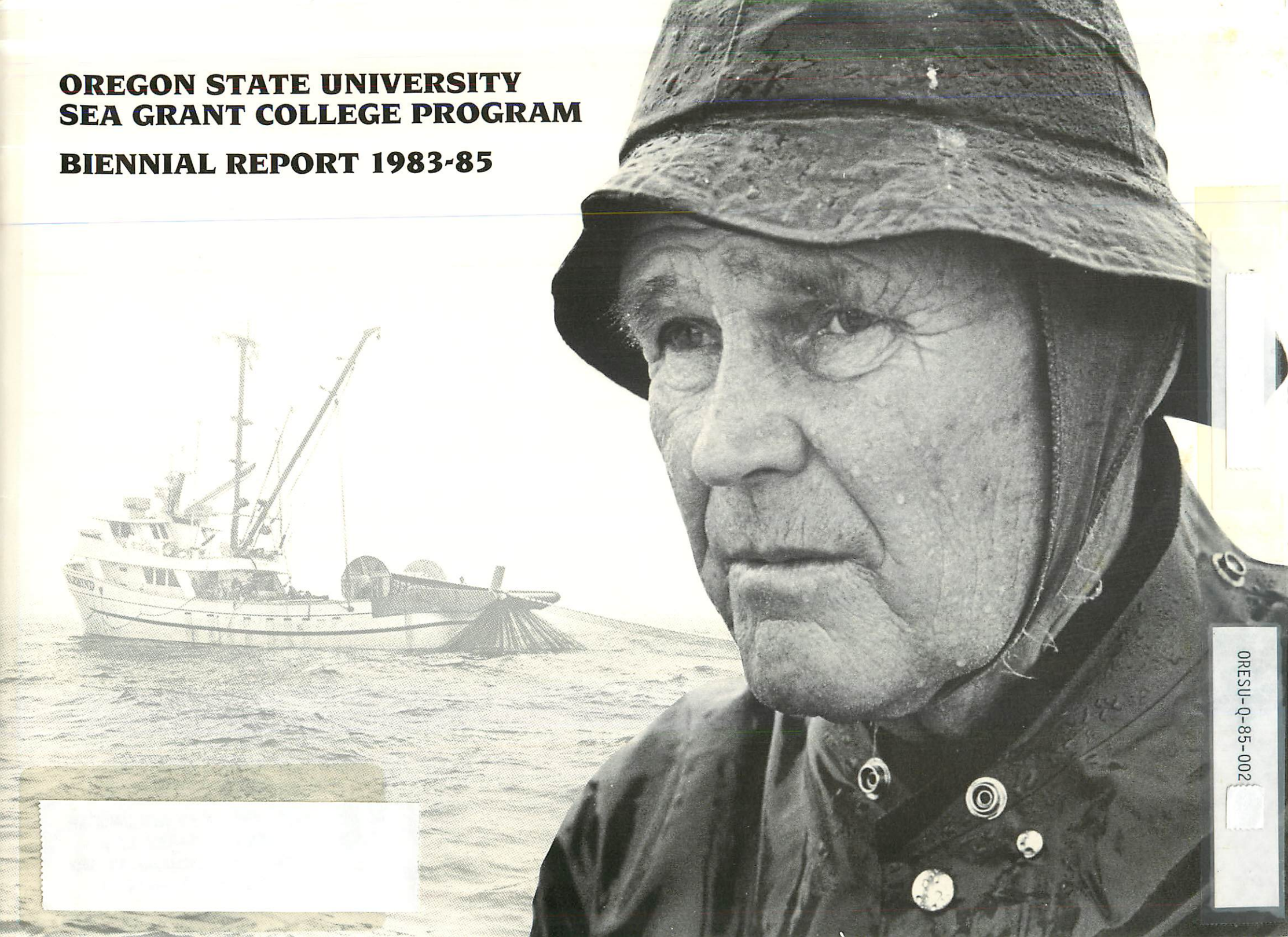
OREGON STATE UNIVERSITY
SEA GRANT COLLEGE PROGRAM

BIENNIAL REPORT 1983-85



Cover Photo: **Bill Puustinen is typical of most Oregon fishermen. In his nearly 60 years of commercial salmon fishing on the west coast, he's seen good years and bad. But the strains on the wild fish stocks have never been greater than they are today and Bill is catching fewer fish.** *Background*: **Using the purse seiner *Pacific Warwind*, a group of Oregon State University oceanographers are looking for some of the answers. They are examining the factors which affect survival of young salmon when they leave their natal streams and enter the open ocean. (Photo composite by Jim Larison and Tom Gentle)**

The Sea Grant college program was created in 1966 by an act of Congress. It is a nationally coordinated, university-based, grassroots program with facilities, equipment, and staff in every coastal and Great Lake state. Sea Grant is a partnership of government, university, and industry. It is supported with funding from the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce, individual states, local governments, and private sources.

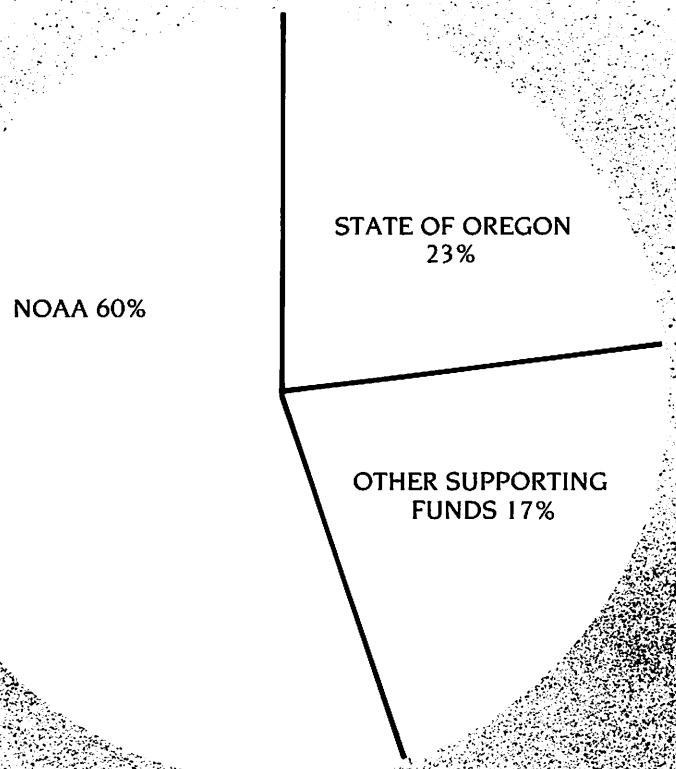
Oregon State University was among the first universities to establish such a program. Our goal is to integrate research, education, and extension functions in ways that will promote understanding, development, and wise use of ocean and coastal resources.

This biennial report documents the 16th and 17th years of continuous operation of the Sea Grant program in Oregon.

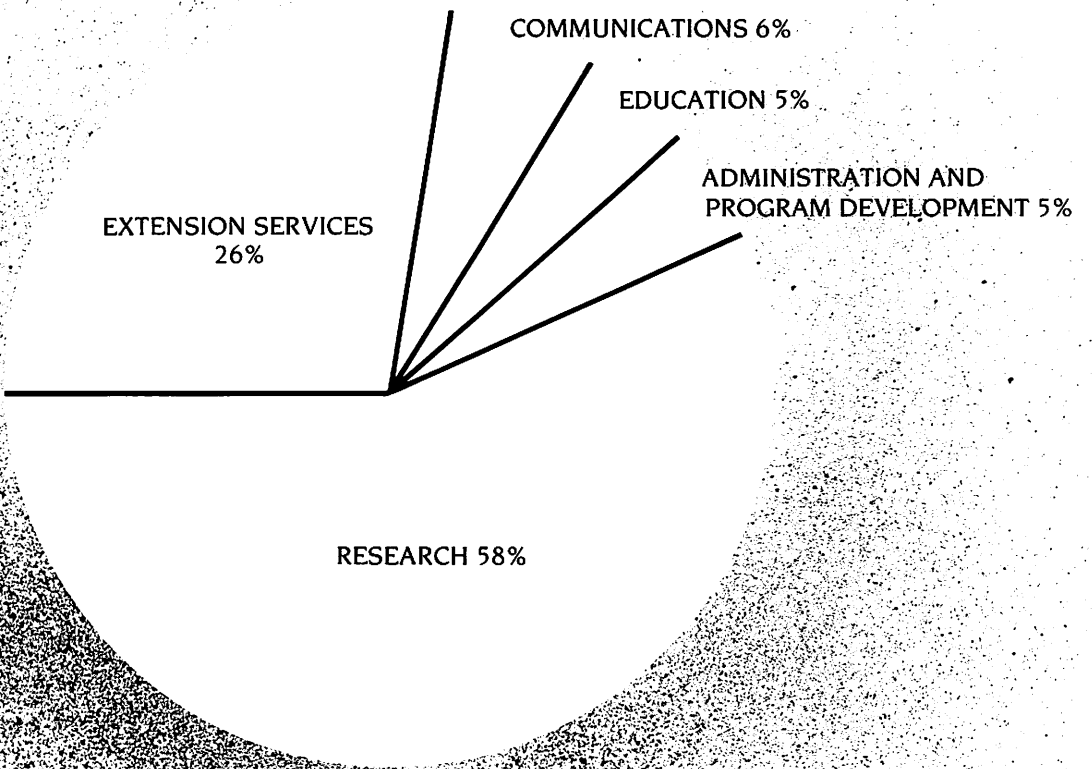
CONTENTS

BUDGET IN BRIEF

SOURCES OF FUNDS



EXPENDITURES OF FUNDS



FROM THE DIRECTOR

The National Sea Grant College Program came out of a pivotal period in American history—the mid-1960s. The time of the Great Society, a time of intense examination of ourselves as a people and a nation. We hadn't claimed to be a maritime nation since the 1800s. Our merchant fleet was small and dwindling. We ranked seventh in world fisheries. We then measured the size of America's sovereign seas by a quaint old custom, the distance a cannonball might fly—three miles. The ocean remained a mystery to the vast majority of land-loving Americans.

But this was an era when all things seemed possible—a time of awakening of ocean interests. Fish catches were growing dramatically. Manganese nodules were discovered on the bottom of the deep ocean trenches. We joined with most other nations of the world to negotiate a constitution for the sea. The future seemed to lie in the ocean.

Two decades later, there have been major changes. Satellites now scan the world's oceans, gathering information far faster than we can unscramble and make use of it. We're capturing more food from the oceans than ever before, and we're producing more fish in captivity. The Pacific has become America's primary maritime trade highway.

But there are many problems, too. Fish harvests seem to have peaked. Manganese nodules remain where they were found, unmined on the bottom of the ocean. An ocean phenomenon called El Nino has brought havoc to fishermen along the west coast. And we are still without a comprehensive Law of the Sea.

Oregon's Sea Grant college has evolved and grown through this period, from its beginning in 1968, to college status in 1971, to maturity today. We have not changed our fundamental goal—to help put America's oceans to work through education, research, and extension services—but because the program is mature, we have been able to anticipate needs. Yet we remain flexible and able to move our resources to trouble spots, solving the problems of a dynamic society.

I enjoy being director of the program because I believe in the Sea Grant concept and in the people who work with us as teachers, researchers, extension agents, and citizen advisors. We are fortunate to be Oregonians with active support at local, state, and national levels.

With this biennial report, we try to convey a sense for the real problems that confront marine resource users on the west coast in the mid-1980s. But there are surely opportunities here as well. A diverse and talented group of Sea Grant professionals is responding to these challenges.

William Q. Wick has directed the Sea Grant college program at Oregon State University since September 1973. "Universities can play an important role," says Wick, "in helping put America's oceans to work. We have been able to anticipate needs, yet we remain flexible, able to move our resources and people to trouble spots to solve the problems of a dynamic society."

FISHING FOR ANSWERS

Twice before they had set the big purse seine out from the side of the *Pacific Warwind*, and twice they had hauled in precious few young salmon. The day was gray and the ocean fogbound, as it had been since the OSU researchers and the ship's crew had set out from Newport at 5:00 a.m. But this time the haul showed a dozen silvery salmon, and Bill Pearcy allowed himself a little smile.

Quickly Pearcy and research assistant Joe Fisher examined the small fish, identified whether they were chinook, coho, sockeye, or steelhead, checked for coded-wire tags which would tell them a good deal more, and put the fish aside in specimen trays for later.

The *Pacific Warwind* set its course toward the next spot, five miles away. There the net would be set again and the faces would peer through the fog and into the dark sea, hoping to fathom some of the mystery of what happens to salmon in this other world.

Perhaps no question facing the Oregon fishery in recent years has been more elusive or more important. For the better part of two decades, from the mid-1950s until the glory years of the mid-1970s, the coastal salmon industry enjoyed increasing harvests, the result of greater production and better management practices at state and federal salmon hatcheries.

But then in 1977, the downturn started. Despite continuing high and, in fact, increased releases of juvenile fish from both public and private hatcheries, the number of adult coho returning to coastal streams declined. What was happening?

Bill Pearcy, a fisheries oceanographer, reasoned that ocean conditions were probably a major factor limiting salmon production, but, he says, "No one knew, because research in the ocean simply hadn't been done." Beginning in 1979, Pearcy set out to do it.

The results have been of use both to biologists and to fish managers.

In sampling the nearshore area out to 20 miles offshore, from northern California to Vancouver Island, Pearcy has uncovered new information and begun to describe some patterns of salmon life in the ocean.

From data based on recoveries of fish with coded-wire tags, Pearcy has observed that the majority of juveniles entering the ocean from Oregon estuaries at first turn south and then, later in their first summer, swim north. The greater abundance of coho salmon off Washington in later summer has been a regular event through four years of the study.

Some of the other data about migrations upset the conventional wisdom, says Pearcy. "It was always assumed that salmon migrate vast distances in the ocean," he says, "but our evidence suggests that at least some coho salmon don't travel very far at all."

In September 1984, for instance, the researchers captured nine young coho whose home stream and time in the ocean could be determined from their coded-wire tags. Six of these fish had been in the ocean for 90 days or more and yet had travelled less than 125 miles.

Pearcy has also been able to observe firsthand the inverse relationship between coho abundance and upwelling, the ocean-mixing phenomenon which provides nutrients for the coho food chain.

Lack of nutrients is likely not the only factor limiting young coho survival in the ocean, he cautions, and managers are not left merely at the mercy of the sea. Instead, the researcher says that his observations about fish size, abundance, and migrations suggest that "coho management needs to be flexible."

"The best strategy is to hedge your bets, for example, by having different stocks released at different places and times, so that in the case of poor ocean conditions the fish don't all encounter the same low food conditions or high predation concentrations and suffer heavy mortalities."

Jim Martin, fish harvest manager for the Oregon Department of Fish and Wildlife, says that the state agency has adopted just such a flexible strategy. "We've spread out our hatchery releases to try to get at least some of the fish into more advantageous ocean conditions," says Martin, "because it's clear that these conditions play a major role in determining coho populations."

While Pearcy's research has been providing new knowledge that assists in the management of the saltwater phase of the salmon's life cycle, Sea Grant researcher Carl Schreck's findings have been an asset to freshwater production.

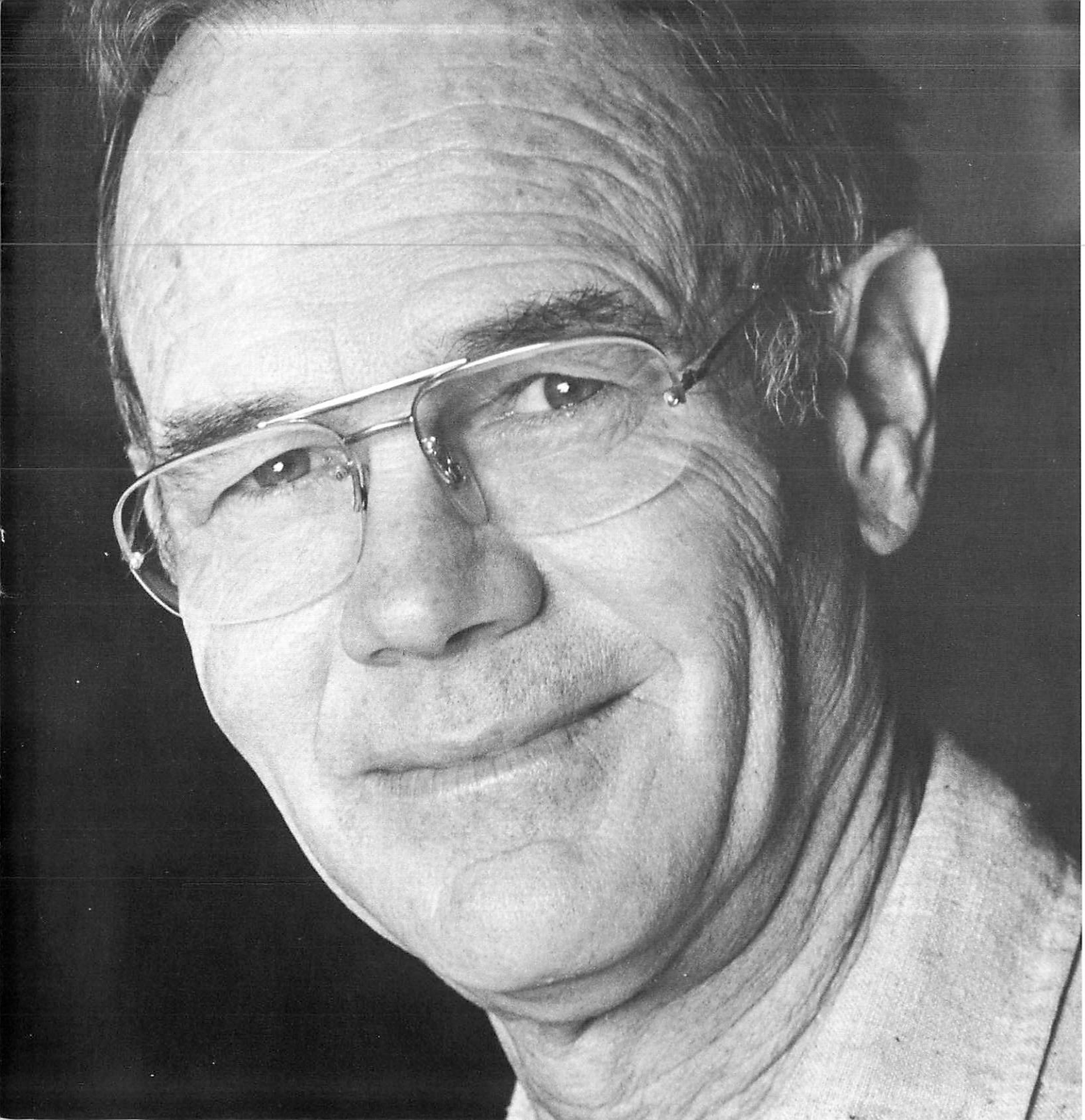
As hatcheries become increasingly important to production, it's fundamental, says Schreck, that fish return to the hatcheries and that they spawn there. They must not be lost through straying or disease.

Schreck, leader of the Oregon Cooperative Fisheries Research Unit, has conducted Sea Grant research to address these two issues.

He explains that once scientists discovered, in the 1970s, that adult salmon used their sense of smell to find their way home, it was a straightforward matter to ask if young salmon, exposed to an artificial odor before going to sea, would respond to that odor as returning adults.

If they would, Schreck explains, "it could be very useful in keeping them from straying."

Grad students Brian Jonasson and Brad Rehnberg carried out the key preliminary experiments. Using a Y-trough, a water-tight wooden box with two branching arms, they found that young salmon indeed would recognize



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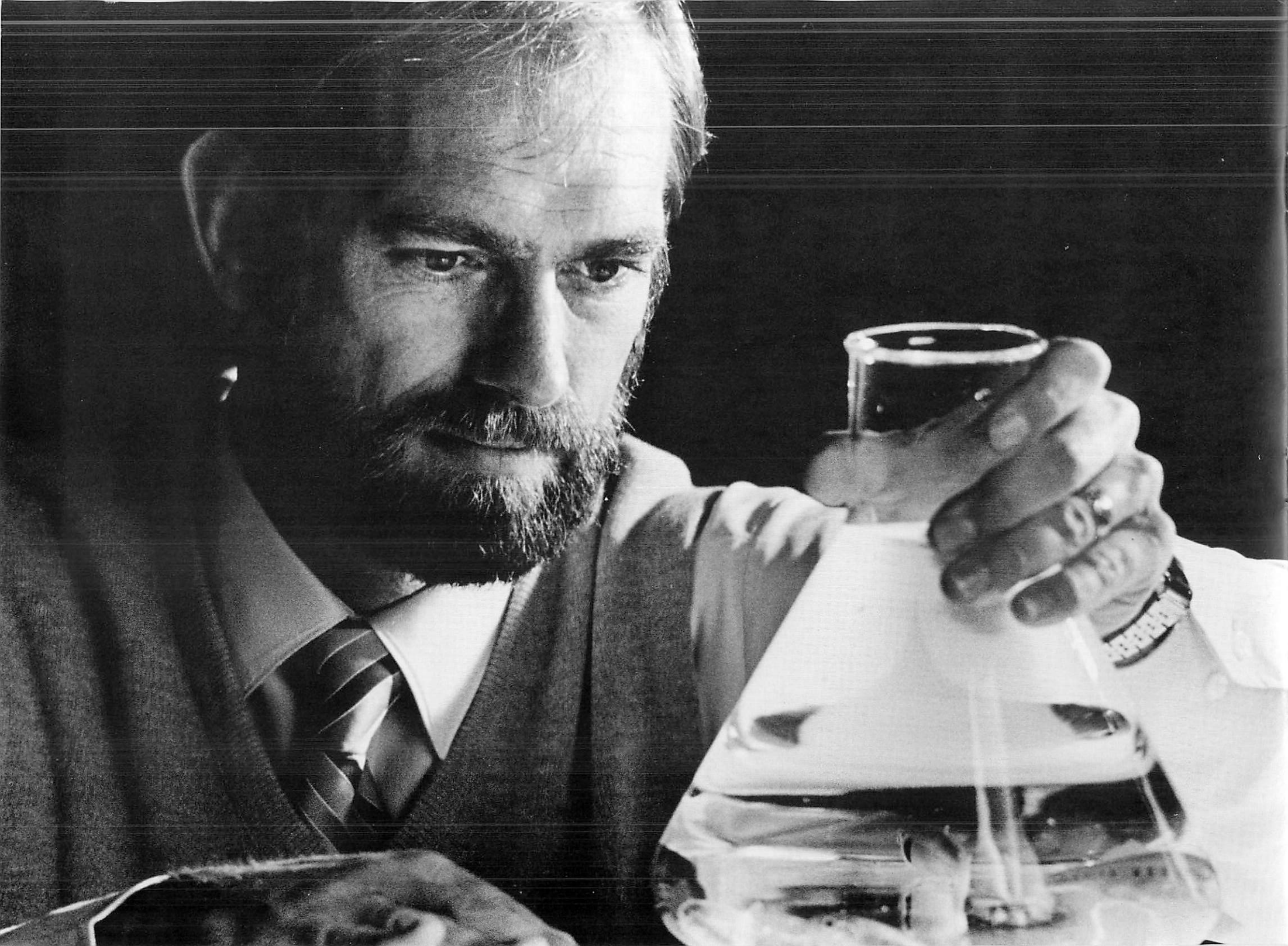


minute quantities of the synthetic chemicals morpholine and phenethyl alcohol, which could be used for imprinting.

"These odorants are nontoxic, stable in water, and effective in imprinting," Schreck says. But, he adds, before the chemicals could be used on any large scale to assist homing, one potential side effect needed to be checked.

"We needed to know whether untreated or wild fish would be confused by the unfamiliar chemical and see it as a kind of signpost indicating that they had come the wrong way."

With the cooperation of the Oregon Department of Fish and Wildlife, Schreck conducted a demonstration project at the Salmon River hatchery near Lincoln City.

Experimental results reported in 1984, based on returns of coho in the fall of the previous two years, showed that a trace of morpholine at the hatchery entrance did not repel returning hatchery adults that had not been exposed as young fish to the odorant. This nontreated control group and the morpholine-exposed trial group returned in similar numbers, Schreck says.

"Our interpretation of these data is that managers don't have to worry that using the odorant might confuse nontreated or wild fish," he says. "It won't."

As gratifying as this information is, getting fish back to the hatchery is only one part of the job of ensuring continued hatchery production, Schreck observes. In some cases, females have died in large numbers from stress or disease before ovulating, thereby severely limiting production.

Particularly troubled by this problem, Oregon Aqua-Foods, the Weyerhaueser salmon-ranching subsidiary in Springfield, Oregon, cooperated with Schreck by providing female coho for some experiments.

The first tests, in 1978, used an extract of a hormone naturally found in the salmon pituitary gland. It successfully induced ovulation within two weeks in 90 percent of the cases. However, the natural hormone was hard to obtain and expensive to use, costing about $5 per fish.

After further tests, Schreck and graduate student Marty Fitzpatrick found that a synthetic hormone worked just as well as the natural one. Plus, it was much cheaper to use: about three cents per fish. Ore-Aqua enthusiastically began using the new drug—known as LHRH, for luteinizing hormone-releasing hormone—on a portion of its brood stock.

Research conducted in 1984 showed that by monitoring hormone levels in the females' blood, hatcheries can determine the best time to administer the drug. Fitzpatrick is optimistic that with this information hatcheries will be able to fine-tune their treatment of females, avoid barren mortalities, take eggs sooner, and accelerate the rearing of young salmon.

In yet another area of salmon hatchery practice, Schreck's research promises significant returns. Schreck and colleague Hiram Li are developing new techniques to increase salmon egg production.

"This research is a logical extension of our Sea Grant work with spawning of female coho, and it builds off of research we've been conducting for 10 years," says Schreck.

The logic appears basic: to produce more eggs, Schreck and Li plan to produce more female salmon. They will be working not only with coho, Oregon's commercially most important salmon, but also with chum, which formerly was abundant off Oregon, but today exists only as a remnant stock.

The techniques the researchers use are novel. "One essentially involves irradiating the sperm, which makes it incapable of transmitting genetic information to the egg," says Schreck. The result is progeny which are all female. The other technique accomplishes the same thing by treating juvenile fish with sex hormones.

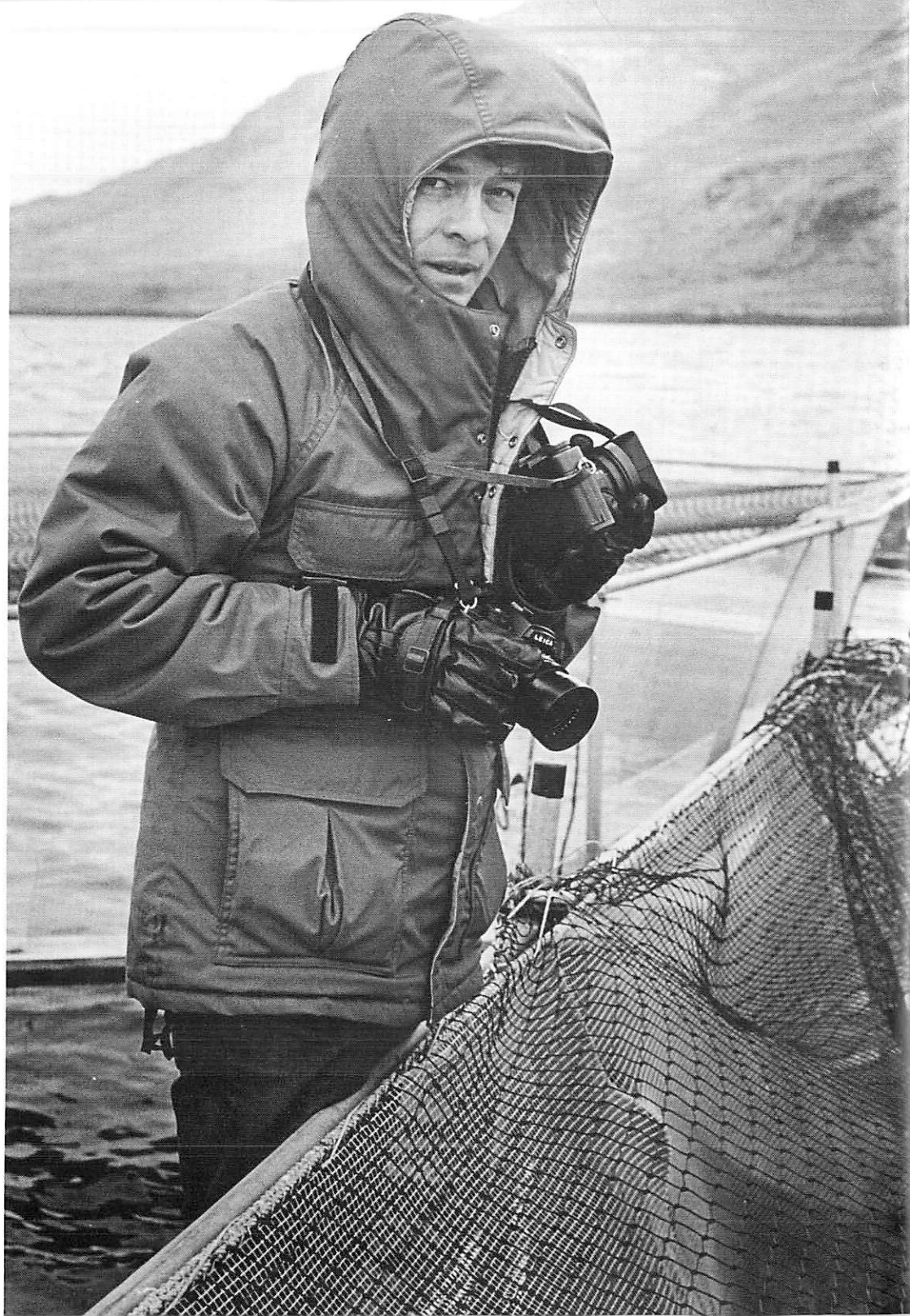
Both techniques have been effective in producing 100 percent female populations in trial experiments, and during the 1985-87 biennium, Schreck and Li plan to address a number of specific questions about their new fish.

"We need to evaluate the performance of these altered salmon during the stages of their life cycle, specifically their growth, seawater adaptability, and reproductive fitness," says Schreck. Research is being conducted in hatcheries and at the Marine Science Center, he notes; none of these experimental animals will be released into the ocean.

If the altered salmon do prove to be viable, Schreck foresees significant benefits. Public and private hatcheries will use additional coho egg supplies to enhance stocks, while more chum eggs will aid the ongoing efforts of the Oregon Chum Growers Association to restore this fishery. Beyond these benefits are export opportunities.

"The Japanese have been paying $35 per pound for salmon eggs for caviar," Schreck notes, adding, "Export of surplus eggs could offer a very attractive new foreign trade opportunity."

Carl Schreck, leader of the Oregon Cooperative Fisheries Research Unit, has been adapting freshwater salmon hatchery techniques to find ways of improving return rates and boosting egg production.



Atlantic salmon, raised in floating net pens in Scotland and Norway, compete for a share of the world market and affect the price fishermen in the northwestern United States receive for wild coho and chinook. Sea Grant communications director Jim Larison spent a week in Scotland filming net pen culture for a television program on world seafarming broadcast November 13, 1984, on the PBS science series NOVA. (Photo by Elaine Larison)

International salmon trade has been changing significantly in recent years, and monitoring and attempting to understand those changes have been concerns of another Sea Grant research project during this biennium.

OSU resource economist Dick Johnston has devoted several years to developing mechanisms for better sharing of information among seafood industry participants. This interest led to the formation of the International Institute of Fisheries Economics and Trade in 1982, sponsored initially in part by OSU Sea Grant. While the Institute and Johnston's 1983-85 Sea Grant project address many other world seafood markets, Johnston says that the information being gained about the changing salmon market is of particular interest to the Northwest.

Time was, says Johnston, when Pacific salmon from the U.S. was the undisputed king in world markets and canned salmon was the market leader. But today, increasing competition from fresh or fresh-frozen Atlantic salmon raised in several other countries, notably Norway, is cause for concern. The U.S. itself imported almost 4 million pounds of Norwegian salmon last year, valued at more than $12 million, and the trend is likely to continue.

"My belief is that U.S. producers may do well with the market niche that Norwegian aquaculturists have been developing in the U.S., once the dollar again becomes more competitive with the Norwegian kroner," says Johnston. On the other hand, the economist sees U.S. producers facing stiffer competition in Europe, where Atlantic salmon has the price and taste preferences of Europeans more in its favor.

Even as new and complex international economic factors now affect the fate of Oregon-produced salmon, so too, new, even unprecedented, laws regulating salmon production in the Northwest have come into effect in the 1980s. Both changes require those involved with the salmon resource to make adjustments.

Sea Grant, long an innovator in research and education focusing on the biology and economics of salmon, anticipated the demands of this changing legal regime and, starting in 1979, began an effort to provide information to lawyers, management professionals, and policymakers about the changes affecting them. *The Anadromous Fish Law Memo*, developed and edited by Michael Blumm, professor in the Natural Resources Law Institute at Lewis and Clark College, is the unique result.

"Certainly the most important legislation affecting the long-term abundance of salmon throughout the Northwest is the 1980 federal Northwest Power Planning Act," says Blumm. The Act led to the creation of the Columbia Basin Fish and Wildlife Program in 1982, which Blumm says "has already done more for the fishery resource than was done in the last 50 years."

During the last half century, massive dam building on the Columbia led to a two-thirds decline in the commercial catch of the river's salmon. All legal remedies for the dam-related losses before the new Columbia program "lacked teeth," says Blumm, but the new plan, administered by the Northwest Power Planning Council, offers real hope for "not only restoration, but enhancement" of the salmon runs, the legal expert says.

The Power Planning Council has committed more than $750 million to these salmon efforts over the next 20 years. This money will come mostly from Bonneville Power Administration wholesale power rates. Now that the U.S.-Canada salmon treaty, which will prevent the overharvesting of Columbia salmon, is law, these expenditures "could have dramatic benefits over the long term," Blumm believes.

But the first years of the fish restoration program have been marked by less than unanimous cooperation among affected parties, he notes. Those governmental entities whose former powers are now redefined have been slow to accommodate the new regime.

"This is probably to be expected," says the lawyer. "In any event, it illustrates the need for the *Memo* and for better understanding of the needs of the salmon resource."

Twenty-eight issues of *The Anadromous Fish Law Memo* have been published since 1979, and response among the intended audience of policymakers has been very positive. A letter from National Wildlife Federation counsel Terence Thatcher to Sea Grant director Bill Wick appraises this Sea Grant effort: "I can say, without question, that the analysis and information provided by The *Anadromous Fish Law Memo* is an invaluable tool both for me and for everyone else I know who is working in this field. That list includes government employees, concerned citizens, and those who represent the region's resource users, such as hydroelectric project operators and commercial fishermen. . . . The region needs this sort of analysis and discussion."

Says Bill Wick, "The *Memo* is just the kind of future-oriented effort that much of our Sea Grant salmon research has been for many years."

MORE FISH, LESS SPACE, MORE RISK

It's March 1985, and John Fryer is beginning to present the Phi Kappa Phi distinguished faculty lecture, reflecting on his three decades of fish disease research. He promises the lunchtime crowd in the OSU Memorial Union a slide show of fish culture around the world, but first he sets the stage.

Fryer, chairman of the OSU Department of Microbiology and long-time leader of Sea Grant fish disease efforts, says that the incidence of bacterial, viral, and protozoal diseases of fish is increasing worldwide. This increase represents a "crucial limitation" on fish raising and a "continuing challenge" for scientists.

Aquaculture production of many fish species has increased during the last decade, Fryer notes. Now public and private fish raising is both a growth activity and one hope for supplementing the world's increasing need for protein.

But raising fish in controlled environments "is akin to poultry production in terms of intensiveness of management and the potential for disease," Fryer warns. Whenever production intensifies, the risk of infectious disease increases. More fish, less space, more risk.

It could be a frame from John Fryer's slide show, but it's real life, the daily, quiet drama of the fish disease lab across campus in Nash Hall. Warren Groberg, a fish pathologist with the Oregon Department of Fish and Wildlife, is pointing to a tray of tissue cultures with an accusatory finger.

"When our salmon cell cultures are infected with IHN virus, it takes less than four days, and then they look like this."

The neat plastic tray has a dozen tiny reservoirs, each holding thousands of translucent salmon cells. On this morning, however, some of the cells appear glassy and misshapen. Under a high-power microscope the drama comes closer; the normal cells, cobblestone shaped and clear, are being invaded by something that makes them shine and swell and, later, burst. The cause is IHN, infectious hematopoietic necrosis virus.

First isolated in Oregon salmon by John Fryer in 1958, the deadly IHN has occupied the attention of a decade of fish biologists and pathologists in the Northwest. Groberg, who has been on the trail of the salmon virus since the late 1970s, was the first to document its spreading through the Columbia Basin, in a Sea Grant research paper with Fryer in 1982.

"It's a frightening disease for a hatchery manager because it strikes quickly, kills in large numbers, and has no known cure," says Groberg. The number of young salmon fry and eggs that have been lost to IHN in the Columbia Basin from 1980 to 1983 is 14 million. The estimated value of this lost salmon production ranges from $30 to $100 million, depending on the value given to the spawning adult fish.

The struggle to understand and control the disease now has top priority with a number of state and federal fish agencies. The stakes are high. Many people are rallying around long-needed efforts to restore dwindling Pacific salmon stocks and put them on a sustainable basis.

The regional Northwest Power Planning Council operates perhaps the most comprehensive and ambitious government program, while each of the Northwest states also has its own stock-enhancement plans. Hundreds of individual fishermen throughout the Northwest are giving nature a hand as well, involving themselves in dozens of small-scale projects. In-stream hatchbox rearing of fish sponsored by the Oregon Department of Fish and Wildlife Salmon and Trout Enhancement Program (STEP) is one such effort. Even international cooperation has been forged to benefit salmon. After 20 years of discussion, the U.S. and Canada finally agreed in 1985 to a treaty that would lead to the rebuilding and fair harvest of salmon runs from California to Alaska.

But all this effort and good intention could be undermined, pathologist Groberg worries, by the "explosive" spreading of IHN. Outbreaks of IHN in the Columbia Basin states of Idaho, Washington, and Oregon surged from a single Oregon hatchery in 1980 to at least 13 hatcheries through 1984.

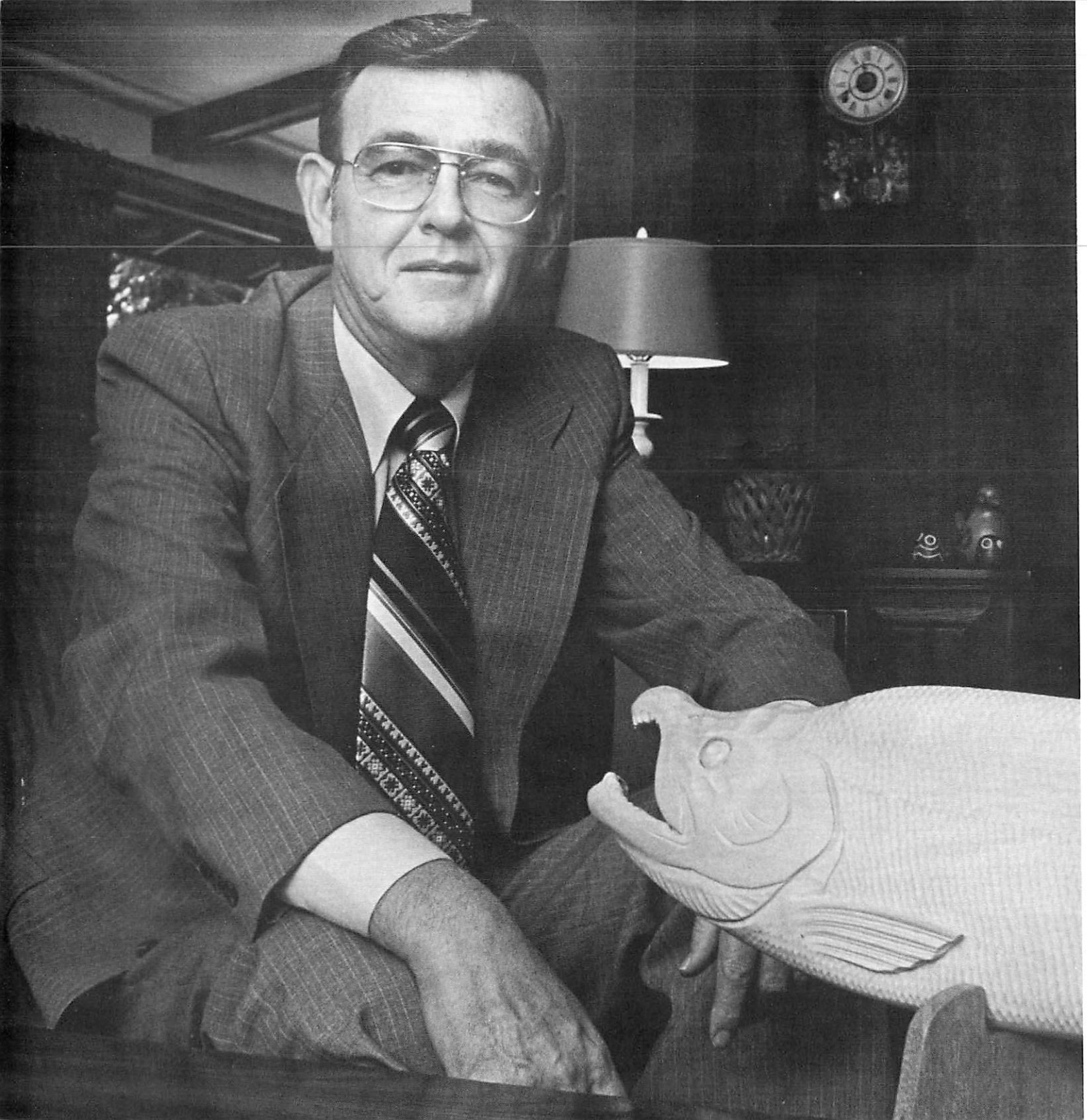
Since no cure for the disease is currently available, prevention is the watchword. On the first line of defense against IHN, and other fish diseases, is the partially Sea Grant-funded Fish Disease Laboratory at the Hatfield Marine Science Center in Newport. From there professors Bob Olson and Jim Winton and research associate Cathy Lannan monitor fish health at hatcheries throughout the Northwest.

In an effort to avoid diseases and prevent their spreading throughout the region, state and federal regulations now require fish hatcheries to monitor the health of their stocks to be able to certify that they are disease free. The Hatfield Center fish disease lab provides a diagnostic and certification service to private aquaculturists in the Northwest. It also examines fish for the Oregon Department of Fish and Wildlife and for other state and federal agencies.

The lab is "well used," says Winton. Approximately 3,000 fish representing 91 lots were inspected during 1984. A visitor to the lab can see fish in various stages of examination and the tools—the pipettes, the tissue cultures, the agar plates—used to track down their killers.

That the disease surveillance efforts at the lab are rigorous was given dramatic proof during the last three years. A virus which had never been seen before and which exists only in small concentrations was discovered in a small number of chinook salmon from three different river systems along the Oregon coast.

"Normally, fish viruses will destroy our cell cultures in two to four days, but this virus took 28 to 29 days," Winton says. "We're one of the few labs that looks at cultures for that length of time."



The incidence of bacterial, viral, and protozoal diseases of fish is increasing worldwide. According to John Fryer, chairman of the Department of Microbiology, it's a "crucial limitation" on fish raising and a "continuing challenge" for scientists.

The virus is the first member of the paramyxoviruses, which are normally found in warm-blooded animals, that has ever been found in a cold-blooded species. It doesn't appear to cause disease, Winton says, and is "at present primarily of scientific interest." Winton expects that virologists who study some of the common paramyxoviruses, such as measles and mumps, will find the chinook virus an "intriguing" discovery.

Discovery and characterization of previously unidentified pathogens is nothing new at the fish labs in Newport and Corvallis. During the last two years, Winton also characterized a new reovirus of salmon. Olson found that the parasite *Parvicapsula* occurs in Oregon and can cause mortality in saltwater-reared salmonids.

While the labs remain busy monitoring and identifying pathogens, another component of Sea Grant fish disease research concentrates on another strategy of disease prevention, immunization.

The first commercially available vaccine to successfully provide immunity against a fish disease was developed by Fryer in a 1976 Sea Grant project. That vaccine, against the widespread salmon bacterial disease vibriosis, employed a novel technique which has since become widely used—spraying the fish with the immunizing agent.

"The spray technique made the vaccine practical," Fryer notes, adding, "Can you imagine injecting millions of little fish at a hatchery?"

The technique has since come into common use at hatcheries worldwide, while development of vaccine technology has become a focus of Sea Grant research at OSU. During the last two years, John Rohovec and graduate students Yenling Song-Tsai and Mercedes Zaldivar have completed preliminary studies that are expected to lead to a vaccine against the bacterium *Flexibacter columnaris*.

Another disease has proved a "formidable opponent," says Fryer, though here, too, progress is being made toward developing a vaccine. Bacterial kidney disease, BKD, is this opponent.

BKD has been identified as the most important bacterial killer at freshwater hatcheries throughout the Northwest, Fryer notes. But research at the Newport facility and on campus goes further, suggesting that it is responsible for a sizable number of salmon deaths in the ocean.

One of the unresolved problems in salmon culture during recent years is the decrease in adult salmon populations returning to Oregon, despite the increase in the number of juveniles sent out to sea from Oregon hatcheries.

Microbiologist Jo-Ann Leong is one of a small number of scientists in this country who are applying the powerful tools of genetic engineering to the problems of fish disease. She hopes to build a vaccine for one of the most serious killers of hatchery salmon, the IHN virus.

"Three-tenths of one percent return is thought to be good" for some salmon stocks, Fryer observes. "Certainly disease could be an important factor." The OSU research team, with additional funding from the Bonneville Power Administration and ODFW, began saltwater studies.

They suspected that BKD could be a significant cause of death in the ocean, because the disease weakens the kidney of juvenile fish, and it's the kidney which needs to function properly to maintain fluid balance within the young fish as it attempts to adapt to salt water.

The Newport lab was an "ideal" place to conduct these experiments, says Winton. "This is a unique facility because of its seawater quarantine capabilities."

Juvenile salmon were infected with BKD and kept in pathogen-free saltwater holding tanks for up to three years while scientists monitored the effect of salt water on them. Deaths increased as the fish were kept in salt water.

"Now, we can't say that half of the ocean mortality of salmon is due to BKD," says Winton, "but we do think that BKD may be responsible for some—perhaps a large part—of ocean mortality not caused by predators." A vaccine would be very desirable, he says.

Fryer and Jim Sanders laid the groundwork for developing a vaccine during the last two years by characterizing the bacterium (it has recently been classified as a unique bacterial genus and species), studying its cellular biochemistry, and screening a number of potential antimicrobial agents.

But producing the vaccine is going to be a challenge, says Fryer. The bacterium is able to invade and survive within the salmon's own disease-fighting cells, the phagocytes. In fact, BKD ultimately kills the phagocytes, Fryer says.

Nevertheless, Fryer expresses optimism that what he calls "innovative" research currently in progress by colleague Steve Kaattari will ultimately bring BKD under control.

The pattern in OSU microbiology of taking novel approaches to fish disease vaccines continues in the laboratory of Jo-Ann Leong. Leong is using the technology of genetic engineering to build vaccines against not only IHN virus, but the other major virus of salmonid fish, IPN, infectious pancreatic necrosis.

"Our approach employs basically the same, fundamental gene-splicing techniques used in the recent development of vaccines against poliovirus," says Leong.

She illustrates the principles of vaccine production, referring to IHN. In her Nash Hall lab, Leong points to a specially prepared photograph showing a long, vertical strip broken into several horizontal bands. "This particular

band is very important to us," she says, "because it's the exterior protein coat of the virus."

The protein surface of the virus causes a host organism to build up antibodies against the virus, and it is this virus that she isolates and clones, Leong explains. These cloned fragments are then inserted into beneficial bacteria where they grow into high volumes, and the prepared product, known as a bacterin, becomes the vaccine which is sprayed on fish to give them immunity.

The new genetically engineered IHN vaccine will provide a solution to an otherwise very difficult drug design problem, Leong says. Conventional vaccines are made by weakening the disease agent with heat or chemical treatment and then subjecting the host to the attenuated virus, which prompts immunity. The difficulty with this method is that there is always the risk of the weakened pathogen becoming potent again and causing new outbreaks of the disease it was meant to control.

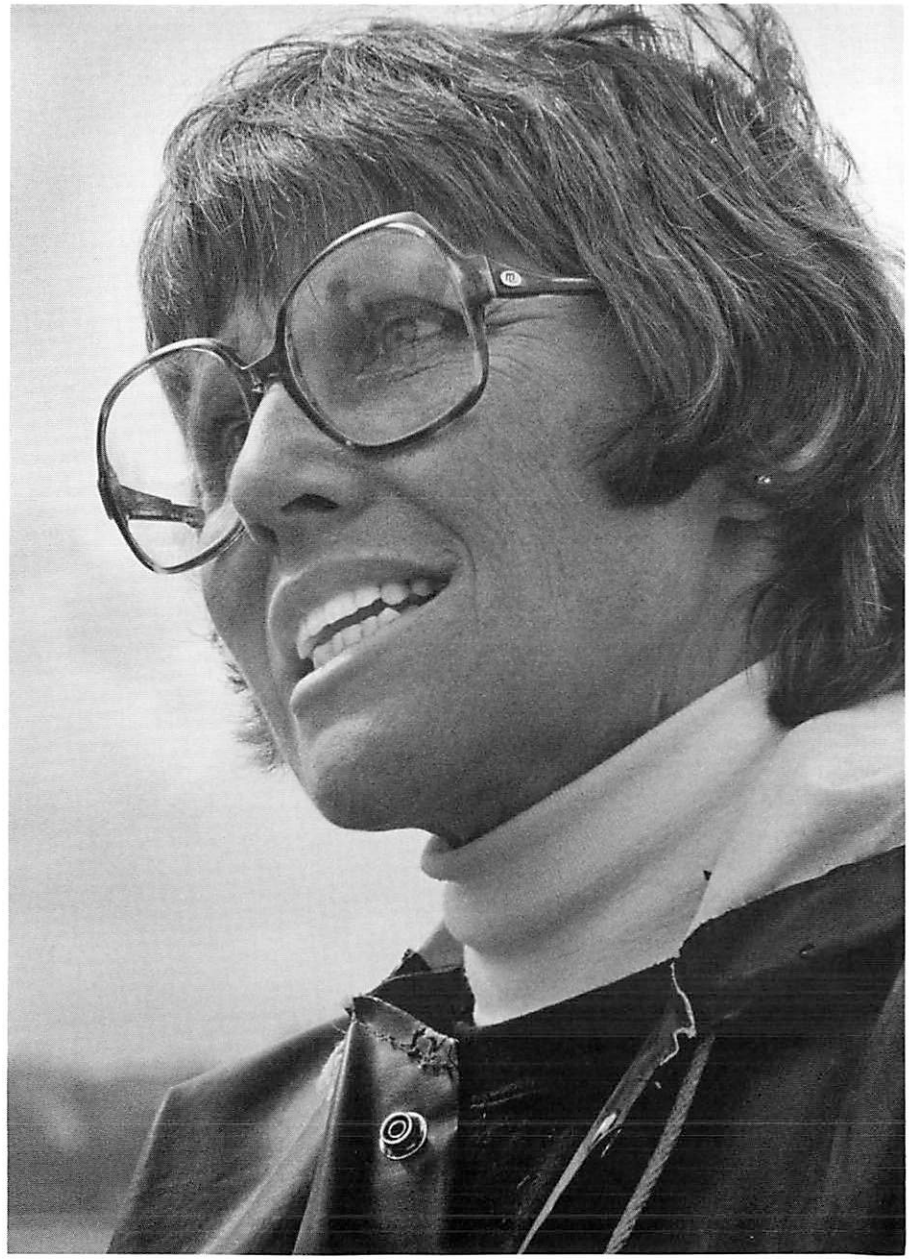
As a result, conventional vaccines must pass through a time-consuming and costly testing period. "Our salmon resources are so precious at this point—there is so much effort toward rebuilding stocks—that we need to act as quickly as possible in developing something very safe," says Leong.

Her IHN virus will not run the risk of causing disease, she explains, because only a portion of the genetic information of the virus has been included in the vaccine. "The instructions just aren't there," she says.

Additional advantages of the so-called "subunit" vaccine are that the cloning technique should allow production in high volumes and at comparatively low cost.

Leong's work on IHN, which is funded by the Bonneville Power Administration, preceded by a year, and now progresses in tandem with, her current Sea Grant work on IPN. Infectious pancreatic necrosis is even more widespread than IHN, attacking salmonid fish in Europe, North America, and Japan, and also infecting eel, trout, and tilapia. Like IHN, IPN causes "catastrophic mortalities—90 percent or more—of infected fish," she says.

Leong's strategy for making a vaccine against IPN duplicates and builds off her IHN work. In the first two years of the research, which began in 1983, Leong cloned the virus and has begun to identify its sequence of genes. During the coming biennium she plans to isolate and clone the gene that codes for the immunizing protein, insert it into bacteria, produce a bacterin vaccine, and test it on juvenile fish. "I hope," she says, "that the vaccine can be available to hatcheries in three to five years."



One of the first lines of defense against the spread of fish diseases in aquaculture facilities in the Northwest is the Fish Disease Laboratory at the Mark O. Hatfield Marine Science Center in Newport. Research associate Cathy Lannan is one of a team of researchers monitoring fish health at the center.

HANDLING THE CATCH

Outside, beyond the deck of the trawler, the Pacific Ocean stretches to the horizon—vast and inscrutable, as it always has been. But inside, in the wheelhouse, TV monitors lay the ocean bare. Superimposed on a gridwork of lines marking the depth, a sonar picture reveals the ocean's treasure in streaks of color. The yellow dots near the top are clouds of plankton. Below, the jagged, red block is a huge school of Pacific whiting just coming on screen.

The captain tugs twice on the airhorn and his crew swings into action. Winches creak and giant trawl doors smack the ocean's surface. The net, one hundred feet long and seventy-five feet in diameter at the mouth, drops toward the ocean floor. With skill derived from years of practice, the captain adjusts the speed of his engines and flies his trawl through the school of whiting.

In an hour 30 tons of fish are on their way to the surface. In another hour the delivery is made—not to a processing plant on American soil, but to a Russian factory ship floating eight miles off the Oregon coast.

Joint ventures, such as this one between American fishermen and Russian processors, have become increasingly important to fishermen the world over. To fishing nations such as Japan, Russia, and Poland, such ventures guarantee continued access to the vast whiting and pollock resources which lie inside U.S. waters. To American fishermen these ventures offer a ready market for fish products which cannot be handled on shore. But many Americans are hoping to find ways to increase their own roles in this huge fishery—possibly by learning to handle and process the catch themselves, without the foreign factory ship.

Oregon Sea Grant is broadening its scope to meet this opportunity in the underutilized trawl fishery.

In June 1983 Bill Wick asked Ken Hilderbrand and Ed Kolbe to survey the seafood science and engineering research needs that would be important to the West Coast and Alaska fishing industry during the coming five years.

With the aid and advice of seafood researchers from industry, government, and academia, the two Sea Grant researchers drew up a list of priority project areas for the 1983-88 period. Underutilized fish stocks were on that list.

The northeast Pacific holds an abundance of fish that could be used for food and other economic purposes, the study found, and yet the opportunity is not being handled as well as it could be. Nontraditional species are not being used profitably, the Sea Grant white paper said.

Ken Hilderbrand took the initiative and put himself in a position to exploit the opportunity.

In 1983 Hilderbrand took a sabbatical in Akutan, Alaska, helping Trident Seafoods develop a huge, new processing plant for cod and pollock and document the plant development for the Alaska Fishery Development Foundation. In 1984, when the AFDF was coordinating a production trial to make surimi from pollock, Hilderbrand received the contract to organize trial production and quality control data.

Surimi is a washed, stabilized fish paste which can be made to take on a variety of textures and flavors. What makes it attractive from the industry's point of view is that an abundant, low-value resource can be transformed into a high-value product: from washed, deboned pollock can come imitation king crab legs or lobster. In fact, the largest potential American market for surimi may not be for seafood analogs at all, but as the protein base for a wide variety of imitation American favorites—"hamburger," "bacon," even nutritious candy.

The Japanese have developed the American market for imitation crab dramatically in just five years. From 1979 to 1984 Japanese imports jumped from minimal amounts to 80 million pounds, with a retail value of an estimated $300 million. Industry observers believe that the American market for surimi products in 1990 may reach one billion pounds, worth $3 billion retail.

American fishery interests are working hard to find out how real this alchemy of turning abundant fish into profitable products is. The Alaska Fishery Development Foundation invested more than $1 million in their pollock surimi trial, which began production in January 1985. Also during 1985, a project coordinated by the West Coast Fisheries Development Foundation, based in Portland, is bringing Northwest trawlers, processors, and seafood specialists together to see whether the surimi magic will work with the vast, underutilized species found off the northwest coast: hake, or Pacific whiting.

Hilderbrand is drawing on his experiences with Alaska pollock production to help guide planning sessions involving industry and academia. Hilderbrand is enthusiastic about the market potential of hake surimi.

"The Oregon fishing industry could make good use of the hake off our coast," he says. "The harvestable resource is perhaps 375 million pounds a year, and if that all were turned into surimi, the value would be in the neighborhood of $75 million."

In the Sea Grant white paper's list of "problems for the fisheries of Oregon," a main problem identified by Kolbe and Hilderbrand was that nontraditional fish species are not used profitably. Two tasks were identified: surimi development and identification of "necessary handling, processing, and storage requirements to enable use" of underutilized fish.

Kolbe's 1983-85 project on seafood handling and preservation was partly a research effort to document techniques for shipboard handling and partly an advisory effort to inform fishermen about equipment and techniques that are successful with different species.

The project brought Kolbe and coworkers on board fishing vessels, where they saw some of the challenges of high-volume, underutilized fishery exploitation at firsthand.

A day's catch in the hold may total 30,000 pounds of sole, Kolbe notes, and "the fish pack down and prevent the water in these cooling systems from getting through the mass and cooling adequately."

With pollock, where the day's catch may total 100,000 pounds, the preservation problems only intensify, says the refrigeration specialist. "If you don't design the fishhold and the cooling system right, it takes days to chill the fish down," Kolbe observes, and at that point quality has declined significantly.

For pollock, the raw material of Alaska surimi, one recommendation made by Kolbe and his Alaska Sea Grant colleagues is an innovative cooling system that uses chilled seawater mixed with ice stored on shipboard. The key element in this "slush-ice" approach is not water, however, but air. A grid of perforated pipes is laid out on the floor of the fishhold and air is bubbled through it.

"Just the physical expansion of the air as it goes up will cause a circulation of the cold water through the fish mass, cooling it," says Kolbe.

This bubbled-air, slush-ice cooling system and systems using mechanically refrigerated seawater were originally developed by Canadian researchers for the salmon industry. But, Kolbe believes, they will also be instrumental in the success of the surimi industry. However, more research by food scientists will be needed to demonstrate the relationship between pollock deterioration and improper cooling systems, he says.

"As an engineer, I can recommend changes, but these systems represent a new expense, and the industry may need more proof," says Kolbe.

But he's optimistic that industry will see the need for improved handling, especially as the volume of the catch of pollock off Alaska and whiting off Oregon increases to meet projected demands for surimi.

"The industry overall realizes that a quality product is the key to growth; that's true in general for seafood, not just for surimi," he says.

Dave Crawford's innovations in shrimp processing are a notable example. In the late 1970s Crawford, director of the OSU Seafoods Laboratory in Astoria, turned his attention to shrimp and the industry methods that were essentially washing a significant portion of the meat down the drain.

"Ice water," he says, "was part of the problem." Everyone else in the shrimp industry apparently saw ice water as the solution to keeping whole shrimp from spoiling after being caught. But the washing of the shrimp by the ice water abetted the natural enzymatic breakdown of shrimp protein and led to excess losses of shrimp meat, Crawford explains.

His approach was to find a harmless chemical, commonly used in food processing, which would allow more of the shrimp meat to be conserved. A phosphate bath did the trick.

"When the shrimp are dipped into a phosphate bath, it penetrates through the shell and essentially seals the protein, making it less soluble during processing," Crawford says. The phosphate dip increased meat yield from 20 to 22 percent to 28 to 30 percent of the original raw shrimp, as much as a 33 percent gain over then-current industry practices. Crawford's technique, presented to the industry in publications and workshops, has since become widely adopted.

Crawford's 1983-85 shrimp research returned to the ice water problem.

Shrimp boats put their catch in refrigerated seawater or ice, which retards spoilage but sacrifices some shrimp meat, Crawford knew. The challenge was to find an antibacterial medium that would still allow for a high-quality finished product.

A mixture of potassium sorbate, citric acid, and phosphate developed at the Astoria lab solved the first problem, maintaining antimicrobial effectiveness twice as long as refrigeration in ice water.

And when Crawford refrigerated the shrimp in the lab without ice, the yield of meat after processing gained another 4 percentage points above the 30 percent yield the lab regularly attains with the phosphate dip innovation. "Those 4 points translate into 40 pounds per 1000 pounds raw weight," Crawford observes.

"At $4 per pound, that's an additional $160 of profit per 1000 pounds for the processor," he says.

Crawford, Hilderbrand, and Kolbe—their approach to research attests to the value of a multiyear commitment of funds to worthwhile projects; such continuity allows for the identification and resolution of the real problems. Such continuity is often provided by Sea Grant funding.

Dave Crawford heads the Oregon State University Seafoods Laboratory in Astoria. Investigators at the laboratory are finding better ways of preserving and handling foods.

Within our 200-mile Exclusive Economic Zone lie great numbers of underutilized fish species such as pollock. Most are either caught or processed on board foreign factory ships. American fishermen hope to displace these Russian, Japanese, and Polish vessels and capture this potential wealth for themselves.

DOWN ON THE DOCKS

Bill Wick is sitting at one of the computer terminals in the Sea Grant administration office, the one that connects to other Sea Grant directors' offices on the Pacific, Atlantic, and Gulf coasts and the Great Lakes. The "electronic mail" is just one piece of a larger puzzle.

Another piece is off to Bill's side. On the wall hangs a display rack with a few dozen brochures and pamphlets. Catchy headlines, splashes of color, these Sea Grant publications wind up in vacationers' pockets, on professors' desks, next to a coffee cup in a wheelhouse. The homely virtues of the tangible.

Above the display rack looms a framed picture, large, imposing. It's a freighter at night on the Columbia River, its lights braving the darkness. The image is a frame from one of communications director Jim Larison's films. Where these Sea Grant films will end up is hard to predict. They have been rented and seen in high school social studies classes in the Midwest and bought by TV stations and shown nationwide to millions. Another piece in the design.

This is the Age of Information, the pundits tell us. Information, readily available information, is today's most valuable commodity. To Bill Wick, the idea is not new.

Making information available to the public was his vision for OSU Sea Grant from the beginning.

There were skeptics within the program at the start, of course. "The originators of Sea Grant were, for the most part, researchers" whose jobs didn't put them much in contact with the general public, Wick notes. But his experience as an extension agent in coastal Tillamook County taught him "there was a big, pent-up demand for marine-related information."

In Tillamook it was technical information first of all that he got calls for, beginning about 1960. Oyster growers mainly, then others in the shellfish industry. It wasn't long before coastal residents with "every kind of question" turned to Wick. He drew what he could from books and "asked lots of questions myself."

"Pretty soon I had become a one-man band" of practical marine information, he says. He wrote a regular newspaper column, worked on some TV shows, talked with coastal residents up and down the coast.

When the Sea Grant concept came along, Wick saw the opportunity to orchestrate his one-man band. When Oregon Sea Grant was officially established in 1968, he was the first leader of the Marine Advisory Program, now known as Extension/Sea Grant.

In a speech to the second national Sea Grant conference in 1968, Wick explained his vision of extension's role in Sea Grant. "Putting America's oceans to work requires major national commitment," he began.

> The universities can play a significant role. Training students, however, is not enough. Applied research on ocean problems is not enough. But insuring the public use of knowledge through an organized advisory program—combined with training and research—is a first team effort.

This vision of "insuring the public use of knowledge" has animated Extension/Sea Grant ever since.

In the early years of the program, marine extension agents earned a reputation for doing what county extension agents had done for years—providing practical information to help people make good use of natural resources.

Extension/Sea Grant county agents and subject-matter specialists still provide this kind of service, says Howard Horton, current leader of the OSU Extension/Sea Grant program. But today, Horton observes, they're doing something more as well—providing leadership to confront the issues of the day.

"People are looking to us and we're responding with leadership—a regional, coordinating, leadership role," Horton says.

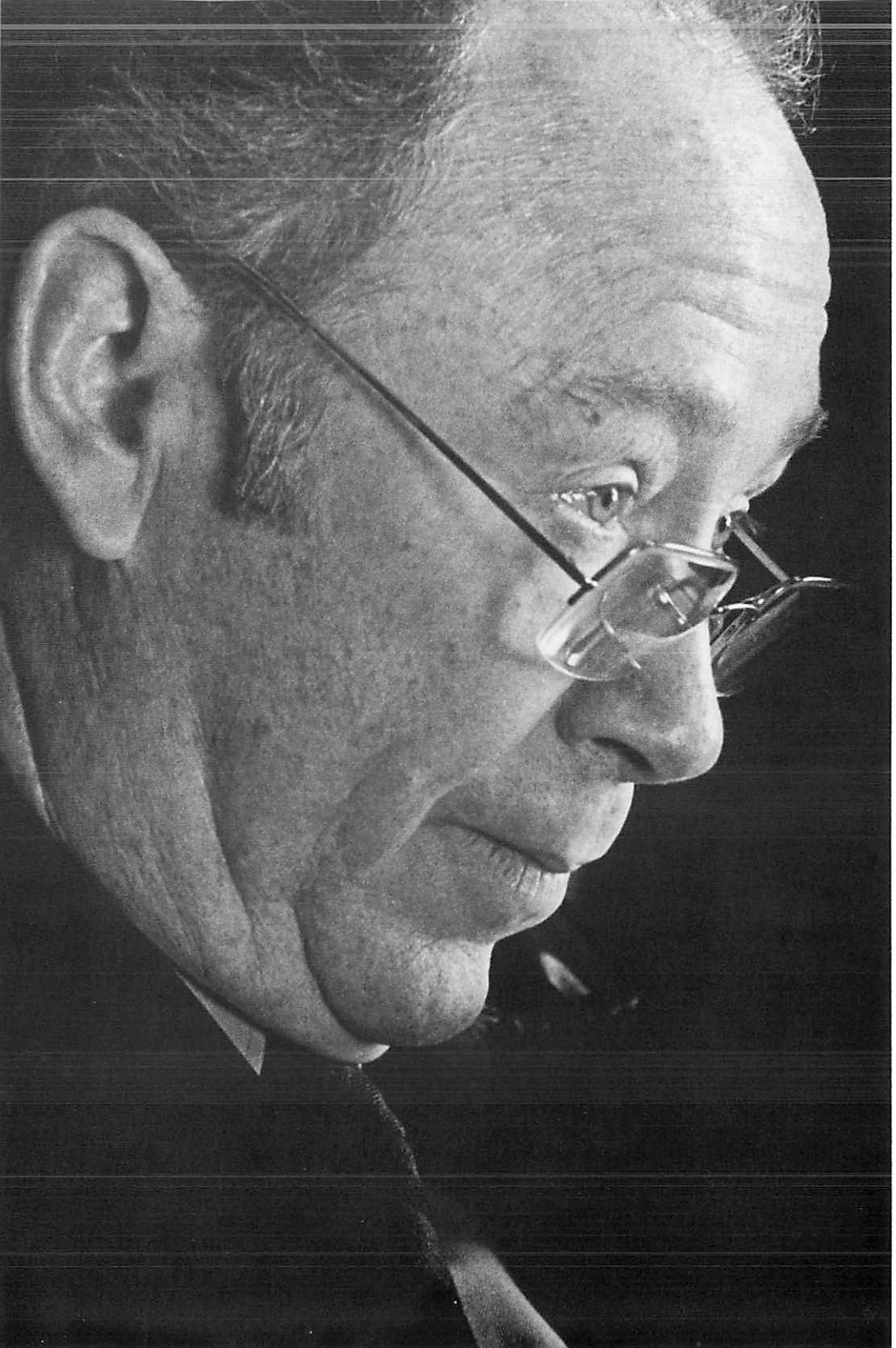
During the last two years, OSU Extension/Sea Grant has organized or cosponsored numerous large-scale public conferences for the marine community. In 1983, for example, Clatsop County agent Jim Bergeron coordinated the three-day Inshore Fisheries Conference at Fish Expo in Seattle. The 16 conference sessions involved 48 speakers and drew more than 3,000 persons from throughout the North American fishing industry.

Gib Carter hosted the 11th and 12th sessions of The Future of Northwest Maritime Industries Conference, attracting participation from agencies as well as commercial interests such as timber and wheat exporters, ports, shippers, and tug operators.

As another example, each June, Mike Spranger, whose duties as an Extension/ Sea Grant specialist cover both Oregon and Washington, ventures deeper into Columbia issues with the Columbia short course. This educational weekend gives 100 or more participants a guided tour and firsthand look at the complex resource and management issues surrounding this unique Northwest resource.

Horton cites several other conferences, involving virtually every one of the 17 agents and specialists, but he singles out one for illustration.

The Fishing for Answers conference, held in Newport in March 1985, was cosponsored by OSU Extension/Sea Grant and the Oregon Coastal Zone Management Association, an intergovernmental organization which has been



giving special attention to the coastal fishing economy. The conference brought together participants from throughout the fishing industry and from each West Coast state as well as Canada and Australia to discuss an issue "that had been on many people's minds for a long time, but was always before thought to be too hot to handle," says Horton.

The issue is "limited entry"—limitations on the number of fishermen in the industry. The hard economic times of the last few years of fishing made the topic timely, says Horton, and it was a combination of its timeliness and the objectivity of the approach of Fishing for Answers that made the conference what Horton calls "a huge success."

But leadership is more than pulling people together at the right time and in the right way. Those are the effects of leadership.

"You can only do these things when you've built up equity," Horton says, meaning the credibility that the extension agents have built up every day, over years. "These agents are down on the docks, talking, working. They know the people. They know what the issues are."

Horton gives much of the credit for the success of the limited entry conference, for example, to Newport-based agent Bob Jacobson, who was both a conference organizer and the moderator of the sessions themselves. As moderator, Jacobson presided with equanimity over the diverse discussions and the potentially volatile question-and-answer sessions that followed them, quietly addressing each speaker by name, keeping things on an even keel.

"Jake has respect," Horton says simply. That respect is testified to by the three major awards Jacobson has received during the last two years, one from the National Marine Fisheries Service for "pioneering achievement and outstanding accomplishment and service to his community, profession, and institution," another Superior Service award from the U.S. Department of Agriculture, and a third, an Outstanding Extension Agent award from the Oregon Extension Association.

When you have the kind of experience in an industry that Jacobson exemplifies, Horton says, it's only natural that the role you begin to assume is more reflective of that range of experience. "As a program we're doing more than imparting particular technical skills," he explains. "We're helping people understand the circumstances they're in, understand their options—and change their way of thinking and behavior."

In a nutshell: Helping people see the opportunities where before they may have seen only the constraints.

According to Howard Horton, head of the Extension/Sea Grant Program, "you have to have the courage to go into a subject that is controversial. Sometimes you get your nose poked, sometimes you get patted on the back. But . . . that's where the need may be the greatest for our help."

In this new, enlarged role, Extension/Sea Grant reaches out to diverse audiences. Connections are made by tailoring the media to the audience, and in the last two years, the use of media often has been innovative.

Economist Fred Smith's workshops on computer applications for ports and small marine businesses are a good case in point.

Five years ago two ports—Portland and Newport—were using computers to help with management. Today, the ports of Coos Bay, Astoria, Cascade Locks, Tillamook, and Brookings have all begun to use computers.

Smith is continuing to offer workshops in port management and computer use and looks forward "to the day when the port manager has a computer on his desk and turns to it regularly to do an analysis or to get a sense of the whole picture of his operations. Then we've made a great leap forward," he says.

Communication specialist Tom Gentle leaped into the world of electronic media during the biennium.

Gentle, a writer, editor, and photographer, combined those media skills to film and produce a half-inch videotape. It shows Oregon fishermen who might want to break into halibut long-lining how it's done.

A fisherman can borrow the tape and learn at his own pace, going back over points he's interested in, and can come away from the viewing with—even more literally than with computers—the "sense of the whole picture." The same tape can serve this function for many fishermen, thereby increasing both the range and the efficiency of Extension efforts, Gentle points out.

The new technology of video and microcomputers is quickly proving its worth in meeting the information needs of Extension clients with specialized interests, program leader Horton says. But he adds that Extension has also pioneered innovative approaches to reaching the general public.

The Hatfield Marine Science Center is "the showcase" for Extension public education activities, Horton notes. More than 350,000 people annually visit the Newport center and its 16-tank saltwater aquarium and 10 museum displays, which are operated by OSU Extension/Sea Grant staff. Education specialists Don Giles and Vicki Osis led some 10,000 students and their teachers through the exhibits during the 1983-84 school year alone.

Workshops, lectures, van tours, films, and dock and tidepool tours are among the attractions during the summer-long Seatauqua program, conducted by Extension/Sea Grant at the Hatfield center. In a day, a visitor can have such diverse pleasures as touching a starfish, seeing a movie about whales, or learning how best to catch a razor clam, all as parts of Seatauqua. Agents and specialists lead many of these activities.

For more directed classroom instruction, education specialist Osis combined with Washington Sea Grant marine resources specialist Spranger to produce two curricula on the Columbia River, one for primary, another for secondary school use. The classroom materials, first field tested in 15 schools, have now been widely distributed, and plans are being made to adapt this information to the current classroom tool of choice, the computer.

"This is a flexible, responsive program, a mature program" says leader Horton. Part of the reason for its maturity as a program is that many of the staff members have worked and grown with it over a number of years.

In 1967, Bob Jacobson became the first full-time marine extension agent, not only in Oregon but in the country, and Jacobson's years of service are nearly matched by those of Giles and Smith (1968), Heikkila and Hilderbrand (1969), Osis (1971), Faudskar (1972), and Bergeron (1974).

The maturity of the program, though, is not so much a matter of longevity as it is ripeness, says Horton.

"We've developed strong roots over the years, and branched out, and now the program is bearing fruit in a number of places," he says.

But it's not as if the next step is to go to seed, Horton indicates. "Leadership means taking on new roles," he says. "It means going in new directions, perhaps challenging the conventional wisdom."

Sometimes, in an effort to provide this leadership, Extension/Sea Grant is taking on what others may consider controversial topics, says Horton.

The limited entry conference was one such topic, but "the response to the conference shows the time was right and the handling was right," says Horton.

The management of the resources of the Columbia River has been the focus of public controversy in the last few years, and in their educational activities, Spranger and Dan Guthrie have not shied from the controversies, Horton acknowledges.

Guthrie, who holds a Ph.D. in zoology and is an author and journalist, has brought his talents in research and communication to bear on the complex issues of restoring Columbia River salmon runs. Guthrie's activities are sponsored by the U.S. Fish and Wildlife Service, U.S. Department of Interior.

Part of his duties involve educating county agricultural extension agents, farmers, and ranchers about Columbia fishery resources and the management changes that will be needed to restore the fisheries to former abundance. His slide show and presentation, "Where Cows and Salmon Meet," is part of this educational effort, as it explains how allowing cattle unrestricted access to streambanks causes damage to salmon habitat and populations.

Since Guthrie's educational message questions the status quo, it's perhaps not surprising that it has not been met uniformly with approval by interested parties.

Spranger, meanwhile, has expanded his own interests in educating the public about management of Columbia River resources. Coordinator of the annual Short Course on the Columbia since 1981, Spranger has guided that public workshop through a period when public discussion has sometimes been quite heated over the various proposed options for long-term management of the Columbia Gorge.

Beginning in late 1984, Spranger took on the additional task of providing public information on perhaps the most far-reaching and complicated issue now facing the public concerning the Columbia River, namely the possible siting of the nation's nuclear waste repository at Hanford, Washington.

Should Extension shy away from providing information on such issues as long-term fishery restoration in the Columbia Basin and nuclear waste policy?

Replies Horton, "I think if Extension is going to be strong and viable, we have to have the courage to go into a subject that is controversial. That's where the need may be greatest for our help. But our role is clear: We are professional; we are objective. We're not going to tell how to vote or how to think, but we will explain the alternatives and consequences."

"I think Bill Wick's philosophy is right," he adds. "When you're a leader, sometimes you stick your nose out. Sometimes you get it poked. Sometimes you get patted on the back. The important thing is you're trying, and people are paying attention."

Ken Hilderbrand advises Joanna Quade of Lincoln City on the best techniques for preparing smoked salmon.

SUMMARY OF 1983-85 PROJECTS

Imprinting in Salmon—R/Aq-38
Carl Schreck

A major problem facing both private and public salmon hatchery programs in the Northwest is the extremely low return rate of adult fish to the spawning or release site. Fish straying into foreign waters, their inability to locate passages around man-made obstacles (such as dams), and their inability to distinquish natal waters may result from improper imprinting of juvenile salmon at the time of their release. The overall objective of this project was to facilitate the culture of salmon and to increase harvest levels by learning more about the homing process. We have found that sensitivity to imprinting cues changes during juvenile development. Artificial odorants, used to artificially imprint young salmon, appear to be safe; they do not confound the orientation abilities of wild, or nonartificially imprinted, salmon.

Reproductive Physiology and Induced Maturation of Salmon Brood Stock—R/Aq-40
Carl Schreck

A key factor in the success of salmon hatcheries in the Northwest is the availability of eggs. Too frequently, there simply are not enough viable eggs to meet the needs of public and private hatcheries. The goal of this study has been to enhance the number of viable coho and chinook eggs by creating more females in the population. At present we are rearing populations of both species that we believe to be 100 percent female. These populations were created by both hormone treatment and manipulation of the mating process.

Survival and Nutritional Requirements of Salmonids in Transition from Fresh Water to a Marine Environment—R/Aq-43
Russell Sinnhuber

The most serious obstacle facing public and private salmon producers is high mortality of smolts during seaward migration and periods of transition to seawater. Nutrition plays an important role in the condition of smolts and, hence, their survival when making the transition between fresh and salt water. This study aimed to determine the nutritional requirements for producing healthy salmonid smolts, capable of making the transition, and to ascertain the nutrient requirements for maximum growth after seawater adaptation.

Molluscan Hatchery Technology—R/Aq-46
Wilbur Breese

Investigators have produced viable seed from the Manila littleneck clam, using methods developed in previous Sea Grant projects. The seed was planted in Tillamook Bay in areas that do not have natural recruitment of larvae. The principal investigator (now retired) will work with the local industry to help solve their technological problems and to encourage the use of the "eyed larvae."

Recombinant DNA Techology in Aquaculture—R/FSD-9
Jo-Ann Leong

Disease is one of the most significant deterrents to the development of aquaculture. It may at times determine the success or failure of the venture itself. Traditional methods of controlling viral outbreaks in salmon hatcheries in the Northwest by destroying the entire brood stock are expensive and often disastrous. The relatively new techniques of genetic engineering offer hope that safe vaccines can be developed which will immunize fish against such infections.

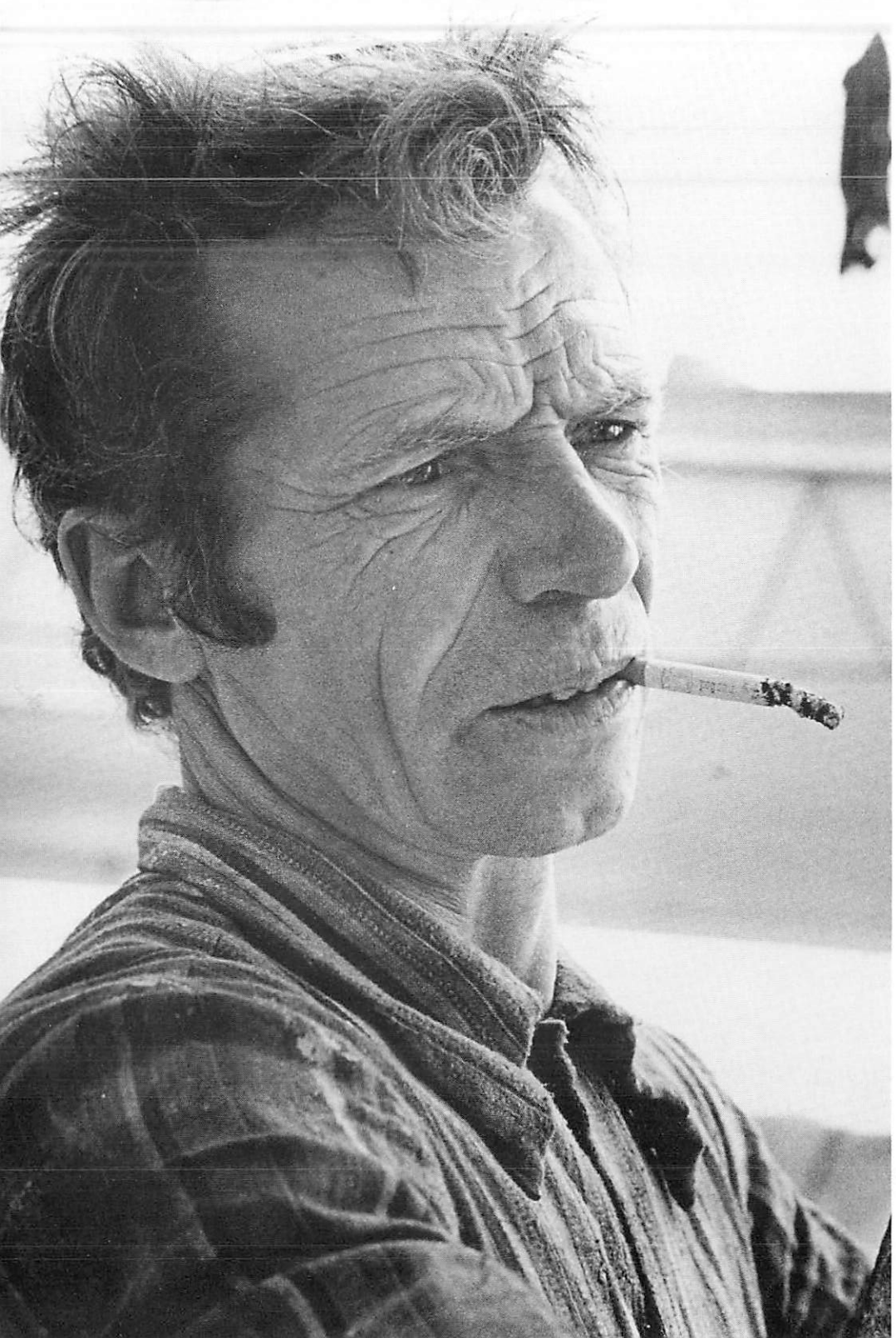
Fish Health Management—R/FSD-10
John Fryer

The detection, prevention, and control of diseases of fish are essential to the success of aquaculture. Oregon State University Sea Grant has long been a leader in fish disease prevention and control. We are continuing the surveillance and epidemiology of fish pathogens by providing an inspection and certification service and by characterizing newly discovered pathogens. Researchers continue to investigate more effective means of immunizing fish against selected bacterial diseases.

Environmental Influences on Fishery Sustainability—R/OPF-16
Richard Tubb

We are working to develop a multifactor statistical analysis of the effects of physical oceanographic processes, fishing effort, and stock density on selected groundfish species. A computer simulation model was constructed to investigate several hypotheses concerning the English sole year classes. Oceanographic conditions over time correlated with abundance of year classes showed that storms, starvation, or general primary production were not significant factors affecting the numbers of English sole recruited each year. The model indicates that the seasonal spawning is cued by warming of the shelf waters.

A band of viral DNA glows in the near-dark when struck by ultraviolet light. Microbiology student Manley Huang uses a syringe to draw off the band of his choice.



Ecology of Salmonids during Their First Summer in the Ocean—R/OPF-17
William Pearcy

Catches of coho salmon have decreased in recent years off Oregon and Washington despite increased releases of smolts from private and public hatcheries. Survival and year-class success of coho are apparently determined by conditions in the ocean during early growth and survival. But little is known about the ecology of juvenile salmonids and factors which affect survival during this first, critical summer at sea. To better understand the mechanisms that limit production of salmonids in the ocean, we have sampled the nearshore ocean with a purse seine. Abundances of juvenile coho salmon during June are correlated with the return of coho jacks to Oregon index streams in the fall, suggesting that factors affecting survival occur soon after ocean entry in coastal waters. Recovery of tagged juvenile coho indicates that a proportion of the population is relatively nonmigratory and resides in coastal waters at least until September, rather than migrating far to the north as previously stated.

Trophic Dynamics of Pelagic Larval English Sole and Its Effects on Year-Class Strength—R/OPF-19
George Boehlert

This research contributes to our understanding of those environmental factors operating during the pelagic larval phase of the English sole which ultimately lead to successful recruitment. Researchers have examined the nature of factors involved in larval survival; both food-related mortality and oceanographic conditions related to larval drift may affect year-class strength in this species. Field studies on larvae and prey microdistribution patterns are complete, and a model of prey temporal dynamics and its relationship to year-class strength is being developed.

Enhancement of Oregon Shrimp and Groundfish Yield Estimates—R/OPF-20
Ellen Pikitch

We are developing a standardized set, or package, of yield-estimate models for use by the Marine Region of the Oregon Department of Fish and Wildlife (ODFW) and by other fishery biologists working with the Pacific Fishery Management Council. The set includes traditional methods, newly published methods, and simulation models already developed for specific stocks within the region. Further, we are assisting in developing an enhanced simulation model of pink shrimp dynamics by evaluation of methods and adequacy of the data base and by formulating model structure with ODFW biologists.

Evaluation of Liquefied Fish as a Protein Supplement for Livestock—R/PD-38

Richard Kellems

The wastes associated with the seafood processing industry consist primarily of high-quality protein material which could be used in producing marketable by-products for the livestock industry. The aim of this research project was to demonstrate to the fishery and livestock feeding industries the potential for using fish protein as a supplemental protein source for feeding livestock.

Seafood Preservation and Handling—R/PD-39

Edward Kolbe

The commercial fishing/processing industry is gaining access to greater volumes and varieties of species requiring unique on-board preservation and handling. Our long-term objective was to generate and supply the industry with new information about seafood preservation and handling. Our emphasis was on vessel stowage and its relationship to shoreside processing. We pooled resources with colleagues at the University of Alaska and presented a short course on small-boat refrigeration and an on-board stowage system using chilled seawater.

Market Analysis for Pacific Groundfish—R/PD-41

Bruce Rettig

We launched a research program to assist investigators conducting contemporary research on Pacific groundfish markets and to develop insights which would assist participants in adapting to those markets in the decade ahead. Economic models were used to show that both fishery and transportation regulations in one part of the country affect groundfish prices and consumption throughout the country and to demonstrate the value to fisheries of extended fishery jurisdiction. We also developed a list of trucking firms involved with transporting certain Pacific coast seafood products and responded to requests for advice on matters of fishery management and groundfish markets received from several state, federal, and international agencies, the West Coast Fisheries Development Foundation, and private individuals.

Seafood Processing and Development—R/PD-42

David Crawford

Improving the quality of seafood products and the economy of processing and marketing is one key to maintaining the vitality and competitiveness of the fishing industry. To achieve this goal, investigators applied antibacterial agents to shrimp and used mechanical refrigeration procedures which eliminated the need for ice; thus, they provided a handling system for round Pacific shrimp which improved the yield and quality of mechanically peeled, cooked meat. They found that applying condensed phosphate to Dungeness crab prior to cooking improved cooked-meat yield. For practical purposes, the muscle compositions of various species of rockfish were shown to be identical. Investigators developed preprocessing procedures which facilitated the removal of squid skin.

Controlling Biological Deterioration of Wood in the Marine Environment—R/CP-18

Robert Graham, Jeffrey Morrell, and Jefferson Gonor

Losses in the United States from decay fungi and marine wood borers exceed $1 billion annually. Improper use and maintenance of wood are major contributing factors to this damage. Much can be done to prevent or stop such damage. We have developed and evaluated a number of easily applied remedial wood protection devices for coastal environments. We have also developed a marine maintenance manual for users of Douglas fir. Studies indicate that there is little physiological difference between L. *tripunctata* specimens from around the world and those found in Oregon. We are continuing to search for other reasons for the resistance of Oregon *tripunctata* to creosote.

Origin of Black Sand Deposits along the Southern Oregon Coast—R/CP-20

Kenneth Scheidegger

Black sands (placers) are found on the Oregon beaches (where they originate), in the uplifted marine terraces, and on the submerged continental shelf. Analyses show that the heavy minerals are concentrated by selective grain entrainment and transport. We have found that placers are best developed to the south of headlands because of the changing wave directions and their differing energies.

Unusual Storm Waves and Oregon Coast Erosion—R/CP-21

Paul Komar

Erosion on the Oregon coast is primarily caused by the occasional occurrence of storm waves exceeding seven meters in height. A principal objective of this investigation was to study these exceptional storms to determine what particular attributes generate these waves. Many occurrences of exceptional erosion on the Oregon coast have taken place during El Nino periods. We were able to study such occurrences during the most recent El Nino in the 1982-83 period.

Applications of Acoustic Control to Marine Mammals in Fisheries Conflicts—R/CP-22

Bruce Mate

The primary objective of this project was to demonstrate the effectiveness of acoustic harassment as a technique for marine mammal management. The new methods being tried here were expected to reduce marine mammal-fishery conflicts while simultaneously reducing pinniped mortalities, damage to fishermen's gear, and loss of fishermen's catch to pinniped predation. Acoustic harassment of seals in the vicinity of two commercial salmon hatcheries has, in fact, reduced the number of seals in the immediate vicinity of the hatcheries and has resulted in a 90 percent drop in the number of fish showing signs of seal predation. When used in conjunction with salmon gill nets, these acoustic techniques not only reduced the number of seals and the percentage of damaged fish, but also had a positive effect on total salmon catch—up by 160 percent.

Stability of Marine Foundations—R/CE-13

William McDougal

The primary objectives of the research were to develop and verify models for predicting the adequacy of caisson foundations in the marine environment. Two models were developed: an analytical model for describing the response of a fixed caisson with a coarse-aggregate foundation separating the structure and seabed, and a dynamic caisson model which includes the influence of wave-induced caisson motion on seabed stability. Two sets of large-scale experiments were conducted to verify and demonstrate the utility of the analytic models. Results identify both critical and optimum design conditions regarding wave-incuded hydrodynamic and geotechnical instability.

Computer Modeling of Flexible Membrane Interaction with Ocean Waves—R/CE-14

John Leonard

The primary objective was to determine the technical feasibility and economic advisability of using inflatable membranes in the coastal zone. We are developing a technique for simulation on a computer for the nonlinear interaction of a deformable membrane with coastal waves.

Adaption, Deployment, and Stability of Surplus Concrete Products Used as Artificial Reefs—R/CE-15

Charles Sollitt

Surplus concrete products are abundant, inert, and durable. The purpose of this project was to resolve engineering problems associated with the adaptation, deployment, and stability of various alternative products for creating artificial reefs. Results of this project are being incorporated into an engineering design guide and a journal article. The published results will provide the user with a procedure to design reef configurations that will survive a specific wave and current environment.

World Trade in Seafoods—R/PPA-20

Richard Johnston

The objective of this project is to develop and share new information relating to international seafood trade. We have compiled and published such information regarding seafood consumption and the seafood trade patterns of nations with whom we trade and are developing a homogeneous and expanded data base on seafood trade. To date, investigators have found that fluctuating exchange rates play several—sometimes conflicting—roles in affecting international seafood trade, that consumption of canned salmon is more sensitive to price changes than previously believed, and that while extended fisheries jurisdiction has been associated with increased U.S. seafood exports, it appears to have resulted in decreased seafood trade on a global basis.

Law of the Sea and Coastal Zone Federalism—R/PPA-21

Jon Jacobson
Richard Hildreth

Much has happened in the last decade concerning ocean management and jurisdiction. The investigators have monitored progress on a Law of the Sea treaty and have published two works on major LOS issues; revised teaching materials on Law of the Sea; published two journal articles regarding federalism in the coastal zone; published six *Ocean Law Memos* and *Coastal Law Memos*; placed four interns with the NOAA General Counsel's office, two of whom have been permanently hired by that office; continued other professional training efforts such as preparation of a bibliography on limited entry fisheries management; published a revised edition of the guidebook *Federal Fisheries Management*; and acquired additional materials for the Ocean and Coastal Law Center Library.

Columbia River/Pacific Rim Commerce—R/CR-1

Jim Jones

We proposed to provide an economic framework for understanding the implications of recently proposed or implemented changes regarding cargo preference. A spatial equilibrium model is in the process of development for this purpose. We are also analyzing the prospects for coal trade in the Pacific Rim markets. A survey of ports and coal production in China supplemented by a literature review of other countries indicates little prospect for short- to intermediate-term movement of coal from Columbia River ports.

Anadromous Fish Law—R/CR-2
Michael Blumm

Our goals in this project were first, to educate the public concerning federal, state, and regional initiatives designed to preserve and restore Columbia Basin anadromous fish runs; second, to increase awareness among policymakers of the interdependence of water resource and hydroelectric policies and anadromous fish protection; third, to analyze the implications of legislative, administrative, and judicial decisions affecting the vitality of Columbia Basin migratory fish; and fourth, to educate present and future Pacific Northwest lawyers in the role of the law in protecting and restoring the fishery. Seven *Anadromous Fish Law Memos* have been published on issues such as the implementation of the Columbia Basin Fish and Wildlife Program, the effect of electric power sale policies on fishery protection, the state of Oregon's Wild Fish Policy, and hydroelectric licensing by the Federal Energy Regulatory Commission. Several more *Memos* are being prepared. In addition, three more detailed law review articles have been published, and two others are in press.

Development Program for Professional Fishermen—E/PT-1
David Phillips

The purpose of this project was to assist American professional fishermen in developing more refined, technical fishing skills by providing them short-term, intensive training on such subjects as fisheries electronics and fishing strategies.

Marine Resources/Marine Affairs Educational Program—E/MRM-3
Victor Neal

Through a number of individual initiatives, we have improved the training of professionals in marine resource management/marine affairs and the quality of OSU graduate and undergraduate students. We have been able to provide financial assistance to a few top-quality students, permitting them to complete the program. A workshop for faculty from MRM/MA programs around the country permitted us to evaluate our program. Ideas from the workshop are being implemented to strengthen our curriculum. Graduates serving in public positions and private enterprise are now helping to manage and develop marine resources.

Latin American International Sea Grant—E/ISG-4
Victor Neal

The long-term objectives of this project are to help Latin American nations develop and maintain viable educational, research, and extension programs in marine science and to improve mutual trust, friendship, and respect between the U.S. and Latin American nations. The program has earned respect throughout Latin America. OSU has assisted institutions in Chile, Mexico, and other countries to plan and develop educational and practical research and extension programs directly related to marine science.

Extension Marine Advisory Program—A/EMAP-3
Howard Horton

Activities of the Marine Advisory Program fall into five major areas: marine education, commercial fisheries development and assistance, coastal resources and environment, communication, and an international program. Objectives for the biennium were to continue public education on the value and limits of marine resources, to provide more diverse options for fishermen, to improve seafood marketing practices, to increase access to aquaculture technology, to facilitate the development of ports and marine transportation, and to work with other agencies in reducing conflicts.

Program Administration—M/A-1
William Wick

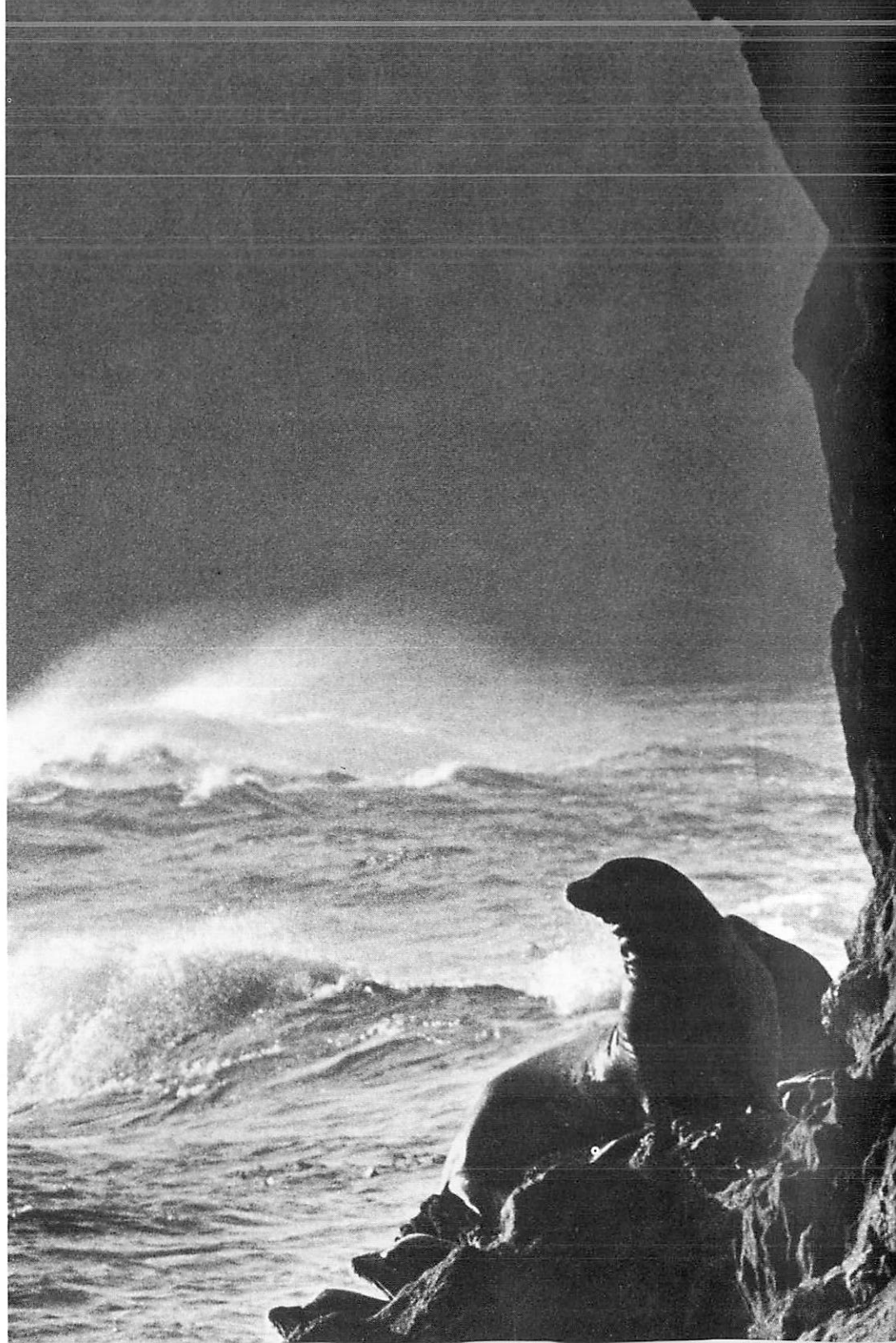
The OSU Sea Grant College Program's long-range goal and commitment are to develop a program that is attuned to the needs of the state, region, and nation; that is trusted by the agencies, industries, and people who use and manage marine resources; and that is capable of providing the research, education and training, and advisory services needed to support the nation's Sea Grant mission.

Program Development—M/A-2
William Wick

Ten rapid-response and special-need projects were supported during the biennium. These ranged from publications and minority fellowships to funding for short-term research and visiting Sea Grant professorships. Aquaculture was the topic for five projects; wild fishery problems were involved with four of the efforts. The remaining project was an engineering study of the impact of animal and plant growths on submerged pipelines. In addition, the Extension/Sea Grant project conducted other timely, short-term studies, mainly on underutilized fisheries.

Sea Grant Communications—M/A-7
Jim Larison

The communications office provides support to Sea Grant researchers and administrators, promotes better understanding of marine resources in general and Sea Grant work in particular, and disseminates technical information resulting from Sea Grant-supported research to a variety of interested audiences. This biennium we produced 96 *Coastwatch* radio public service announcements, 50 radio features, more than 100 newspaper stories, and a special section in the *Corvallis Gazette-Times* newspaper. We produced 10 institutional publications, 20 special publications, and a periodic marine mammal newsletter. With funds from outside Sea Grant, we produced *Farmers of the Sea*, a documentary about world aquaculture for broadcast on the popular PBS science series NOVA; *Riches From the Sea*, a 23-minute educational film for the National Geographic Society; and a multimedia program for the Hatfield Marine Science Center. We won two Gold Medals from the Council for the Advancement and Support of Education, two CINE Golden Eagles from the Council on International Nontheatrical Events, and the Ford Fund's Grand Award for film.



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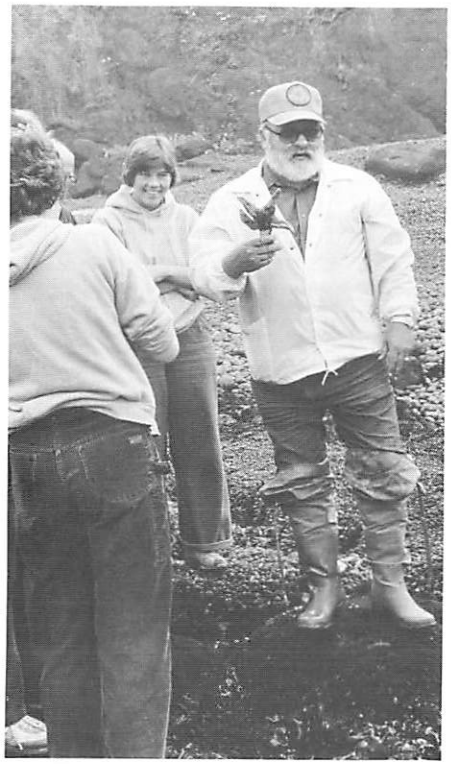

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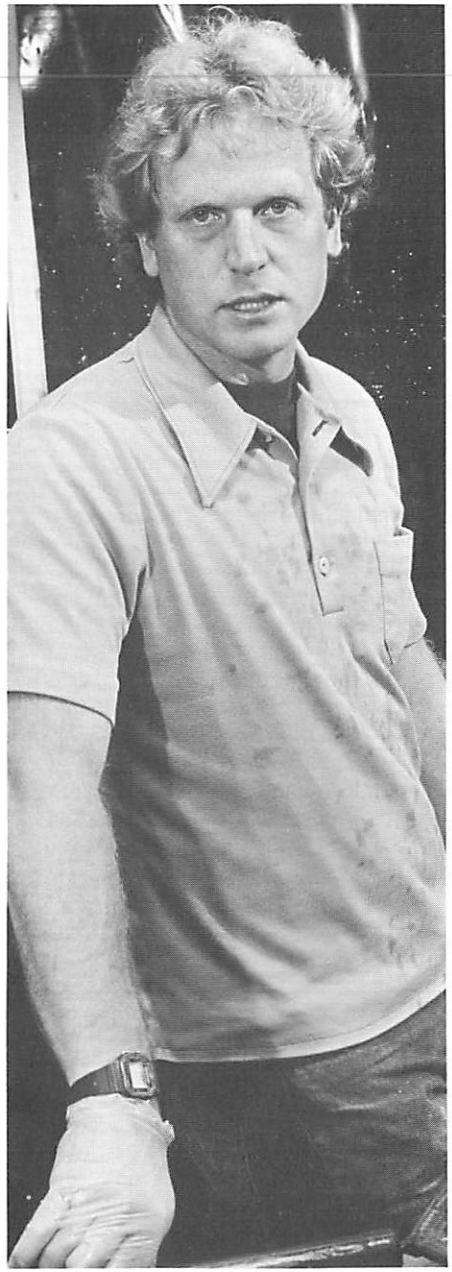

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Budget Summary 1983-84 (By Area of Activity)

	NOAA Grant Funds	State Funds	Other Supporting Funds
Research			
Aquaculture	131,600	14,900	31,800
Living resources, other than aquaculture	442,100	119,500	122,300
Mineral resources	40,300	0	12,600
Marine law and socioeconomics	273,800	76,100	122,500
Ocean engineering	230,600	55,700	83,100
Resources recovery and utilization	128,800	69,300	51,900
Research and studies in direct support of coastal management decisions	39,200	40,600	0
Applied physical oceanography	10,400	19,200	12,100
Education			
College level	22,300	0	6,400
Vocational marine technician training	6,600	0	6,000
Other education	61,200	0	0
Advisory Services			
Extension programs	515,000	224,500	149,900
Program Management			
Program administration	97,500	110,800	0
Program logistic support	124,100	31,600	0
Program development	19,500	13,100	0
TOTALS	$2,143,000	$775,300	$598,600

Budget Summary 1984-85 (By Area of Activity)

	NOAA Grant Funds	State Funds	Other Supporting Funds
Research			
Aquaculture	68,700	0	8,800
Living resources, other than aquaculture	307,400	149,700	116,100
Mineral resources	34,900	0	12,400
Marine law and socioeconomics	347,300	99,000	143,100
Ocean engineering	180,600	36,600	32,100
Resources recovery and utilization	135,300	68,800	41,900
Research and studies in direct support of coastal management decisions	55,100	10,500	0
Applied physical oceanography	10,000	18,500	11,800
Education			
College level	22,700	0	6,000
Other education	59,700	0	0
Advisory Services			
Extension programs	601,400	217,900	143,800
Program Management			
Program administration	116,400	110,100	0
Program logistic support	107,000	56,100	0
Program development	96,500	13,100	0
TOTALS	$2,143,000	$780,300	$516,000

DIRECTORY

Advisory Council

The Sea Grant Advisory Council, external to the university, counsels the director, provides policy and planning advice for the program, and aids in developing public support for Sea Grant.

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Pendleton

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Executive Committee

Within Oregon State University, the Sea Grant Executive Committee serves in a companion manner to the external Advisory Council by providing advice to Sea Grant administration on policy, program balance, and decisions about project support. The Executive Committee comprises the following faculty members.

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OSU Extension Service and Department of Fisheries and Wildlife

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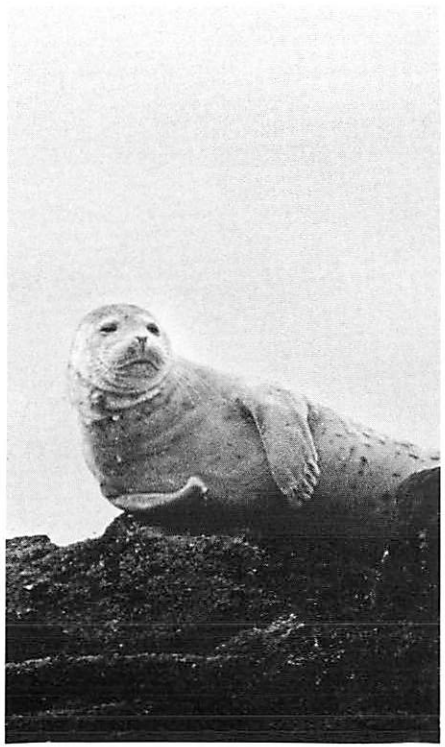

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