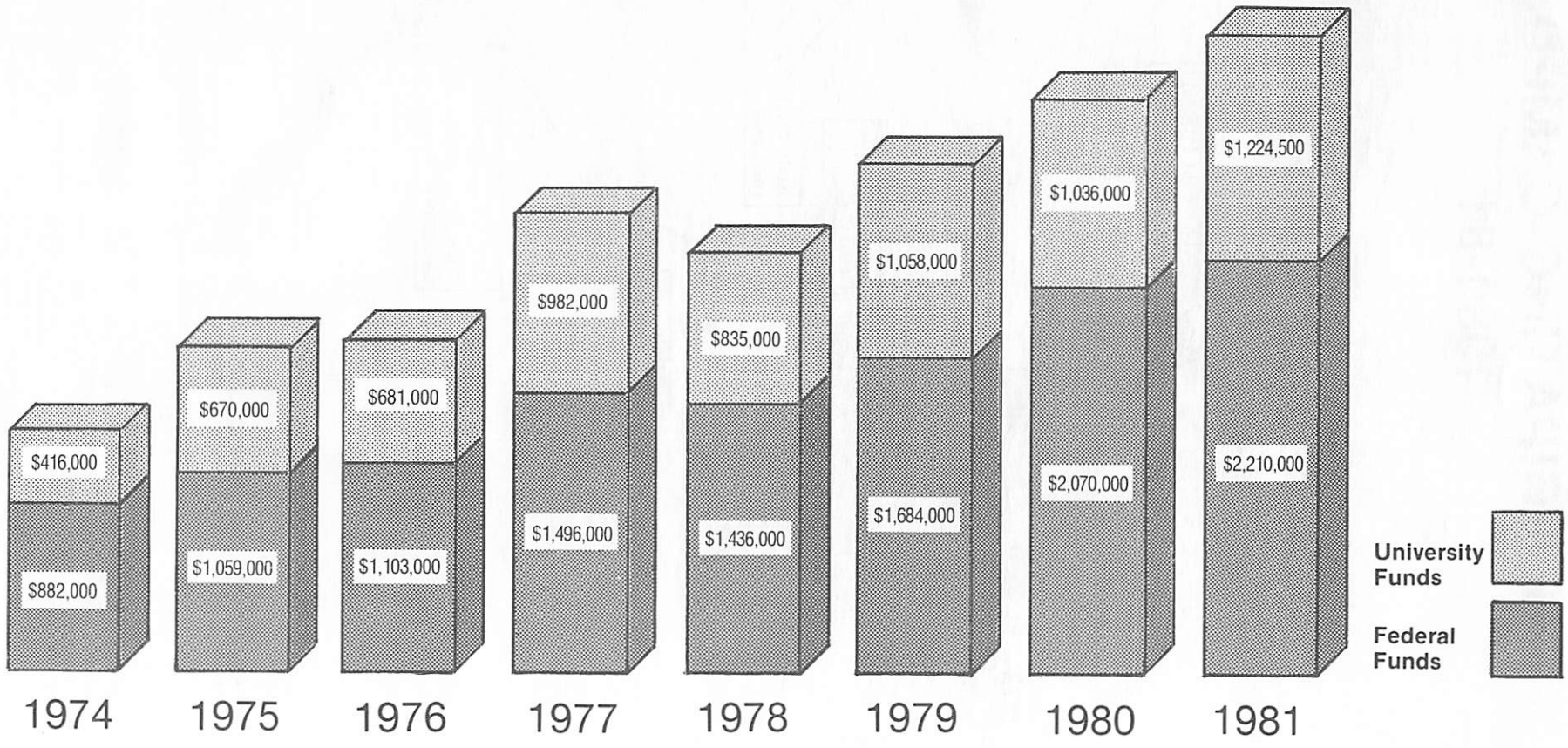
Additional Campuses

Iowa State Univ.

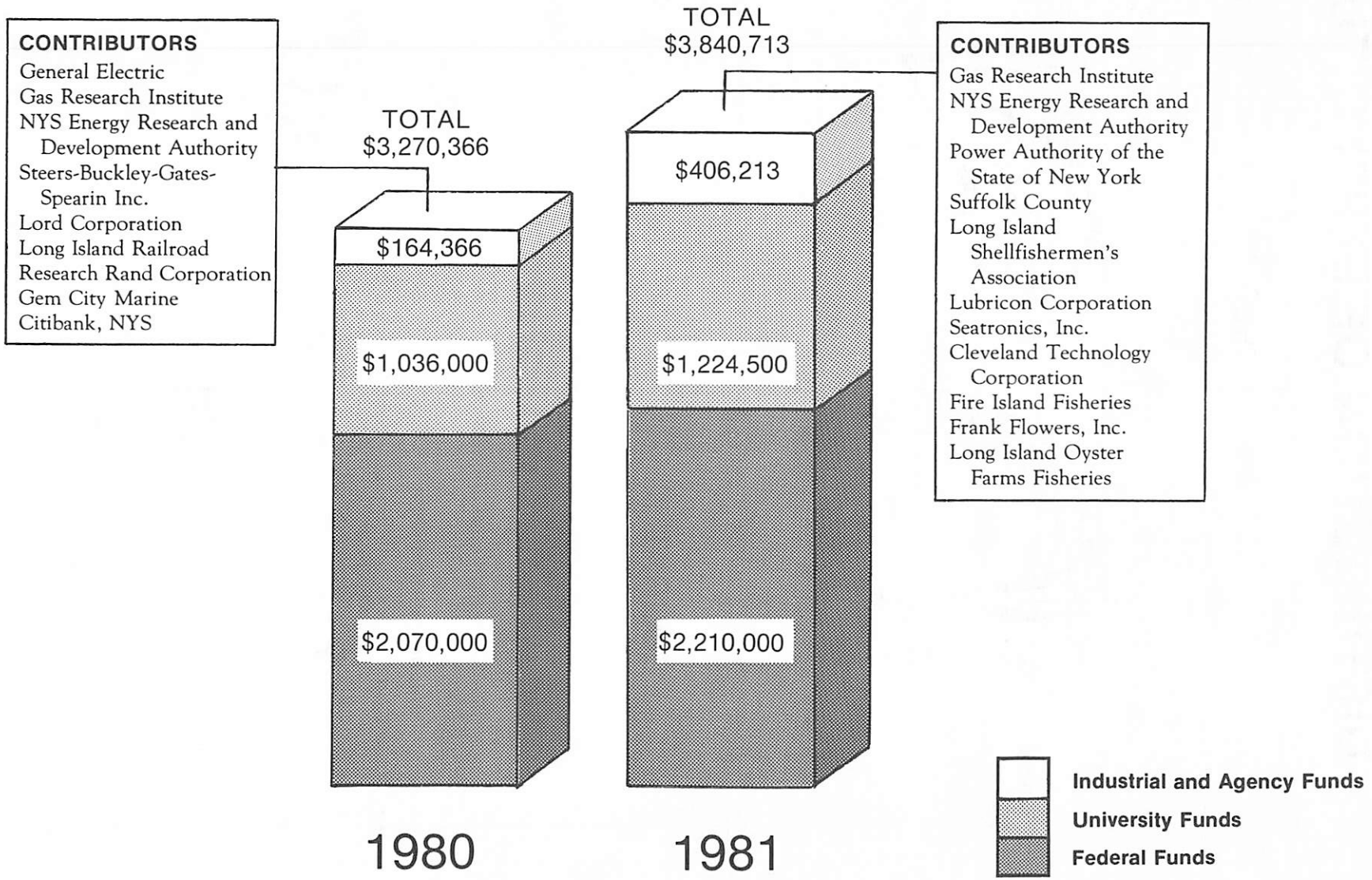
Lake Erie Institute of Marine Science

Univ. of Pennsylvania

SEA GRANT FUNDING
Federal & University Funds

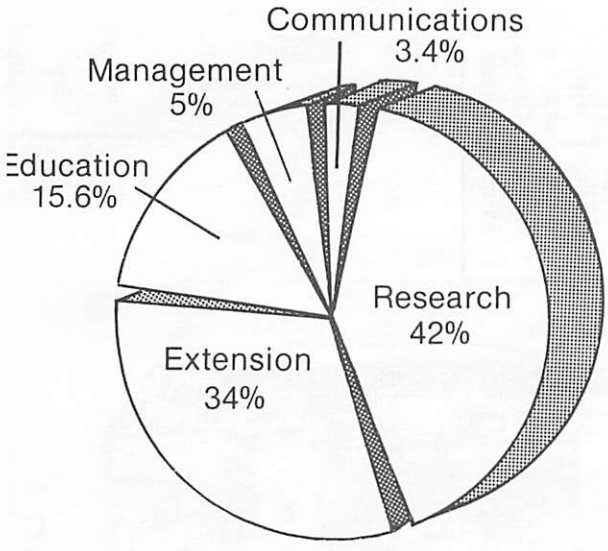


SEA GRANT FUNDING
For Report Period

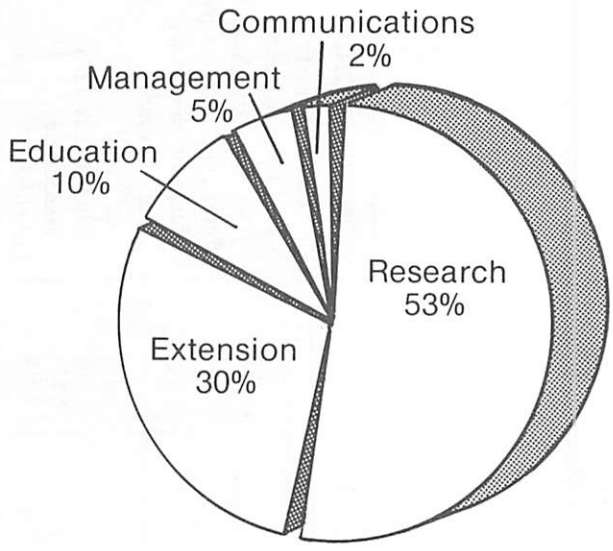


DISTRIBUTION OF EXPENDITURES

1980

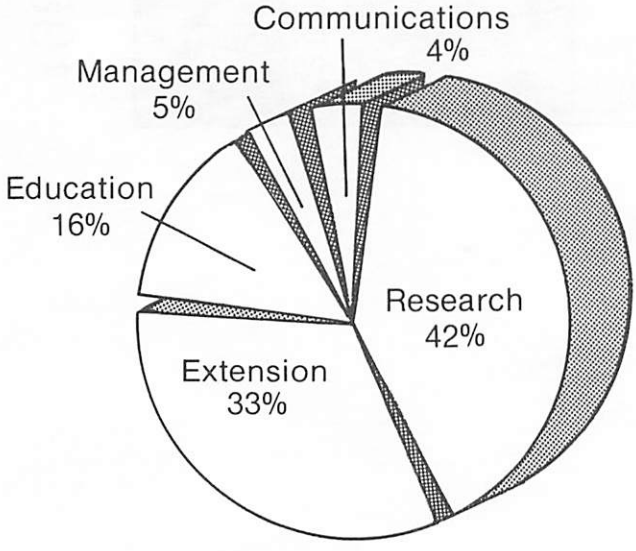


FEDERAL $

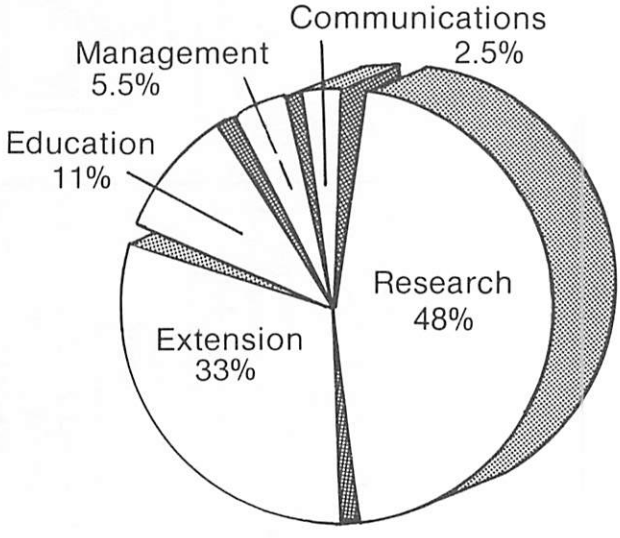


TOTAL $

1981

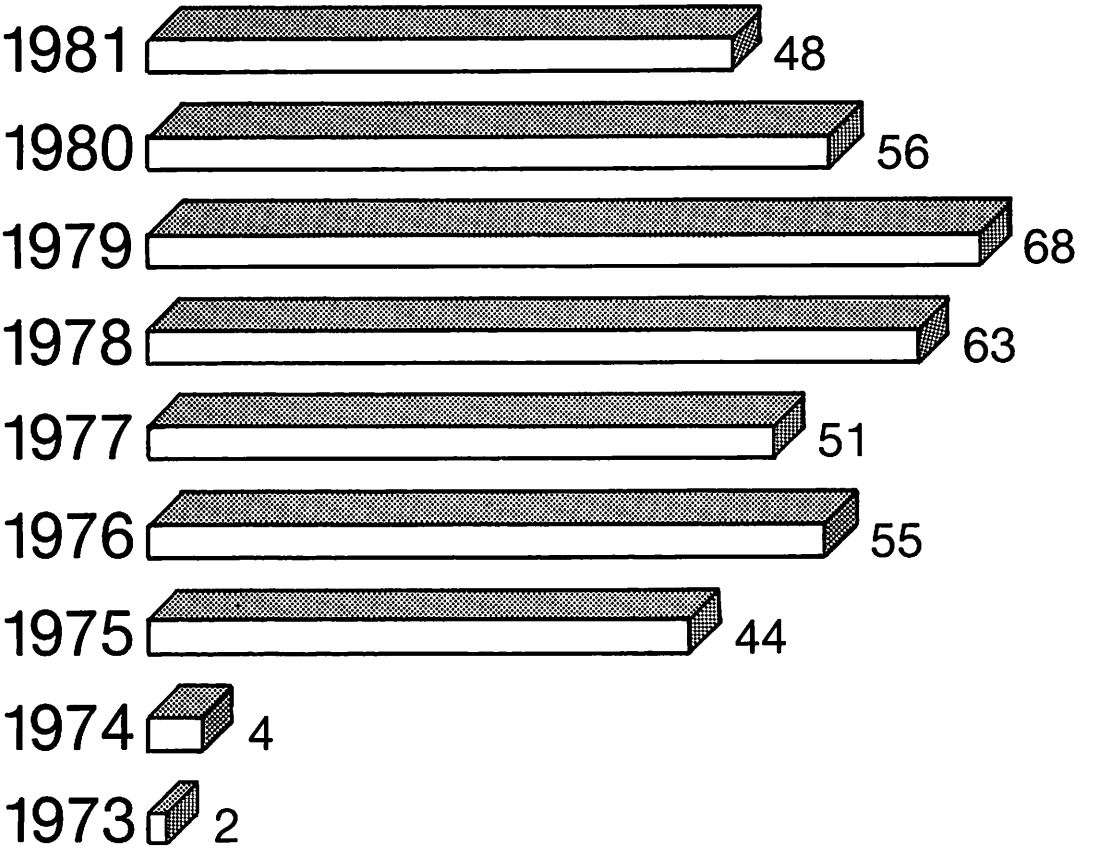


FEDERAL $



TOTAL $

GRADUATE STUDENTS SUPPORTED



Distribution by Campus 1981

SUNY at Buffalo	6
SUNY at Stony Brook	14
SUC at Oswego	3
Cornell — Statutory	12
Cornell — Endowed	7
SUC at Brockport	1
SUC at Buffalo	1
Institute Policy	2
Total SUNY/Cornell	46
Adelphi University	1
Clarkson University	1
Total non-SUNY/Cornell	2

New York Sea Grant Institute
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NEW YORK SEA GRANT IS...

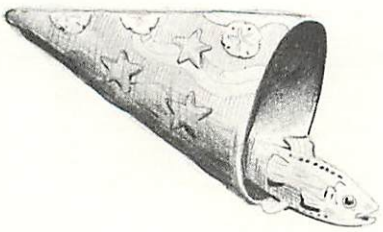
Sea Grant is a university program set up by Congress in 1966 to help the states and the nation to wisely use and manage their coastal resources. In New York State, Sea Grant is a joint venture of the State University of New York and Cornell University, set up by the trustees of both institutions. Sea Grant's Board of Directors is jointly appointed by the chancellor of SUNY and the president of Cornell.

The Institute coordinates and manages a research program by supporting faculty and graduate students investigating coastal problems. Its extension offices around the state's marine and Great Lakes districts assist those who use coastal resources.

Sea Grant receives about half its funds from the National Sea Grant College Program office, part of the National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce. The other half comes from university and other non-federal sources. Many of Sea Grant's projects are funded by and planned cooperatively with industry.

Many agencies and institutions working with Sea Grant have found it to be an experienced program that can effectively tackle problems. This unique non-profit group has the capability to tap university resources; it is a program that takes the extra steps to convert ideas into action.

Sea Grant can respond to diverse problems or needs and find the best resources or people to solve even the most complicated, multi-disciplinary problems. It can conduct research projects, educational programs, and outreach programs on almost any coastal topic. Sea Grant brings to any task more than a decade of experience from its unique role in the university community and in government.



conceived and mostly written by Bruce Kantrowitz; cover by Robert M. Durlak, illustrations by Sharon Ellis and Robert M. Durlak, design by Lesley Weissman, "Let Them Eat Fish" by Sally Dana Willson, "Of Holes and Spoils" by Peter Hornik.