SEA GRANT AT OREGON STATE UNIVERSITY

THE FIRST 15 YEARS

Sea Grant at Oregon State University The First 15 Years 1968-1983

Oregon State University Sea Grant College Program
Publication No. ORESU-Q-83-001 c2

A Note on the Production of this Report

Contributors have been many. Principal investigators wrote about their own work and that of their colleagues. Sea Grant science writer Jim Bottom (1980-83) began collecting and editing the various chapters in 1981. A first draft was printed in 1982; later that year a second revised version included publication lists for each program area.

Science writer Joe Cone inherited the task of developing the final version in 1983; he re-contacted each of the chapter writers, asking for revisions. An approved final version of the text, incorporating changes in the program through 1983, was edited by Cone and Sea Grant editor Sandy Ridlington.

Credits

Editing: Joe Cone, Jim Bottom, Sandy Ridlington

Design: Joe Cone, Susan Irish

Typesetting: Candi Lavelle, Maureen Boles, Patsy Vaughn

Photography: Jim Larison, Jim Bottom, Tom Gentle, Joe Cone, Al Hollister

Support

The Oregon State University Sea Grant College Program is supported cooperatively by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, by the state of Oregon, and by participating local governments and private industry.

Ordering Publications

Copies of the publication are available from

Sea Grant Communications
Oregon State University
AdS 418
Corvallis, OR 97331

Please include author, title, and publication number. Upon request, we will also send a free copy of our catalogue of Oregon State University marine-related publications.

Table of Contents

Introduction 1

Marine Advisory 3

Research 15

- Aquaculture 17
  - Salmon Culture 17
  - Molluscan Culture 27
  - Fish Nutrition 31
  - Fish and Shellfish Disease 35
- Ocean Productivity and Fisheries 39
  - Fishery Oceanography 39
  - Fishery Population Dynamics 45
  - Fish Life History and Management 49
- Marine Product Development 53
  - Seafood Processing 53
  - Seafood Microbiology 61
- Coastal Environments 65
  - Ocean Engineering 65
  - Fisheries Engineering 71
  - Nearshore Processes 75
  - Wood in the Marine Environment 79
  - Coastal Weather 85
  - Marine Mammals 89
  - Columbia Regional Sea Grant 95
  - International Sea Grant 97
- Public Policy Analysis 99
  - Marine Economics 103
  - Ocean and Coastal Law 109

Education 113

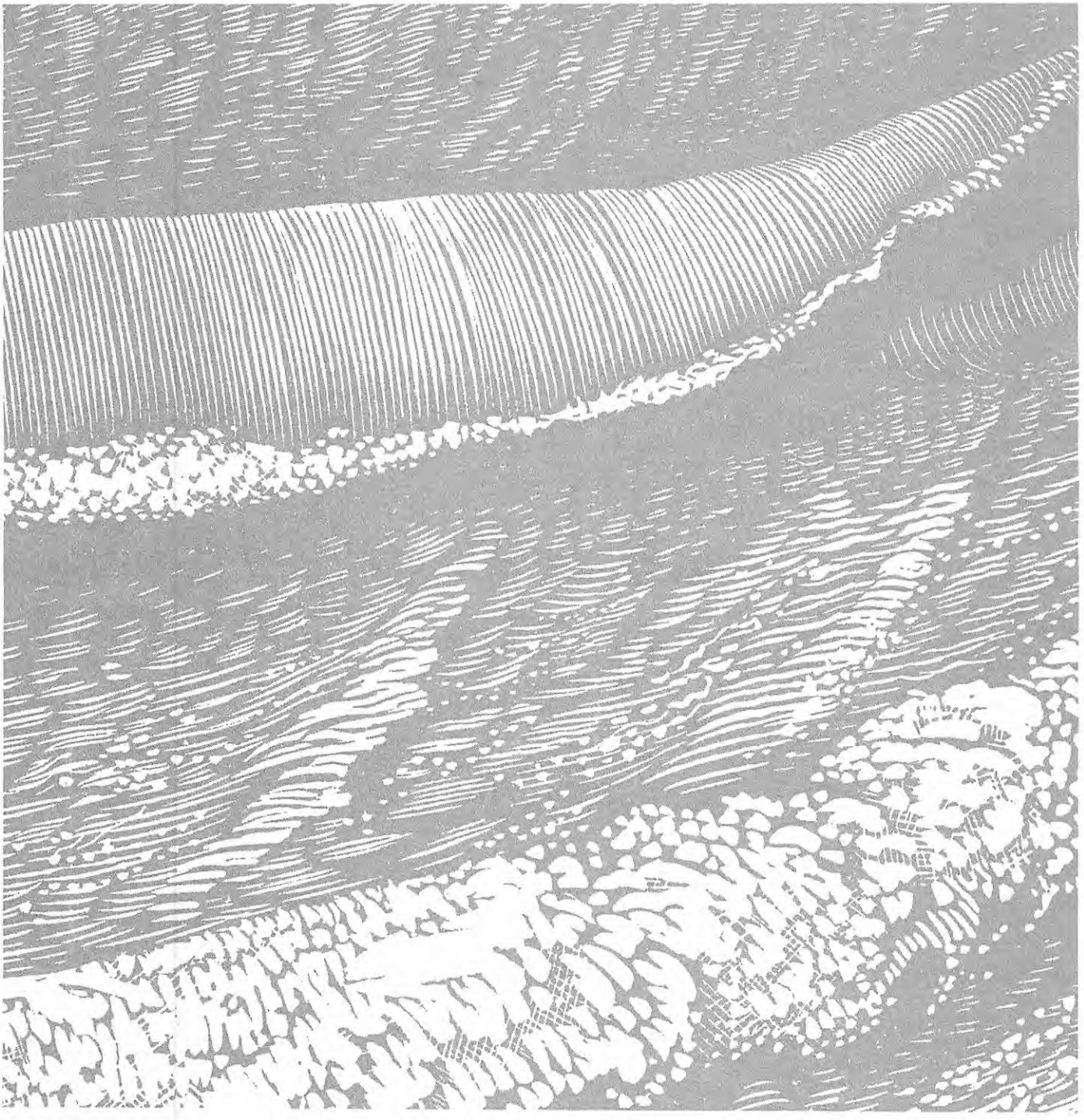
Administration 123

Communications 127

Sea Grant Students 131

Publications 146

Introduction



> ...I have suggested the establishment of "sea-grant colleges" in existing universities that wish to develop oceanic work. The sea-grant college would focus attention on marine science, and it would develop strengths in the applications of marine science in the colleges of aquaculture and oceanic engineering. These would be modernized parallels of the great developments in agriculture and the mechanic arts which were occasioned by the Land-Grant Act of about a hundred years ago...Establishment of the land-grant colleges was one of the best investments this nation ever made. The same kind of imagination and foresight should be applied to the exploitation of the sea.
>
> (From an editorial in Science Sept. 4, 1964 by Athelstan Spilhaus.)

So timely was Spilhaus' idea that by 1966 an act had been passed by the Congress and signed into law by President Johnson, establishing a National Sea Grant College Program.

In history and philosophy Oregon State University was a Sea Grant college long before the passage of the act. In fact, we should have originated the idea. No one, however, thought to articulate the concept in the manner of the writer-scientist-inventor Spilhaus.

In thrashing out the ideas which led to passage of the act, Wayne Burt --then Chair of the Department of Oceanography and now Associate Dean Emeritus of Oceanography at OSU, -- and Emery Castle, -- then Dean of Faculty, OSU, and now President of Resources for the Future -- played an active role.

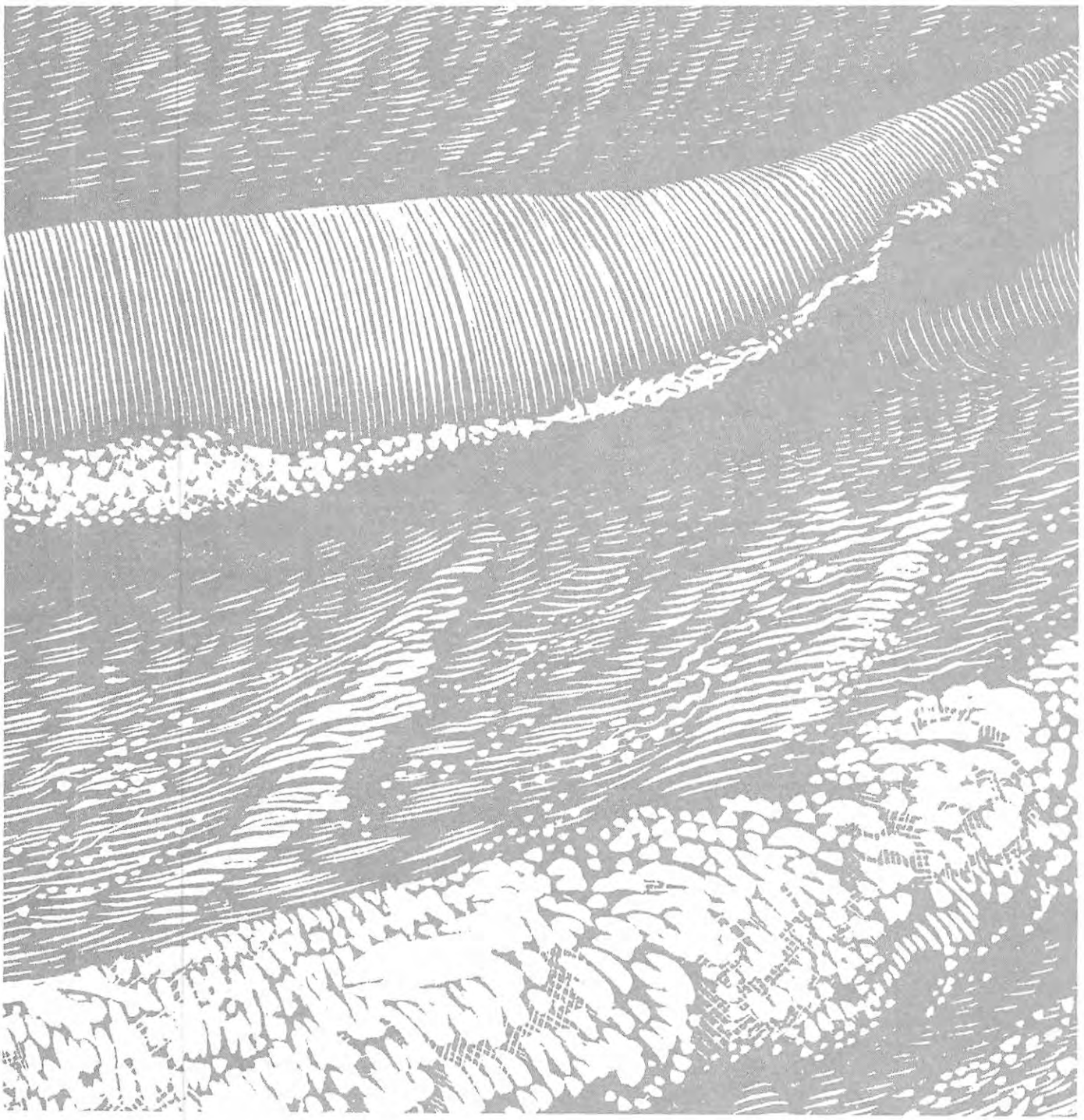
Thus, in 1968, when the first three Sea Grant Institutions were announced, it was no surprise that Oregon State University had the largest initial program. Dedicated work by faculty, technicians, and students resulted in the designation of OSU as a Sea Grant College in September 1971.

This report is a summary review of the progress and evolution of the Oregon State University Sea Grant College Program. It is not a historical document in the sense that all occurrences are chronicled. We have attempted to distill and report that which appears significant and to explain how we have matured to the program which exists today.

You will note a distinct difference in writing style from program to program. Since the story is best told by those who have been involved in the various research and advisory areas, there is no single author. Our hope is that individual memories and impressions of the different authors will give this report a personal flavor.

William Q. Wick, Director
Sea Grant College Program

Marine Advisory



The OSU Marine Advisory Program has been fortunate not only in attracting well-qualified personnel, but in retaining them.

Bob Jacobson became the first Advisory marine agent in Oregon in 1967. Don Giles, marine education specialist, and Fred Smith, marine economist, joined Advisory in 1968. Paul Heikkila became the Coos County marine agent in 1969, and Ken Hilderbrand was named a seafood technology specialist the same year. Vicki Osis began as a marine education specialist in 1971. John Faudskar, Tillamook County marine agent, started in 1972, and Jim Bergeron, Clatsop County marine agent, joined Advisory in 1974.

All these people are still with the Marine Advisory Program. In 1980, Advisory added an agent in the Portland metropolitan area. Today, Advisory has 14 agents and specialists, including two agents shared cooperatively with the Washington and California Sea Grant programs.

Advisory responds to needs along the entire Oregon coast, in Portland, and along the Columbia River.

In the beginning, Advisory's primary goal was to disseminate technical information to commercial fishermen. During his first six months on the job, Bob Jacobson talked with fishermen along the coast about areas where Advisory could offer assistance.

My first major educational undertaking came in January 1968, when

Increased use of coastal resources since the mid-1960s has placed Advisory agents and specialists in demand.

> the first issue of the Oregon Commercial Fisheries Newsletter (OCFN) was published. This monthly periodical provided fishermen with accurate, timely fisheries-related information. But more importantly, it gave the fledgling Advisory program much needed visibility and credibility.

The newsletter provided information about fishing gear and methods, business management, marine economics, alternative fisheries, marketing, vessel and crew safety, marketing, fish biology, industry legal issues and more. The contents came from many sources: fishing publications, workshop summaries, research reports, fishery agency materials, and articles written by Sea Grant researchers and Advisory agents. As the fishing industry press gradually improved its coverage of the West Coast fishing industry, the Advisory agents saw less need for the OCFN, and it was gradually phased out. The last issue was published in December 1979.

In the early days of Advisory, however, the newsletter was one method Jacobson used to find out the types of education programs fishermen wanted. One of the first requests solicited through the OCFN came from a fisherman who wanted "to know more about what the Oregon Fish Commission is doing in resource management."

In response, according to Jacobson,

> ...within months, the first in what became a yearly series of town hall meetings was organized. These meetings, held in the major coastal fishing communities, served as a forum for getting key Oregon Fish Commission people together with fishermen. Discussions were sometimes heated. These meetings were, nevertheless, what I now consider to be the first step towards gradually improving relations between resource users and the management agency.

Using Satellites in the Fishing Industry

Another of Advisory's first educational projects led to the use of environmental-sensing satellites in West Coast commercial fishing. In 1969, "Albacore Central" began as a research and Advisory project to look for possible links between various oceanographic and meteorological conditions and the catch of albacore tuna. Such connections, if they existed, would enable albacore fishermen to rapidly locate offshore concentrations of tuna.

In addition to the Advisory Program and OSU oceanography researchers, Albacore Central involved 11 federal and state agencies, private companies, and individual commercial fishermen (123 fishermen supplied data to the project). This cooperative approach has been a hallmark of Advisory projects through the years.

Albacore Central gathered information on marine weather, ocean surface temperatures and color, and the location of upwelling areas and the edge of the Columbia River plume. This information was broadcast daily to albacore fishermen and published in weekly sea-surface temperature charts.

Once the usefulness of Albacore Central was established, responsibility for gathering and disseminating the information was turned over to the Bureau of Commercial Fisheries in La Jolla, California.

According to Paul Heikkila, "Albacore Central taught albacore fishermen the importance of basic oceanography and how to apply it to their operations." And it laid the groundwork for a later project that used space satellites to gather the same types of information as collected by Albacore Central.

The SEASAT satellite project, which lasted from 1978 to 1981, was a cooperative effort with NASA and the California Institute of Technology's Jet Propulsion Laboratory. It involved testing the

feasibility of using Seasat and other space satellites to gather sea surface oceanographic and weather data and transmit it directly to fishing vessels equipped with single sideband receivers and radio facsimile machines. The Advisory agent worked with twelve fishermen in Oregon and northern California to verify the accuracy of the satellite data and troubleshoot radio reception and equipment problems.

Because the satellites offered an ocean-wide perspective compared to the individual ship reports and airplane flights of Albacore Central, the satellite weather information proved useful to all fisheries.

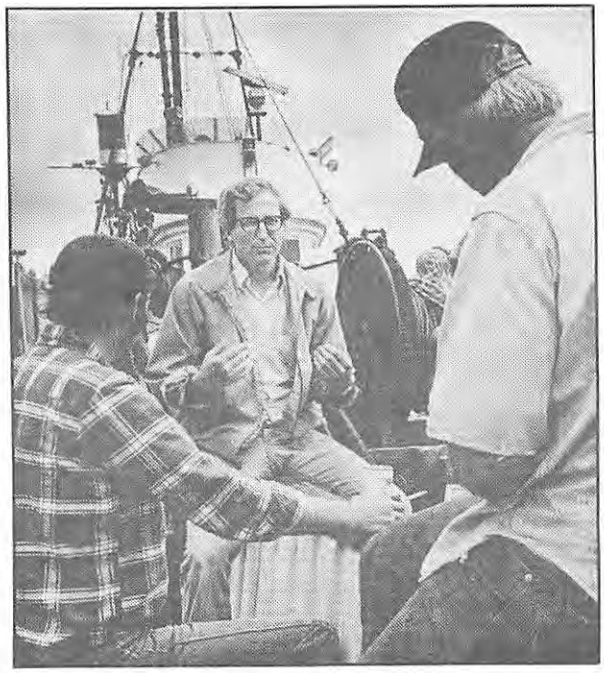
The Seasat project showed that satellites could provide accurate, timely information that was useful to the fishing fleet. Advisory is now involved in yet another NASA-sponsored project using satellite-based weather and oceanographic reporting. With an improved data-gathering and reporting system in place, the project is aimed at getting as many fishermen as possible to take advantage of the information, both for greater safety and more productive fishing.

In 1982, Advisory initiated a cooperative project with the National Weather Service and the Port of Coos Bay to establish a weather reporting system using reports from fishermen of ocean weather conditions. The aim is to improve local inshore weather forecasts by including the fishermen's observations in Weather Service reports.

Organizing Fishermen's Wives to Promote Seafood

Another early activity, the organization of fishermen's wives groups in the main coastal fishing ports, has paid dividends to the Advisory program since Bob Jacobson organized the first group in Newport in 1969.

When Jim Bergeron became the Clatsop County marine agent in 1974, he encountered a fishing community split apart by poor communication and antagonism among various fisheries groups. He organized a fishermen's wives group as a way to reach the entire fishing community.



Specialist Ed Kolbe shares his knowledge of on-board refrigeration systems with interested fishermen.

The Astoria Fishermen's Wives gave Bergeron a channel of communication to local fishermen and provided legitimacy for his Advisory programs. He also credits the wives with playing a leading role in establishing better relations between Indian gillnetters on the upper Columbia and white gillnetters on the lower river.

In the late 1970s, the fishermen's wives groups created the West Coast Fishermen's Wives Coalition, representing groups from Washington, Oregon, and California. They have member representation on the board of directors of the West Coast Fisheries Development Foundation and engage in coastwide projects that benefit the fishing industry.

One such project began in 1979 when Ken Hilderbrand helped the Coalition obtain a grant to train personnel in supermarket meat departments how to buy, handle, display and

promote bottomfish. The West Coast Fisheries Development Foundation funded the project. Hilderbrand organized a one-week training program on the OSU campus for 85 volunteer Coalition members. Says Hilderbrand:

> It was a classic Extension approach. Advisory knew there was a need to educate retailers, but we never seemed able to reach enough of them with our limited personnel. Now we have a large cadre of volunteers trained in the techniques of seafood merchandising who can reach many more retailers than before.

The Coalition's seafood merchandising project has conducted workshops for major supermarket chains in the three West Coast states and has seen the demand for bottomfish increase from the retail sector.

Hilderbrand also worked with the Newport Fishermen's Wives on a project to promote the use of locally-caught bottomfish in the Lincoln County School District lunch program. The project was an attempt to expand the market for local bottomfish, to demonstrate the feasibility and nutritional benefits of serving fresh fish on a regular basis in the schools, and to develop a positive attitude toward seafood among school children.

In 1982, Jacobson helped the Newport Fishermen's Wives conduct a fund-raising drive that netted more than $25,000 for search and rescue equipment. The equipment allows the local fishing community to assist the Coast Guard in saving lives and vessels.

Organizing Other Fishing Associations

The Marine Advisory Program has helped organize other fishing associations for the betterment of the industry. Not all those efforts were successful. In 1971, Advisory helped evaluate the benefits of a seafood commodity commission to promote seafood consumption. When the issue came to a vote, however, the fishing industry turned it down. However, Hilderbrand says it was an important effort.

"It set the stage for a legislatively-mandated crab commodity commission in 1978," Hilderbrand explains. "With Advisory assistance, the Oregon Dungeness Crab Commission has become a major factor in the industry."

Another early success was the formation of the All-Coast Fishermen's Marketing Association. Advisory's participation was led by Paul Heikkila. All-Coast began as a shrimper's organization to change the method of weighing and pricing shrimp. Processors had been paying shrimpers according to the amount of meat recovered after processing rather than the amount of shrimp landed. Within two years, All-Coast was able to replace the old system with one based on landings.

All-Coast expanded into a coast-wide organization representing shrimpers, salmon fishermen, and crabbers. In 1974 and 1975, it worked to eliminate differences in salmon pricing between various ports—differences created by price fixing rather than actual market conditions.

Here, too, it was successful. It continued to be an effective political lobby and voice for the Oregon fishing industry through the late 1970s, when apathy on the part of fishermen, a declining fishing economy, and anti-trust problems led to its demise.

Resolving the Conflict Between Crabbers and Towboat Operators

In 1973, the Advisory program stepped in to resolve a conflict between crabbers and offshore towboat operators. Losses of crab gear snagged by towboats had increased, and the towboat industry suffered, too, as many towboats, their propellors fouled by crab gear, had to lay up for repairs. Advisory arranged a meeting between representatives of the two groups, which led to an agreement to establish towboat lanes that would avoid prime crabbing grounds while creating a minimum of extra transit time for towboaters. Advisory published and distributed charts showing the towboat lanes, which covered the area from Monterey, California, to Gray's Harbor, Washington.

Agent John Faudskar has been working to develop the Oregon oyster industry since 1972.

Annual towboat-crabber meetings continued under the leadership of the late Ed Condon. From 1976 through 1978, the program was turned over to the two industries. However, in 1979, Advisory was asked to resume its leadership, because it was a neutral party and therefore more effective at bringing the two sides to agreement. In addition, Advisory had the ability to publish and distribute materials explaining the agreements and showing the locations of the towboat lanes and fishing areas.

Following Condon's death in 1979, Gib Carter, Multnomah County marine agent, assumed responsibility for the annual meetings. The benefits have been considerable, according to Carter:

> One small fishing port has estimated that this arrangement saves their crab fishermen $150,000 a year. One towboat company estimates a savings of $50,000 a year. Recently the Coast Guard has formally stated that they presently see no need for government-prescribed port access routes in Washington and Oregon because of such existing arrangements as the West Coast Fishermen/Towboat Lane Agreements.

Emphasizing Aquaculture

Aquaculture has also been an area of Advisory emphasis. In 1975, the Clatsop County Economic Development Committee proposed a salmon enhancement project on Young's Bay as one way to promote economic development. Jim Bergeron provided planning assistance for the project and served as a link to the fishing community. He arranged for an input-output economic study of the county by OSU resource economists to measure the benefits of an increased return of chinook. He also provided technical information as the project developed. And he provided publicity about enhancement activities to create local support for the program.

During its seven-year history, the salmon project has released more than 14 million coho, fall chinook and chum smolts. The salmon fishery on Young's Bay has experienced increased catches since 1980. In 1982, fishermen harvested 12,000 coho, an increase of 4,000 over the previous year. The chinook catch totalled 5,500, up slightly from the year before. The aquaculture facility continues to be upgraded, and support from local, state and federal sources is solid.

John Faudskar has been working with the commercial oyster-growing industry since 1972. One of his first efforts was to have oyster growing recognized as an agricultural activity by the state. Although his early efforts in this direction were not successful, in the late 1970s the legislature transferred state jurisdiction of the oyster industry from the Department of Fish and Wildlife to the Department of Agriculture.

> Taking advantage of the opportunity, I made sure the new legislation included a declaration that the commercial cultivation of oysters is an agricultural activity. As such, the oyster industry qualified for property tax

> exemptions and other benefits related to revenue, transportation and land use zoning regulations.

The Oregon oyster industry has already benefitted from this legislation, and the Washington oyster industry is preparing similar legislation.

Another long-term project--expanding oyster production in Tillamook Bay by introducing off-bottom culture methods--is just beginning to show results. Traditionally, Tillamook oyster growers have broadcast seed oysters on the Bay bottom, where they mature in three to five years. However, much of the Bay's substrate is unsuitable to this method and thus, goes unused. For a while, Faudskar's efforts were frustrated until,

> ...seven years after I had begun encouraging the oystermen to try off-bottom culture methods, I convinced one farmer to plant a test crop attached to sticks. The oysters flourished. Their survival and growth rates far exceed oysters that were planted directly on the firm substrate of traditional growing areas. Because of that demonstration, other Tillamook Bay oyster farmers are planning extensive stick culture operations.

Faudskar is now involved in a project to demonstrate the potential for growing oysters on trays. These and other off-bottom culture methods are becoming more significant in the face of growing opposition to the use of the pesticide Sevin to control ghost shrimp. Banning the use of Sevin would severely limit and perhaps eliminate oyster farming on the bottom of the bay.

Assisting Fishermen

The Marine Advisory Program has had many other projects that helped the Northwest fishing industry. Paul Heikkila was instrumental in the development of the Northwest Trawl Conference and Gear Show held in Coos Bay. Since it began in 1979, this annual package of educational seminars and exhibits has provided information and expertise that have helped the trawl fishery expand so rapidly.

Heikkila was also responsible for the Production Credit Association (PCA) loan program for fishermen. The PCA has long been a source of loan capital for traditional farmers. Under Heikkila's guidance, the Coos Bay District PCA developed a loan program for fishermen that has loaned more than $48 million since it began. Other PCAs in the Northwest have begun similar programs and loaned even larger amounts.

Agent Bob Jacobson was among the first to promote the use of survival suits.

Some of Advisory's successes have, in retrospect, paid large dividends in comparison to the time and effort invested. For instance, Ken Hilderbrand's publication Preparation of salt brines for the fishing industry has become the authoritative source on the subject for the U.S. tuna seining industry. Written soon after he became an Advisory specialist, the publication seemed to Hilderbrand to be "pretty basic. I'm really surprised it continues to be so useful."

Another program that had a greater impact than originally intended involved a workshop on bonding boats. Advisory produced a publication based on the workshop. Heikkila says that the publication "turned out to be a best seller. I can almost guarantee that

every boat in the Oregon salmon troll fleet is bonded."

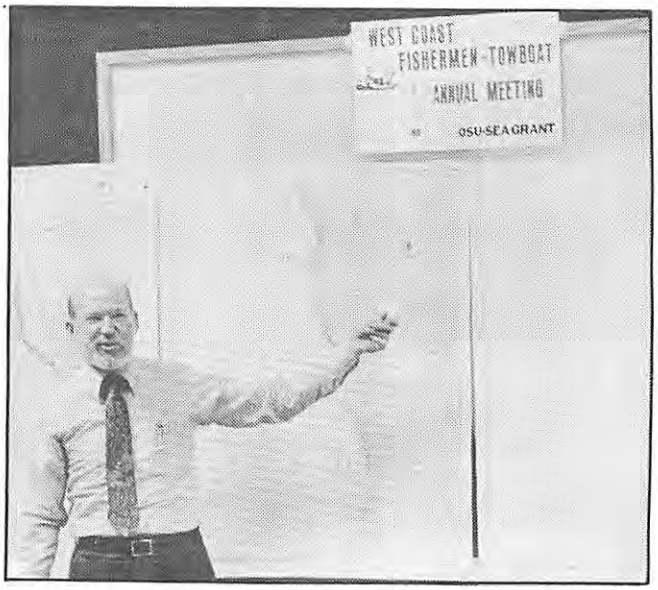
More recently, Advisory successfully extended new shrimp peeling techniques developed by a Sea Grant researcher at the OSU Seafoods Laboratory in Astoria. The techniques increased shrimp yields from 20 percent of wet weight to 27 to 30 percent. Ken Hilderbrand quickly brought these research results to the attention of the industry through one major workshop. He estimates that approximately 90 percent of the shrimp processors on the West Coast have adapted the techniques and are now recovering more than $50 million a year in shrimp meat previously lost.

Working with Small Ports

Small port districts in the Northwest are quasi-governmental entities that promote economic development. The port districts can own and lease land, levy property taxes, and sell bonds to finance economic development. They are governed by elected boards of commissioners. Advisory became involved with the ports through Fred Smith, who conducted management audits at several ports. Smith's work soon expanded into a series of publications on port management and a one-day seminar featuring financial and management experts from the university and the private sector. The seminar was held at various locations on the Oregon coast and along the Columbia River.

In all, representatives of 45 port districts in Oregon, Washington and Idaho attended. Benefits ranged from internal improvements of management and accounting systems to improved long-range planning and a greater understanding of the port development bond process. Work with the small port districts continues, with the emphasis on the use of microcomputers and programmable calculators.

In Astoria, Jim Bergeron serves on the Port of Astoria Advisory Group. He headed an effort to educate the community about the importance of the fishing industry to the local economy. He also helped the Port develop a comprehensive plan to upgrade the East and West Boat Basins. So far the West Boat Basin has been rearranged to give more area to large commercial boats; a crane was installed for offloading, and a marine radio system allows fishermen returning from long voyages to secure dock space before arriving at the dock.



Gib Carter presides over the annual meeting, which saves fishermen and towboat operators from conflict and financial loss.

Taking an Interdisciplinary View of the Columbia River Basin

In the spring of 1973, Advisory sponsored the first "Future of the Northwest Maritime Industry" conference. This conference, a creation of the late Ed Condon, was aimed at getting representatives of business, government, other agencies and appropriate academic disciplines together to discuss problems and interests related to maritime commerce in the Columbia River basin. The conference objectives are to improve communications within the Columbia River maritime industry and to achieve a better informed and more productive maritime community. Conference topics have included such items as user fees, coal shipping, Bonneville Lock improvement, Columbia River bar constraints, intermodal technology and commodity forecasts.

The Future of the Northwest Maritime Industry Conference has been held annually

since 1973. Gib Carter is its current leader. According to Carter:

> The first conference had about an equal number of speakers and participants. It has grown steadily to an attendance of 190 in 1982. The success of this annual event can be attributed to the many organizations, in addition to the Sea Grant programs in Oregon and Washington, that plan and sponsor the conference: the Propeller Club of the Columbia River, the Portland Shipping Club, the Portland Steamship Operators and the Women's Shipping Club.

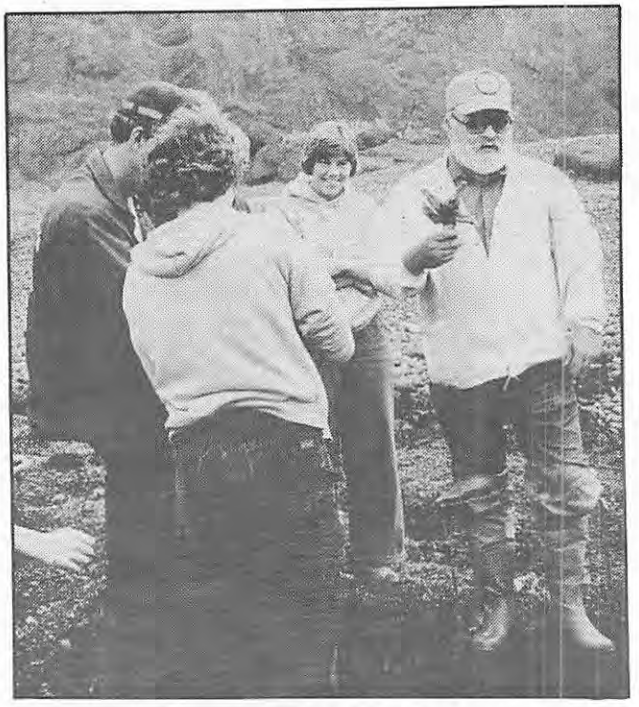
Educating the Public

The OSU Marine Science Center in Newport is the focus of Advisory's marine education efforts. Don Giles, Advisory marine education specialist, is responsible for the Museum-Aquarium in the Marine Science Center Public Wing and for the educational programs conducted there. Giles established the touching pool in the Public Wing, where visitors could touch and handle various tidepool animals. This concept has since been adapted by other aquariums. The aquarium and exhibits attract approximately 350,000 visitors a year.

Giles organizes the annual summer Seatauqua program at the Marine Science Center, a series of workshops, lectures, bus tours, films and beach, dock and estuary walks that takes place from May to September each year. These activities attract more than 50,000 participants per year.

Giles also organizes and teaches workshops throughout the year on such practical and recreational topics as clamming, fish filleting, crab shaking, beachcombing and coastal bird watching.

Vicki Osis is responsible for Advisory's efforts to improve the teaching of marine subjects in elementary and secondary schools. When she began her Advisory work in 1971, there were no marine education programs for school teachers and no curriculum materials. Osis established a program of workshops on various marine



Marine education specialist Don Giles organizes the popular Seatauqua program at the Marine Science Center each summer.

subjects that would provide school teachers with the necessary background and teaching materials to support classroom instructional units.

Osis also prepared the first marine 4-H project in the United States. This project has served as a model for similar projects in other states.

As marine education gained momentum in the Northwest, Osis participated in the establishment of a professional organization, the Northwest Association of Marine Educators (NAME). With Marine Advisory support, NAME has expanded to include a educators in Washington, Alaska and British Columbia. The NAME regional chapter now has 125 members and is affiliated with the National Association of Marine Educators.

Although this account of Advisory accomplishments only touches on those projects singled out by the Advisory staff, it does indicate the far-reaching effects of

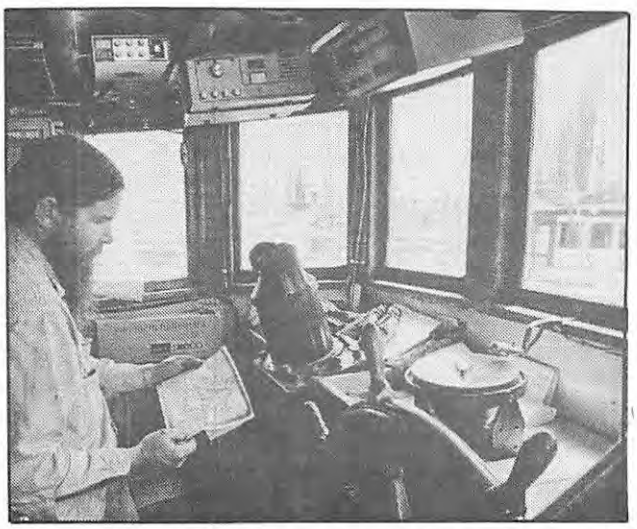
Advisory work. Advisory's educational efforts have brought it into contact with all levels of government, with all manner and type of citizen and fishing industry groups, and with thousands of others. At times Advisory's influence has been quite visible; at other times it has been more subtle. And there have been times when the outcome, although welcome, has not been what was expected.

Throughout its history, however, Advisory has maintained a sense of innovation and experimentation that has made it a leader, making Sea Grant research and expertise available to people who can put them to use.

Tom Gentle

Seafood technology specialist Ken Hilderbrand provides assistance to processors like Johanna Quade of Orpac-Lox, Lincoln City.

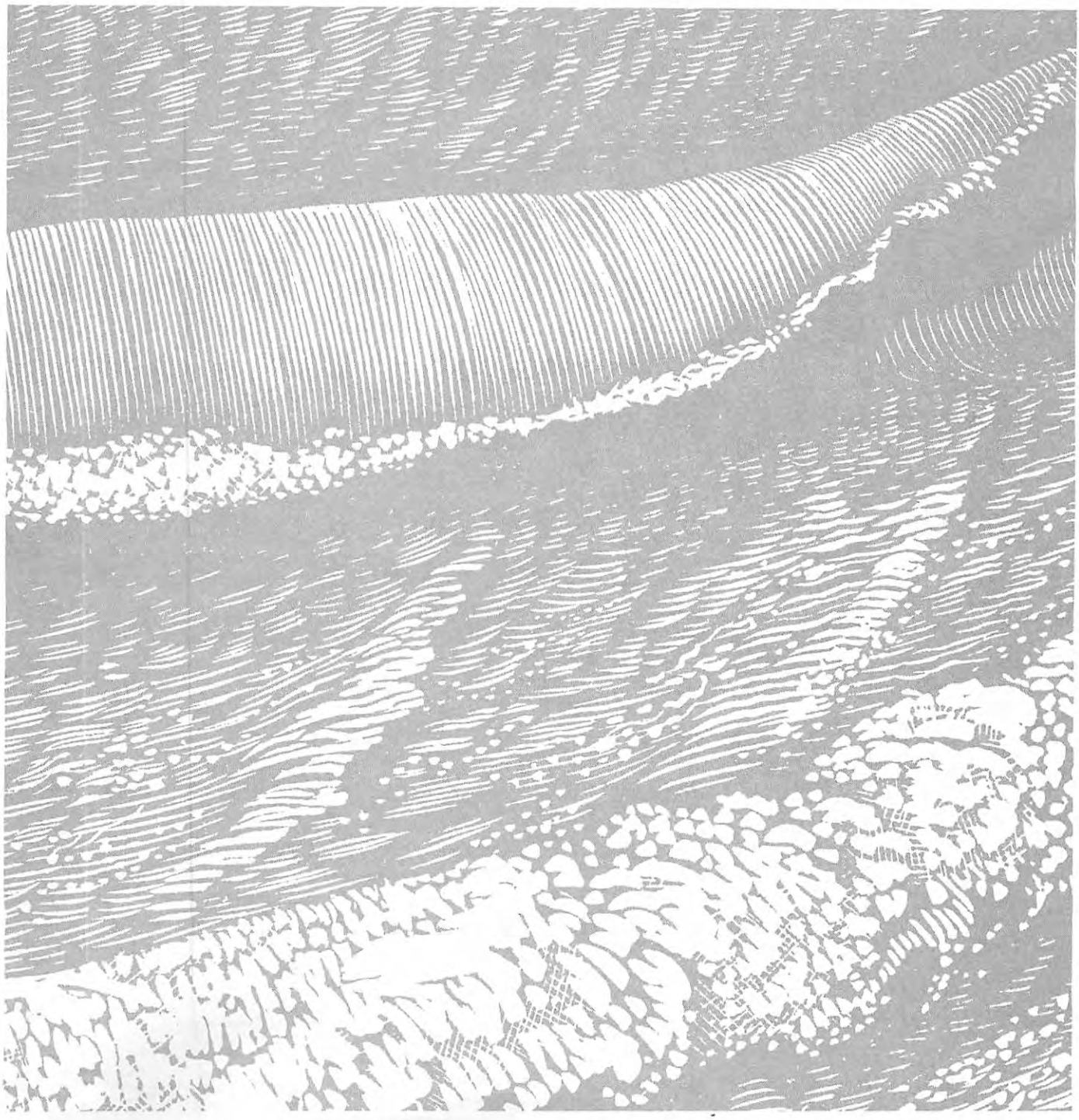
Ruth Nevitt and other members of West Coast Fishermen's Wives Coalition participated in advisory seafood handling training, then passed this learning along to supermarket "meat" department personnel.



Newport fisherman Tom Shafer helped Advisory check the usefulness of satellite ocean-surface data.

The Hatfield Marine Science Center displays are popular with all ages.

Research

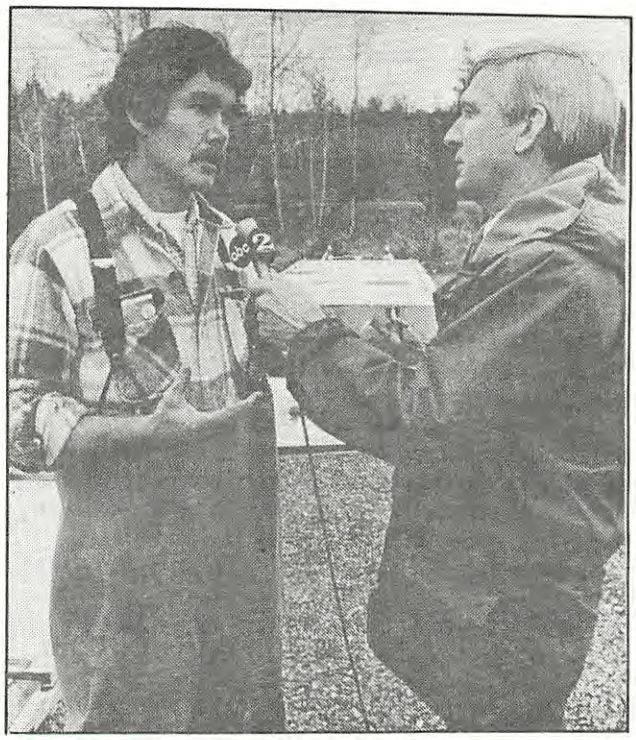


Salmon Culture

At the time when the National Sea Grant Program began, two philosophies of salmon aquaculture were being explored. The first intended to produce marketable-sized salmon through intensive farming systems in floating net pens or other enclosures. The other contended that it would be more cost effective in the long term to produce juvenile Pacific salmon in intensive hatchery systems, release them into the marine environment, exploit the tendencies of the fish to graze and grow in the open oceans, and then harvest returning adults. This concept became popularly known as salmon ranching, drawing an analogy to farming versus ranching the open range on land.

These divergent views gave rise to a lively controversy about the relative merits of intensive versus extensive production systems. In retrospect, it is rather ironic that the salmon ranching concept was regarded as the more radical approach, while the farming system was considered more conservative and analogous to other livestock production systems. In fact, the farming approach represented the more recent concept.

Salmon ranching had been routinely practiced for at least a decade in the Pacific Northwest at that time. For example, hatchery contributions to coho salmon landings in Oregon had been increasing since the early 1960s. By the latter part of that decade the majority of coho salmon landed in Oregon's commercial and recreational fisheries originated in hatcheries. Thus, while some antagonists of the sea ranching concept maintained that this was not aquaculture, they could not deny the important role which aquaculture played in sustaining Oregon's important commercial and recreational salmon fisheries.



Jim Lannan informs the public about aquaculture.

Oregon State University was already evolving a philosophy of salmon aquaculture at the time it was designated a Sea Grant College. The farming concept was being intensively promoted in the Puget Sound region of Washington State and in British Columbia. However, Oregon has only limited water resources which might be suitable for salmon farming, so much of the early salmon research at OSU was directed toward

producing high-quality juvenile fish for release into the marine environment.

Still, much of this work was applicable to both production concepts. For example, the Oregon Moist Pellet ration, which was originally formulated as a hatchery ration, became the standard for salmon farming as well.

Sea Grant researchers believed there were at least four ways in which new technology or refinement of existing technology could contribute to improving the cost effectiveness of artificial propagation of Pacific salmon:

(1) reducing the duration of the hatchery rearing phase either by accelerating growth or increasing production emphasis on alternative species;
(2) reducing the capital and labor intensity inherent in contemporary hatcheries;
(3) reducing the cost of prepared rations; and
(4) expanding the availability of brood stocks for artificial propagation programs.

Oregon Chum Salmon Chosen

One approach taken to reducing the period of hatchery rearing of juvenile salmonids was to explore the possibility of placing greater emphasis on species which were capable of acclimatization to the marine environment at an early age. Pink and chum salmon are adapted to enter the marine environment at the time they start feeding. Thus, these species were attractive candidates. William McNeil began a project at Netarts Bay, Oregon, exploring the feasibility of artificial propagation of these species. McNeil's interest in chum salmon was consistent with state concerns about the status of chum on the Oregon coast. In an earlier era Oregon had an important commercial fishery in chum salmon with landings as high as 6,000,000 pounds in 1942. Since that time stocks have declined continuously. McNeil's research focused on the development of substrate incubation systems for pink and chum salmon.

Technician Ken Prevette shows off one of the 7,000 chum salmon that returned in 1980 to the demonstration hatchery at Netarts Bay, jointly operated by Sea Grant and the Oregon Department of Fish and Wildlife.

There have been three distinct phases in Sea Grant salmon ranching activities:

(1) The initial phase involved assessing the state of the art and defining problems requiring technical solutions.
(2) Second phase activities moved towards a demonstration farm concept with various research and extension activities integrated into the production demonstration.
(3) In phase three, which continues to the present time, the program has matured into a full partnership with the public and private sector in development and enhancement activities.

As in earlier Land Grant developments, Sea Grant's role has been providing continuing research, extension and training.

Phase One--Research

The research topics investigated during the initial phase followed from two assumptions. First, it was considered highly probable that increasing user demands for artificial propagation of Pacific salmon would continue beyond the foreseeable future. Second, it was considered a

certainty that the contemporary trend towards increasing cost per unit hatchery production would continue to escalate.

A second approach to reducing hatchery rearing intervals was to explore the possibility of accelerating growth and development through thermal enhancement. Along with Robert Courtright, McNeil studied the relationship of temperature to the energy budget of several Pacific salmon species to assess the biological feasibility of using warm industrial effluents to accelerate growth.

Streamside Incubation

The labor and capital intensity associated with contemporary hatchery methods led McNeil and his colleagues to consider streamside incubation. Research was linked to investigations of incubation methods for pink and chum salmon and led to the development of a low-cost incubation system intended to produce high quality fry at remote locations. The streamside hatchery system was intended to be an inexpensive, yet a biologically efficient incubator requiring only minimal attention once seeded with fertilized eggs.

In related work, Courtright and McNeil explored the feasibility of introducing Pacific salmon to seawater at an earlier age than was presently practiced as another approach to reducing the duration of the hatchery phase. Although it was found that coho salmon had very stringent physiological requirements which precluded premature introduction into the marine environment, the chinook salmon could be introduced into seawater as early as 90 days after hatching, if properly conditioned before the seawater introduction.

The availability of suitable brood stock was already constraining the expansion of some salmon enhancement programs by the mid 1960s, and frequent transfers of brood stock from one location to another was increasing. The loss of viability of the gametes during the transportation process was a major technical constraint. Sea Grant researchers took two approaches in attempting to resolve this problem. The delayed fertilization method, which subsequently became the standard practice, was successfully demonstrated by Derek Poon, a Sea Grant trainee. In a related study, Howard Horton and his student Alvin Ott developed a methodology for the cryopreservation of salmon gametes.

During the initial phase, the University of Oregon School of Law became a partner in the Sea Grant College Program. Under the leadership of John Jacobson, the Ocean Law Program investigated a variety of institutional and legal questions having broad implications to salmon aquaculture. Also during the initial phase there was increasing public interest in involving the private sector in salmon enhancement activities. This interest culminated in the 1971 Oregon legislature's enacting a bill authorizing issuance of private salmon hatchery permits by the Oregon Department of Fish and Wildlife. This legislative action underscored the timeliness of the Sea Grant salmon investigations of this period.

Phase Two--Expansion

During the second phase, Sea Grant College activities in salmon ranching evolved from the initial biotechnical investigations to a broader program addressing biotechnical, social, legal and economic considerations of salmon ranching.

The transition from the initial to the second phase of salmon ranching activities occurred during the calendar years 1971 and 1972. By this time research needs were becoming clearly defined, and substantial progress had been made in assessing alternative production technologies. Alternative technologies required production scale testing and demonstration projects which would facilitate technology transfer.

Streamside Hatcheries

By 1971, McNeil and his colleagues had completed development of a streamside hatchery which appeared to be suitable for Oregon coastal conditions and had accomplished small-scale tests with this system. In 1971 they built a prototype with the capability to incubate 1,000,000 chum salmon eggs. They were able to obtain

265,000 chum salmon eggs from the Netarts stock for seeding the hatchery and ultimately released 225,000 fry the following spring.

In 1972 a new project, entitled "Pilot Production of Chum Salmon," was initiated with Jim Lannan as project leader. The principal objective of this project was to use the 1971 brood year release, plus releases from the three subsequent brood years to evaluate the performance of the streamside hatchery concept. The pilot production activities would also serve as a demonstration project to assist the developing private chum salmon hatcheries. Finally, since chum salmon brood stocks needed for starting production at these hatcheries wasn't available in Oregon, any surplus production from the pilot project could serve this purpose.

This became the core salmon ranching project in the OSU Sea Grant program.

Concern for Hatchery Disease

Other research and technical support requirements were also coming into focus during this era. Until the advent of private salmon hatcheries in Oregon, the Oregon Department of Fish and Wildlife both regulated and accomplished almost all artificial salmon propagation here. As salmon culture activities in the private sector expanded, concern about infectious diseases intensified, partly because of the increased probability of introducing infectious agents into areas where they did not presently occur, as a consequence of intrastate and interstate transport of fish. Also, because of the great increase in the number of fish being cultured in high-density fish culture systems, the probability of outbreaks of infectious disease was increased.

In response, OSU scientists with expertise in fish health management became partners in the Sea Grant College Program. The fish disease sub-program began in 1973 under the leadership of John Fryer. Research projects began adressing the prevention and treatment of infectious disease, and a fish health diagnostic service was organized. This service was available to both the public and industry. It offered diagnostic services in the event of apparent fish health problems and performed routine fish health clearances required for issuance of fish transportation permits.

Investigation of the immune responses of Pacific salmon was also initiated in an effort to improve the efficacy of vaccines developed by Fryer and his colleagues in earlier research.

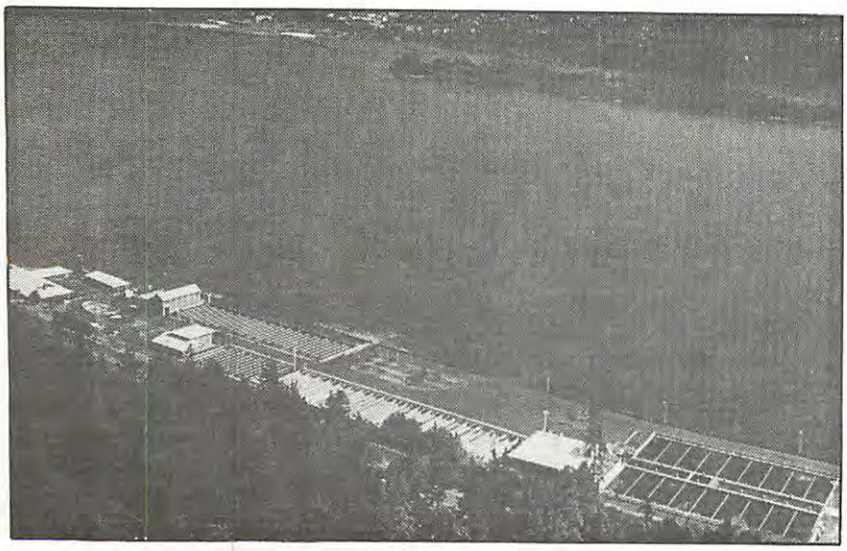
Improving Salmon Nutrition

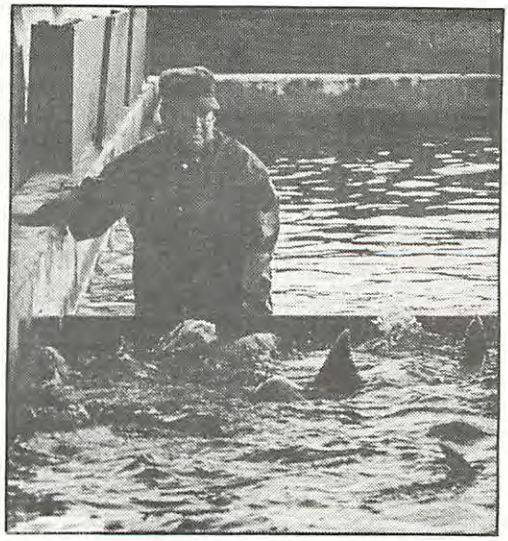
Experts in fish nutrition also joined the Sea Grant College Program team of investigators in this phase. Their activities focused upon improving the nutritional quality of prepared rations for Pacific salmon and rendering the rations more cost effective. Russell Sinnhuber, who was instrumental in developing the first prepared production ration for Pacific salmon, investigated the potential use of animal fats as energy sources in hatchery rations. Don Lee, meanwhile, investigated protein energy relationships and mineral requirements in prepared rations for Pacific salmon.

The financial and economic aspects of salmon ranching received increasing attention during the second phase. Two projects were initiated under the leadership of Richard Johnston. One addressed the feasibility of the production and marketing of seafoods reared by aquaculture. Another involved a broader investigation of seafood market structure and performance.

Phase Three--Enhancement

The third phase of Sea Grant College activities in salmon ranching is characterized by a more direct involvement in regional and state salmon enhancement activities. This trend developed in part in response to technological progress attained in earlier phases, and in part to an evolving philosophy about salmon enhancement in the state. In the latter sense it is noteworthy that the role of industry in the





Public salmon hatcheries have labored to offset the declining number of natural spawners. Both photographs are of the Spring Creek, Washington, hatchery, on the Columbia River.

overall salmon enhancement picture was beginning to clarify.

Oregon statutes that authorize licensing of private salmon hatcheries explicitly provide that while the fish released from private hatcheries are at sea they are part of the common property resource and are subject to the commercial and recreational fishing regulations of the state. Industry has become a partner with the state in the enhancement of its Pacific salmon resources.

Consistent with salmon enhancement trends in the state, the core pilot production project progressed from the demonstration and production trials mode to a more direct role in salmon enhancement. The Netarts hatchery was cooperatively operated as a production hatchery by Sea Grant researchers and the Oregon Department of Fish and Wildlife. One of the principal objectives of the project was to develop the Netarts Bay stock to a degree which could serve as a state brood stock for chum salmon enhancement activities.

Additional research, intended to increase the proportion of returning adults, was integrated into the production program. This research focused upon optimizing the time and size of release of juvenile chum salmon, since the results of earlier production trials indicated that this is a critical decision point which required additional investigation.

Developing New Areas of Support

Technical support and research in fish health management, fish nutrition, and marketing and finance continued through this third phase to the present. Additional needs of the public and of private industry have been addressed through the implementation of new programs.

One new program was developed in response to a clarification of training requirements for technical personnel entering the field. Employers, both in the public and private sectors, indicated that current graduates of fisheries training programs had a fine grasp of the biotechnical considerations but would benefit substantially from a broader exposure to economic and sociolegal considerations. Additionally, programs of higher education lacked job training skills, and recent graduates needed to develop certain skills when they entered the field. It was also noted that, while salmon ranching was not likely to employ large numbers of technically trained personnel, there was a continuing need for such individuals. Furthermore, where the need existed, it was critical.

These observations prompted the development of the Management Oriented Aquaculture Training program within the Sea Grant College Program. Under the direction of Carl Bond, this program was developed around the existing Master of Agriculture degree. This degree requires two minors in addition to the technical major. It also requires an internship (one academic quarter), the preparation of a library research project and a final examination. Students entering the program typically have chosen fisheries as the major area, with minors in agriculture and resource economics, water resources and other areas. Many of the students have served their internships working in salmon producing operations, both with government agencies and private industry.

Another research area added to the Sea Grant Program during the third phase was the investigation of the relationship between certain physiological responses in salmon to production efficiency. Two projects were initiated in this area under the leadership of Carl Schreck. Each of these projects focused on problems identified during the course of salmon enhancement activities. The first investigated the physiological basis for imprinting of juvenile salmonids, while the second concentrated on physiological processes regulating the maturation of salmon brood stocks.

Another new research area investigated the degree to which harbor seal and sea lion predation constrains the development of salmon ranching. A continuation of this project is investigating ways in which predatory marine mammals can be excluded from areas in which adult salmon are concentrated and consequently vulnerable to predation.

In yet another new project area, Marshall English and his colleagues are attempting to use computer modeling techniques and decision-making theory to optimize salmon production processes, such as feeding schedules, rearing intervals and the like. It is likely that these tools can be applied to improving the cost effectiveness of salmon production in much the same way as they have contributed to waste water treatment and other water resource applications.

Throughout its history, salmon ranching has been approached as an input-output system (juvenile salmon are released into the marine environment, and adults or subadults are harvested during their spawning migration). Little is known about salmon life histories during the marine phase, although it is becoming increasingly apparent that the constraints to increasing production are affected during this stage a great deal. In a recent project, Bill Pearcy is looking at salmon survival during the first year at sea. He is collecting data on age, growth and abundance of juvenile salmon collected during nearshore sampling. This is a first step toward increasing our understanding of the complete life cycle of Pacific salmon.

Program Benefits

Most of the technical activities described above address certain of the species of Pacific salmon, though most of the work has broad implications to all Pacific salmon species. In discussing program benefits, we should consider the totality of salmon ranching activities addressing these.

Three classes of benefits can be identified: direct economic benefits; indirect benefits which make an economic contribution, but do not lend themselves to rigorous economic interpretation; and intangible benefits.

An example of direct benefits may be seen in 1981 landings of coho salmon in Oregon's commercial and recreational fisheries. Hatchery releases account for a proportion in excess of 80% of total landings. More notably, 20% of the landings originated in private hatcheries. This is the first year in which a substantial proportion of the total landings was contributed through private hatcheries with virtually no outlay of public funds.

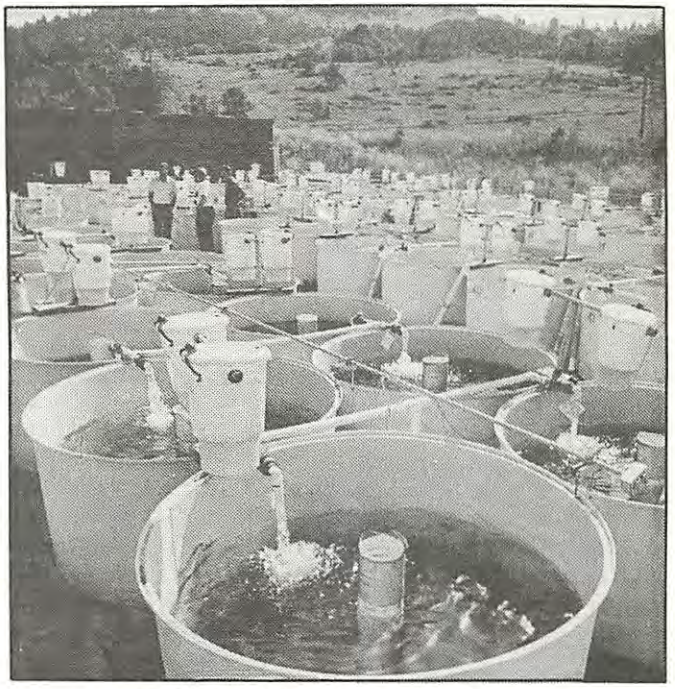
The direct benefits with chinook salmon are less pronounced, although a substantial proportion of fish landed originated in

hatcheries. Direct benefits of chum salmon production are not yet apparent because of a critical shortage of brood stock to support the private salmon hatchery operations. However, the apparent 2% return of 1977 brood year fish to the OSU hatchery at Netarts Bay suggests we are making progress.

Indirect benefits are manifest in improved fish cultural practices in recent years. Nutritionally superior rations are being manufactured at lesser cost. Immunization against the common bacterial disease vibriosis has become a routine practice. Substrate incubation technology is widely used and continues to improve and become more dependable. To the best of our knowledge, no exotic fish diseases have been introduced into Oregon as a consequence of fish transport. Entry level personnel are better equipped than ever before to accept increasing responsibility. Management decisions are based more and more upon an expanding information base. These activities represent a substantial contribution to the development of salmon ranching and to salmon fisheries in general, but it is difficult (if not impossible) to assign an absolute dollar value to this contribution.

Finally, there are intangible contributions which defy measurement by any yardstick but which have certainly had a profound influence on the development of salmon ranching in Oregon. OSU Sea Grant has played an important part. Other agencies have, as well. Sea Grant *investigators* have devoted countless hours to performing advisory services, some of which are formal, many of which are informal. Examples of formal services are the Marine Advisory Program, workshops and symposia. However, in terms of lasting contributions, the informal advisory services may be of greater ultimate value. Informal advising of various users, including commercial and recreational fishing interests, private aquaculture firms and state agencies, are examples of activities not typically summarized in project reports. Yet these activities collectively have had a profound influence on business planning, natural resource policy and on the decision-making processes in general.

—Jim Lannan



Rearing tanks at the Ore-Aqua salmon hatchery at Springfield, Ore. Twenty percent of the landings of coho in 1980 were attributable to private hatchery production.

List of Projects

1968	Culture of Pacific Salmon	McNeil et al.
1968	Rearing of Juvenile Salmon in Brackish Water	
1968	Improvement of Salmon Spawning Grounds	
1970	Cryogenic Preservation of Salmonid and Molluscan Gametes	

1970	Hybridization of Salmon		
1971	(Clumped as research project)		R/A-1
1973-76	Pilot Chum Salmon Production	Lannan	R/Aq-6
1973-74	Seawater Culture of Salmonids	Caldwell (1974) Davis	R/Aq-7
1977-82	Enhancement of Coastal Chum Salmon Resources	Lannan	R/Aq-31
1978	Genetic and Artificial Bases to Imprinting in Coho Salmon Reared in Salt and Fresh Water	Schreck	R/Aq-34
1980	Imprinting in Salmon: Odorant Recognition, Effects of Pollutants and Artificial Cues in Salt Water	Schreck	R/Aq-38
1981	Reproductive Physiology and Induced Maturation of Salmon Brood Stock	Schreck	R/Aq-40

Molluscan Culture

OSU Sea Grant research in the culture of molluscs has centered around the production of seed and related technology. Areas primarily studied have dealt with breeding research, oyster nutrition, artificial food and algal culture. In addition, spawning and rearing techniques have been investigated for clams and mussels.

Oyster Seed Supply

Before the advent of Sea Grant, the greatest problem facing Pacific Northwest oyster farmers was inadequate and fluctuating oyster seed supplies. Japan was the major seed source, with wild caught seed from Canada and the state of Washington supplementing the supply. Natural disasters interrupted the seed supply, and increasing costs priced Japan out of the market. The solution was thought to lie in private oyster seed hatcheries, and Sea Grant began research to implement this idea.

At least ten private hatcheries now operate on the West Coast, and new ones are being established. Their combined capacity could supply the seed for the industry. Cultched seed--cured oyster shell with oyster spat attached--from hatcheries is used extensively.

A Sea Grant hatchery manual was written for Pacific oysters and was well received. Cultchless seed is being used where applicable. A recent innovation, the eyed larval technique, has also been well received. This method allows the grower to purchase the advanced larvae and set the seed at his location on his cultch. The results have lowered transportation costs and allowed the grower to make better use of his employees' time, thereby lowering the seed cost. With this technique, hatchery seed is economically competitive with wild caught seed. As a result of efforts to educate growers, eyed larvae are now purchased and used by growers from California to Alaska.

Wilbur Breese pioneered Pacific oyster aquaculture techniques in his Marine Science Center lab.

Optimum temperatures and salinities for maximizing sets from eyed larvae have been established. Effects of transportation time and larval storage for up to one week on the survival and setting of eyed larvae was demonstrated in a thesis and will be published.

Breeding Research

Sea Grant investigators researched oyster breeding to improve the hatchery production, growth and survival of oysters. Oysters could be self-fertilized by cryopreservation of sperm until sex reversal. Broodstock management was investigated. Techniques for conditioning oysters were established, which greatly increased larval survival and seed production. Broodstock management protocol was written and disseminated to hatchery managers.

Growing Oysters

Oyster culture research demonstrated that raft culture increased the growth rate of oysters as well as making better use of the growing areas. Single oysters (cultchless) were tried and grew well, if reared to an inch or larger before planting. Single oysters are more desirable as they bring a higher price. It appears that some of the newer collectors along with eyed larvae will allow economic culture of single oysters. Trays and cages are now used but are labor and capital intensive.

Outbay culture demonstrated that seed growth could be increased about four times by water management. Utilizing the fertilizer from upwelling, growers can enhance the plankton crop by a 30-hour retention period. This technique is recommended for early seed growth with the goal of shortening the time to maturity, thus increasing production on existing grounds.

A summer oyster (one that can be harvested all year round) is needed by the growers to maintain cash flow. Rearing techniques for the Kumamoto and Crassostrea rivularis were perfected. Both oysters show promise along with the Hiroshima variety of C. gigas. All three oysters have a higher spawning temperature than the Pacific oyster and retain flesh firmness during the warmer summer months.

Oyster Nutrition

Oyster nutrition was investigated in a more basic manner. An energy budget for the Pacific oyster was established. It was determined that 15 degrees C. was the optimum temperature for food conversion. The effect of heated seawater on oyster growth was investigated because of a potential use of seawater for cooling atomic reactors.

Increased temperature promotes oyster growth. However, care should be exercised since in late fall, when the ecology of the ocean is changing from summer to winter conditions, the food level drops. At this time a temperature increase raises the oysters' metabolism and the lack of food in the water accelerates starvation.

Artificial food research turned up little new. Food could be encapsulated, but the oysters could not make use of it. To date no artificial food has been successfully used in growing oysters. The problem is thought to be with the delivery system and not with the diet composition.

Algal culture has progressed to adequately handle larval production. However, it is not adequate for growing seed or young adults. Local algal species were isolated and tested as larval food but none proved to be nearly as good as those available from other areas.

Clam and Mussel Culture

Clam populations are diminishing, making a need for clam seed likely. Spawning seasons were established for the native clams, and spawning techniques were perfected. The native clams were screened for potential culturable candidates. Razor clams, cockle clams and gaper clams were studied further. Rearing techniques are being developed for these species, and their post-larval charcteristics are under study. The larger the clam seed, the better the survival after planting.

Research for the sea mussel is beginning. Natural spawning cycles are being documented and larval rearing techniques developed. At this time larval setting may be the problem. If seed methods prove successful, the mussel may be an excellent candidate for culture because of reported growth characteristics in estuaries.

Wilbur Breese

List of Projects

1968	Culture of Bivalve Molluscs	Breese	
1968	Culture of Improved Natural Environments	Breese	
1968	Selective Breeding	Breese	
1971	Culture of Algae for Molluscs	Phinney	R/F-3
1973-74	Development and Evaluation of Hatchery Techniques for Producing Oyster Seed	Breese	R/Aq-15
1973-74	Development and Evaluation of "Factory" Systems for Raising Oysters in Heated Water	Breese	R/Aq-16
1973	Determination of Nutritional Requirements of Oysters and Development of Artificial Diets	Breese	R/Aq-17
1973-74	Culture of Algae for Molluscs	Phinney	R/Aq-18
1973-77	Selective Breeding of Oysters	Lannan	R/Aq-19
1975-77	Biological Feasibility of Intensified Oyster Culture	Breese	R/Aq-26
1978-80	Biological Feasibility of Clam Hatcheries for Recreational Harvest in the Pacific Northwest	Breese	R/Aq-32
1978-80	Commercialization of Recent Advances in Oyster Technology	Breese	R/Aq-33
1981-	The Use of Eyed Larvae as an Oyster Seed Source	Breese	R/Aq-45
1981-	Molluscan Hatchery Technology	Breese	R/Aq-46
1981-	The Shellfish Advisory Program	Breese	A/Aq-44

Fish Nutrition

During the early 1970s, high mortality rates in hatchery-raised salmon and trout caused concern among hatchery operators. OSU Sea Grant researchers Russell Sinnhuber and T. C. Yu analyzed the tissues of some of these fish and discovered an abnormally high accumulation of unusual fatty acids (FAs) in the fish lipids (fats). The two assumed these fatty acids resulted from feeding deficient diets, which in turn led to higher fish mortality.

Sea Grant-sponsored studies led to establishing the optimum fatty acid requirements for trout and coho salmon. Lee et al. showed that replacing the dietary corn oil (rich in ω6 FAs--which are required and essential for growth in mammals) with fish oil (rich in ω3 FAs and low in ω6 FAs) markedly improved trout growth and greatly reduced mortality. Castell et al. demonstrated that 1% of linolenic acid (18:3ω 3) was needed in the feed to maintain a normal growth of trout. A number of deficiency symptoms occurred, including a shock syndrome, when fish rations were high in ω6 FAs and deficient in ω3 FAs. Yu and Sinnhuber revealed that the long carbon chain and more unsaturated ω3 FAs were equally effective as 18:3ω3, and proved that fatty acid of the ω3 series are essential for trout.

Feeding Trials

Our studies on ω3 FAs have revealed the existence of species differences in the requirement of specific FAs which are essential for growth and reproduction of fish and aquatic animals. A long-term feeding trial was carried out by feeding rainbow trout a test diet containing pure linolenic acid (18:3ω3) as the sole source of essential dietary lipid. The fish matured during the second and third years and produced viable eggs and a healthy second generation. These results demonstrated and confirmed that ω3 FA is the major essential FA supporting growth and reproduction of trout.

Pure ω3 FAs are too costly for use as a dietary lipid, so fish oils were added to trout rations. Our work showed that fish oils contain a high percentage of ω3 FAs and also are a good source of dietary energy. Salmon and trout readily accepted diets containing these oils, and fish oils are now being included in the formulation of commercial fish feeds. Adding fish oils to trout rations (according to one of the largest trout producers) has resulted in a reduction in cost alone of 1/3 to 1/2 to produce the same amount of fish.

Beef Fat Improves Fish Diets, Lowers Costs

Our studies have brought about a demand for diet quality fish oils, which in turn has led to shortages and higher prices. We investigated using low-cost animal fats for partial replacement of the dietary fish oils. We were especially interested in using the abundant and cheaper beef fat (tallow) as a dietary component. Tallow is highly saturated and is a solid at room temperature. Fish culturists have advised against the addition of solid fats in diets for cold water fish because of their assumed poor digestibility at low temperatures.

In our experiments, we mixed different proportions of tallow with fish oil. Trout and salmon had no difficulty digesting these lipid mixtures, and results indicated that the growth rate of trout and coho salmon was increased when a tallow-fish oil (1:1 ratio) mixture was included in their diets. Only a slight increase in saturated FAs was found

in the body lipids of coho fed this ration. This demonstrated that coho salmon are able to maintain the degree of unsaturation required for their body lipids, regardless of the increased intake of saturated fats.

The cost of fish oil is about 35¢ per pound, while beef tallow is 22¢ per pound. The commercially produced Oregon Moist Pellet (OMP) contains 16% fish oil. The current annual production of OMP is about 28 million pounds. The total saving to federal, state and private fish hatcheries, from using this tallow/fish oil mixture, could be $280,000 annually for OMP production alone.

The tallow-fish oil mixture was used in another experiment designed to study the most economical protein/fat ratio for fish feeds. Our purpose was to conserve the valuable protein ingredients and to reduce the cost of feeds. Results showed the percentage of protein in trout feed could be reduced from 40 to 35 percent, without lowering the fish growth rate if the dietary energy density were maintained by proportionally increasing the dietary lipid. Calculations showed slightly more than one cent can be saved for each pound of feed.

Feeding Experiments

A long-term feeding experiment was conducted to study the quality of a biomass protein, a single cell protein prepared from the waste treatment of the potato processing industry. Biomass, containing 60 percent protein, was used to replace about 45 percent of the animal protein in rainbow trout diets. The fish grew very well. To insure there were no toxic effects or reduced flavor quality after a long feeding period, the experiment was extended until the fish reached marketable size. The accumulated mortality was very low. A 40-member taste panel found no differences between fillets from bio-mass fed fish and those from control diet fish in flesh color, texture, flavor and over-all desirability. Since biomass is a by-product from the mandatory waste treatment operations of the potato industry, the cost of the biomass protein is expected to be much lower than

Russell Sinnhuber.

that of fish meals and other animal proteins.

Growth Promoting Studies

Several steroid compounds were tested for their growth-promoting properties. A diet supplemented with 17 ω-methyltestosterone, 2.5 mg/kg dry diet increased the growth rate of coho salmon by 26% over that of the unsupplemented control diet fish. The results indicate that steroid supplementation can be beneficial in that fish could be raised to the desirable size in a shorter period of time with less food (higher feed efficiency). Additional savings in labor, feed and operation costs could mean a more successful aquaculture industry. The residual level of steroids was estimated to be insignificant.

Current Fish Nutrition Work

A new project has been initiated (1981-1986) to study the survival and requirements of salmonids in transition from fresh water to the marine environment. The first and second years will study the influence of diet quality and hormone supplementation on the parr-smolt transformation of coho salmon.

Russell Sinnhuber

List of Projects

1968	Marine By-products and Nutritive Value of Seafoods	Sinnhuber	
1969	Waste Utilization and Nutrition Studies	Sinnhuber	
1970	Nutrition and Waste Utilization	Sinnhuber	
1971-72	Nutrition and Waste Utilization	Sinnhuber	R/S-4
1973-76	Protein-Energy Relationships and Mineral Requirements of Rainbow Trout	Lee	R/Aq-11
1973-74	Essential Fatty Acid Requirements of Salmon	Yu	R/Aq-8
1973-74	Essential Fatty Acid Requirements of Rainbow Trout	Yu	R/Aq-8
1974-77	Animal Fats: An Energy Source in Fish Rations	Sinnhuber	R/Aq-21
1976	Pigmentation of Hatchery-Reared Salmon	Yu	R/Aq-29
1977-81	Interrelationships of Dietary Lipid and Protein on the Growth, Quality and Production of Cultured Fish	Sinnhuber	R/Aq-30
1981-86	Survival and Nutritional Requirements of Salmonids in Transition from Freshwater to the Marine Environment	Sinnhuber	R/Aq-43

Fish and Shellfish Disease

Projects in fish and shellfish diseases undertaken since 1968 dealt principally with the prevention, detection and control of infectious diseases in cultured fishes.

Early work concerned diseases induced by higher parasites in fish and shellfish. Leeches were found to transmit microsporidan parisites in English sole in the estuarine nursery grounds. In addition, leeches were found to transmit parasitic blood flagellates in Oregon marine fishes.

In 1972, research in viral fish diseases began. At that time, infectious hematopoietic necrosis virus (IHNV) was isolated from several stocks of fish in Oregon. As a result of further efforts we now recognize the presence of infectious pancreatic necrosis virus (IPNV) and viral erythrocytic necrosis (VEN) in Oregon. The distribution within the state and the host range of these three agents have been established and are the subjects of an extensive report (OSU Sea Grant Publication No. ORESU-T-80-004). An exotic virus was also isolated from chum salmon in Japan and characterized.

John Fryer guides Sea Grant fish disease research.

Finfish Disease Study

Perhaps the most significant research contribution has been the development of a vaccine for the control of vibriosis, a common bacterial disease, in finfish. Prior to the introduction of this vaccine, the most important problem facing aquaculturists concerned with rearing Pacific salmon was control of Vibrio anguillarum, the causative agent of vibriosis. This vaccine was developed from the cells of V. anguillarum. It is administered to fish by including it in their diet or by spraying directly upon the animal's surface.

Extensive use of the vaccine produced from one serotype led to the discovery of a second serotype of V. anguillarum in Oregon. The two serotypes caused infections in different ways, one through bacterial cells dispersed throughout blood and blood-forming tissues, the other through colonization of muscle tissue. This second type prompted the development of an efficacious polyvalent vaccine containing both serotypes.

Advisory Services

We have conducted an advisory program for the aquaculture industry. It is directed toward prevention, detection and control of infectious diseases of cultured Pacific salmon. The program has resulted in an

effective disease control in cultured salmonids along the Oregon coast. It has prevented the introduction of exotic, nontreatable infectious agents of fish into the state of Oregon.

In addition, we have held a conference designed to inform fish culturists from both the private sector and government agencies about the perils of transporting diseased or carrier fish and fish eggs. An active diagnostic laboratory has been very helpful to the Oregon aquaculture industry.

Cholera Concerns

Research concerning human pathogens and seafood products has shown that Vibrio cholerae should not present a problem in the food chain unless the seafood is temperature abused. This is due to the unique, cool Pacific Northwest climate. Through collaborative efforts with three other Sea Grant supported projects, a computer-assisted analysis at OSU has provided useful information to predict the numbers and incidence of cholerae in marine waters. Laboratory research involving experimental animals has revealed previously unknown virulence factors produced by V. cholerae from marine waters.

Cooperative Efforts

For the past six years we have worked to develop a strong international program with fish pathologists from other Pacific rim countries to include Japan, Taiwan, Korea, the USSR and Chile. This has been done through the National Science Foundation and the Sea Grant College Program at Oregon State University. Five candidates have completed the Ph.D. degree and one person has obtained a master's degree. All are working in the field of infectious diseases of fish.

John Fryer

List of Projects

1968	Training Project in Parasitology	Pratt	
1972	Symbiosis and Parasitism	Pratt	R/F-2
1972	Fish Diseases	Fryer	R/F-10
1973	Glugea Disease of Fish in Oregon Estuaries	Olson	R/Aq-13
1973	Flatfish Blood Diseases	Pratt	R/Aq-13
1973-75	Study of a Neoplastic Disease of Bivalve Molluscs in Yaquina Bay	Mix	R/BR-9
1973	Virus Diseases of Fish	Fryer	R/BR-10
1973	Rockfish Populations Identification (through Parasitic Fauna)	Pratt	R/BR-8
1973-74	Detection, Prevention, and Control of Infectious Diseases in Fish	Fryer	R/Aq-9
1974	Fish and Shellfish Diseases Subprogram R/Aq-13, R/BR-9, and R/Aq-9 continued		
1974-76	Immunization of Fish for Control of Vibrio anguillarum, the Causative Agent of Vibriosis	Fryer	R/FSD-1

1974	Ectoparasites as Limiting Factors in Aquaculture	Olson	R/FSD-2
1975-77	Microsporan Diseases of Shrimp and Crabs	Olson	R/FSD-3
1976-77	The Immune Response in Pacific Salmonids	Fryer	R/FSD-4
1978-81	Detection, Prevention and Control of Diseases in Fishes	Fryer	R/FSD-5
1979-82	Distribution of Vibrio cholerae and Related Species, Pathogenic and Non-pathogenic, in Shellfish and Estuarine Waters	Seidler	R/FSD-8

Fishery Oceanography

The fishery oceanography projects supported by Sea Grant from 1968 to 1981 include eight different projects with eight principal investigators that span a diverse area of biological oceanography, from plankton dynamics in estuaries to albacore tuna in oceanic waters. Most of these projects can be classified as fishery oceanography in the broad sense, since basic objectives include the effect of the ocean environment on the distribution, abundance, growth or survival of marine organisms, many of which have actual or potential commercial value.

Early Research Efforts

The Pelagic (open seas) Fisheries Environment project included study of hydrographic factors influencing primary production of coastal waters off Oregon, as well as in selected bays in Southeast Alaska. A sophisticated pumping system was developed for real-time profiling of hydrographic properties.

Cruises supported by Sea Grant and remote sensing aircraft flights supported by the Bureau of Commercial Fisheries, U.S. Coast Guard, and NASA provided information on upper ocean conditions affecting the distribution and availability of albacore tuna. Commercial fishermen used log books to enable correlations to be made between albacore catches and ocean features. Radio broadcasts and sea-surface temperature charts were disseminated to fishermen off Oregon, products that were later provided by the National Marine Fisheries Service.

A synthesis of the basic fertility of the Oregon continental shelf environment during upwelling (spring-summer) season was also completed. Unfortunately, the two subprojects did not complement each other much because the primary productivity studies were mainly shelf studies, while the albacore studies were further offshore.

Oregon's Commercial Fish/Shellfish

"Early Life of Boreal (Northern) Fish and Shellfish" was a major study of the distribution, ecology and mortality of the early life history stages of commercial fish and shellfish of Oregon. Initially, we concentrated on crustaceans (pink shrimp and crabs) and later shifted to studies of larval fishes. It was one of our most successful projects from the standpoint of number and quality of publications, interaction and cooperation among investigators and education of graduate students. (Several excellent Ph.D. theses resulted.)

The success of the "Early Life" project was founded on a commitment to long-term, systematic sampling of zooplankton and pelagic larvae off Oregon, and a strong common interest by competent investigators.

The series of the samples that resulted proved invaluable in providing basic data in six areas:(1) spawning times and locations; (2) species assemblages; (3) distribution and dispersal patterns; (4) abundances; (5) larval duration; and (6) annual variations of year-class strength of important fishes and shellfishes.

A great deal was learned about the larval biology of English sole, an important species in the Oregon trawl fishery. The abundance

Pacific Warwind, a purse seiner used by Bill Pearcy in his study of juvenile salmon populations off the Oregon and Washington coasts.

of northern anchovy off Oregon was estimated for the first time by egg and larval surveys.

This study was the predecessor and provided basic samples for other projects.

Plankton Dynamics

"Pelagic Food Chain Processes of the Oregon Coastal Zone" included research on the distribution of zooplankton in the nearshore coastal zone and the influence of hydrography and upwelling on their distribution and dynamics. Most samples came from the Early Life of Boreal Fish and Shellfish study.

The analysis of the biology of Acartia clausi in Yaquina Bay, a subproject of this research, provided unique data on the life history and dynamics of this abundant, estuarine copepod. This subproject formed the basis for a study of the zooplankton population dynamics in Yaquina Bay that would help to predict the effects of man-made alterations in the estuary on the plankton.

Oregon State Sea Grant provided the means and impetus for producing a substantial understanding of the general ecology of the waters off the Oregon shelf.

A zooplankton sampling project in Yaquina Bay in the early days of Sea Grant demonstrated the basic seasonal abundance cycles for copepod populations, which overwhelmingly dominate the zooplankton of the bay. These are principal food sources for bay fishes: herring, anchovy, smelt and others. Three principal species of copepods hold important possibilities for studying population dynamics in the bay. We concentrated on Acartia californiensis. Later, that work became a Sea Grant project entitled "Plankton Dynamics of Oregon Estuaries."

J. Kenneth Johnson showed that the summer population of Acartia californiensis increases at a rate largely controlled by the predation of fish, rather than by food (phytoplankton) availability or by physical conditions. The fish limit their feeding to the adult female copepods, probably because the females have opaque eggs and are visible.

It appears that the fish actually migrate upstream every two to three weeks at the time

when the maximum number of female copepods is maturing. This needs further investigation, but it could be important in fishery management, capture tactics for fishermen and other uses.

Focusing on Salmon

Included in the realm of the pelagic environment are two other projects with a common focus on salmon. One reviewed the literature on possible limitations of production of salmon in the oceanic North Pacific Ocean and developed a model for dynamics of lower trophic level production of the region.

The other project was on the ecology of salmonids during their first summer in the ocean off Oregon. It was begun because of recent declines in coho salmon catches off Oregon and the indications that year-class success was determined early in ocean life and was related to intensity of coastal upwelling. This study was the first to systematically sample juvenile salmon off Oregon and to study their food habits, growth rates and migrational tendencies. It also draws on past research of oceanographic features and abundances of food organisms from earlier Sea Grant projects.

In recent studies we have looked at a special area regarding salmon. The salmon of the northern North Pacific are one of the prized resources for fishermen in the Pacific Northwest and around the northern Pacific rim. Many fish spend their ocean phase in a special oceanic habitat that is characterized by complete lack of phytoplankton blooms. This appears to result from the continuous control of plant stocks by the grazing of a small number of species of copepods.

With Bruce Frost of the University of Washington, we were able to evaluate the probably relative roles of different features of the grazing-plant growth interaction. This understanding allowed us to propose a complete reevaluation of the life cycles for subarctic copepods. The data from that study have led to a major study by many scientists of the region, entitled project SUPER.

It is our ultimate goal to understand the food web of this region so we can evaluate the salmon carrying capacity of the Pacific, explain variations in salmon production and year-class success and provide advice about the general development of salmon culture around the Pacific rim.

Recent research on salmon has focussed on the biology of juvenile salmonids during their first, critical summer in the ocean off Oregon and Washington. Collections with purse seines have provided new data on the distribution, movements, growth rates and feeding habits of young salmonids.

Juvenile coho salmon, for example, are most common within 20 miles of shore, usually in cool (10-14 degree C.), green coastal waters. Recovery of tagged fish indicates movement to the south of the river of ocean entry in May and northerly migration later in the summer.

Growth rates of juvenile coho are generally similar to those reported off British Columbia, and body condition improves with time since release. Euphausiids and small fishes are the major prey of juvenile coho and chinook salmon.

Benthic Environment Project

The benthic environment project was an interdisciplinary, biological-geological study. Studied were the effects of sediment water depth on the distribution and seasonal and annual variations in species composition and standing stocks of benthic invertebrates and fishes. Seasonal cruises provided new data in a number of different areas: community structure of benthic animals; feeding habits of flatfishes; pink shrimp and sediment-depth relationships; standing stocks of benthic invertebrates; and seasonal changes in the depth distribution of benthic fishes.

Shallow Water Animals

"Reproductive Cycles and Abnormalities" studied reproduction and spawning of intertidal and shallow water organisms, the temperature effects on the oyster gonadal

cycle grown in laboratory conditions and the neoplasm, or tumor, of bivalves in Yaquina Bay. This project was closely allied to aquaculture.

Its objective was to determine the factors controlling annual reproductive cycles. The project produced publications and theses on reproductive cycles in echinoderms and molluscs. These publications were notable in emphasizing the independence of reproductive cycles from such commonly accepted control factors as the annual temperature regime.

As a by-product of laboratory studies, the project developed laboratory methods for producing out-of-season, market quality sea urchin roe, a still unused potential production method. The work led from field studies on adults and larvae to laboratory studies.

Bill Pearcy

List of Projects

1968 -Early Life of Boreal Food Fish and Shellfish
-The Benthic Environment
-The Pelagic Fisheries Environment off Oregon
-Intertidal and Shallow Water Organisms and Habitats

(Most of these project areas required operations at sea. Although they were costly, we maintained blue water projects throughout the program history, perhaps the only Sea Grant program to do this.)

1971	Reproductive Cycles	Gonor	R/F-1
1971	Estuarian Algal Communities	McIntire	R/F-4
1971	Early Life of Boreal Food Fish and Shellfish	Miller	R/F-5
1971	The Pelagic Fisheries Environment off Oregon	Small	R/F-6
1971	The Benthic Environment	Carey	R/F-7
1973-74	Pelagic Fisheries Environment off Oregon	Curl	R/BR-4
1973-74	Pelagic Food Chain Processes of the Oregon	Miller	R/BR-5
1973-74	Early Life of Boreal Food Fish	Pearcy (Richardson--1974)	R/BR-6
1975-77	Plankton Dynamics of Oregon Estuaries	Miller	R/EM-11
1975-78	Assessment of the Northern Anchovy Population Off Oregon	Richardson	R/OPF-4
1975-81	Pleuronectid Production System and Its Fishery	Pearcy	R/OPF-1
1978	Modeling Studies of Ecological Processes in the Subarctic Pacific Ocean	Miller	R/OPF-9
1981	Feeding Ecology and Behavior of Larval English Sole and Butter Sole	Boehlert	R/OPF-14
1981	Ecology of Salmonids During Their First Summer in the Ocean off Oregon	Pearcy	R/OPF-17

Fishery Population Dynamics

Studies in stock dynamics have investigated aspects of the natural productivity of commercially valuable fish stocks off Oregon by treating the stocks within the context of a larger system. The investigators have examined factors that affect the productivity of these stocks, the structure and dynamics of the multiple-species communities and the exploitation of these communities by local trawl fishery.

The Need for a Multiple-Species Approach

The initial stock assessment study in 1974 examined the distribution of catches over the continental shelf by developing computer-drawn charts of catch concentrations. It quickly became evident that a traditional species-by-species approach was not likely to produce as much insight into the nature of fish productivity as a multiple species study would because a complex mix was taken by the trawler fleet. Evidence from previous studies showed that some of these species were linked in their reproductive and growth processes because of predatory relationships and the blanketing effect of upwelling in these biological processes.

An Interdisciplinary Approach

In 1975, several OSU biologists from different areas of oceanographic research proposed to integrate their work in an effort to come to grips with this natural production system. After reviewing a number of proposals for an integrated study of fishery ecology, the team focused on the complex of species associated with two commercially important flatfishes: Dover sole, a dominant of the outer continental shelf, and English sole, a dominant of the inner, more shallow areas of the shelf.

Five senior investigators tackled the problem: Andrew Carey in benthic ecology, William Pearcy in juvenile fish ecology and feeding relationships, Sally Richardson in larval fish ecology, Albert Tyler in ocean-fish community ecology and population

The 54-meter Wecoma assists OSU researchers in explorations from the Arctic to the Antarctic.

dynamics modelling, and Charles Warren in theoretical fishery studies. This team was joined by Robert Demory, a fishery biologist of the Oregon Department of Fish and Wildlife. Project R/OPF-1 was called the Northwest Pleuronectid (flatfish) Production System and Its Fishery.

Results

Investigators mapped commercial catch locations and seasonal shifts in catch patterns. Those migrations were related to spawning behavior. Nearshore nursery grounds were located that are at least as important to productivity as estuarine areas for certain species. It was also discovered that flatfishes in the study region grow faster as water temperature drops, which is the inverse of temperature's effects on the growth of North Atlantic flatfish stocks.

Upwelling is a dominant determining influence on the survival of flatfish larvae and the growth of juvenile flatfish, investigators demonstrated statistically. They also discovered a long-term trend in upwelling that is a dominant influence on biological productivity in the region, and developed computer software for estimating brood strengths of representative species five years in the future, given current data on upwelling.

Statistics from the early 1960s and 1970s were used to show that calculation of flatfish catch quotas by traditional methods would have damaged local stocks had not economic constraints curtailed markets. Interestingly, investigators demonstrated that stock size and fishing effort had little effect on resulting brood strength for a 25-year period.

A fisheries strategy for flatfishes requires choosing either constant yield or maximum productivity (which fluctuates with variability in oceanic conditions), investigators found, and they determined from a model that managing one flatfish species in an association for maximum productivity precludes achieving maximum productivity for other species in that association.

As a result, they developed a conceptual model showing that an alternative multiple-species fishery strategy should be to optimize productivity of selected species and maintain species population levels within associations (and not to attempt to optimize yields of all species).

A Simulation Model for the Pacific Whiting

In 1979, another group pooled their efforts to carry out a bioeconomic project on the Pacific whiting with pass-through funds from the Northwest-Alaska Fishery Center of the National Marine Fisheries Service. D. Bernard and Albert Tyler were involved with the biological modelling, Courtland Smith and Jeffrey Stander with fleet dynamics, and Richard Johnston and Fred Smith with fishery economics.

Jeff Stander, Court Smith and Al Tyler cooperated on the Pacific whiting project.

The group developed a self-generating, age-structured simulation model of the offshore stock of Pacific whiting (Merluccius productus) to estimate effects of management on stock productivity and fishery yields. Model experiments mimicked possible management policies between 1981 and 2010 and indicated that the stock has no maximum sustainable yield (MSY) independent of oceanographic conditions. Also, the fishery significantly impaired simulation recruitment, but the greater influence of oceanographic conditions hid this effect. Pulse fishing is the most productive simulated policy, but it drove stock size down beyond recently observed levels. The

current management policy (prorating total allowable catch--TAC--to stock size) significantly increased simulated yields over a constant TAC without significantly affecting recruitment.

A Study of Variability in Natural Productivity

The most recent project is a direct descendant of the flatfish system project. This new project, titled "Environmental Influences on Fishery Sustainability," was developed by Tyler (fisheries modelling), Huyer (physical oceanography), and Bledsoe (ecosystem modelling). The statistical studies will identify the influences of factors causing variability in natural productivity in the Pacific Northwest and Gulf of Alaska. More accurate and dependable methods of estimating fishery yields will result.

Methods that are useful in the broader contexts of oceanographic systems are much needed in fishery management. Improved mathematical computer models will be developed to show how to make fishery yield estimates in the face of variations in stock productivity caused by density-dependent, food-web related responses combined with variations due to temperature change, water-mass transport and upwelling.

——————————— Al Tyler

List of Projects

1973	Population Assessment of Fishing Stocks	Tyler	R/BR-7
1975-81	Pleuronectid Production System and Its Fishery	Tyler *et al.*	R/OPF-1
1979	System Dynamic Model of the Pacific Hake Stock	Bernard	R/OPF-10
1980	Biotic and Hydrologic Influences on Fishery Sustainability	Tyler *et al.*	R/OPF-12
1981	Environmental Influences on Fishery Sustainability	Tyler *et al.*	R/OPF-16

Fish Life History and Management

The fish life history and management investigations were aimed at identifying either new fisheries or methods to improve old ones. In some cases potentially large fisheries were documented while others were judged to be too sparse and scattered to suggest a profitable venture. Some new fishery management procedures offered advances that were technically sound but socially unacceptable.

Anchovy Populations

Assessment of the northern anchovy population off Oregon indicated an annual spawning biomass of from 700,000 to 1,000,000 metric tons. Similar sized populations off central California were judged to support an optimum yield of some 64,000 metric tons per year. A fishery of this magnitude could have substantial economic benefit to coastal Oregon fishermen, as well as the associated support, supply and processing industries.

Yet, because of perplexing questions and problems associated with harvesting anchovies, the fishery hasn't developed. Aside from the economic factors of costs versus revenues, the impact of harvesting anchovies on the marine ecosystem is little understood. Many people are concerned that commercial harvest of anchovies may adversely affect the predator-prey relationship between anchovies and seabirds, and anchovies and salmon and tuna. Sea Grant research clearly revealed the magnitude of the resource but left many important questions unanswered. Much more work needs to be done.

Subtidal Clams

A smaller, but economically more successful study assessed the subtidal populations of clams in Oregon estuaries. Large subtidal populations of gaper clams were identified in Yaquina, Coos and Tillamook Bays. In one 39-acre subtidal tract in Yaquina Bay, approximately 480,000 pounds of gaper, cockle, butter and littleneck clams worth about $120,000 were found.

As a consequence of this study, a limited commercial subtidal clam fishery was established in the bay with yields of up to 3,000 pounds of clams per day. Additionally, detailed maps of Oregon's subtidal clam populations were produced for use by recreationists and ecologists.

Crab Fishery

The Dungeness crab fishery of Oregon is noted for its high product quality, its importance economically to fishermen, and a highly cyclical abundance pattern. Two separate studies developed methods of forecasting the size of the harvestable crab population in advance of the fishing season. One study looked at numbers of three-year-old sublegal crabs to estimate the abundance of legal-sized four-year-olds the next year. Estimates had an 80 percent or higher accuracy.

A second method used coastal weather conditions, especially rainfall, to construct a mathematical model which would predict the legal crab catch four years later. The utility of these two methods was never realized for complex reasons. Fishermen feared that processors would use the predictions of a large crab catch as a

way of controlling prices to the disadvantage of the fishermen, while some processors were fearful that the reverse would be true in years of predicted crab scarcity. In the face of these reservations by the industry, the state showed little interest in financing the necessary manpower to collect the survey data.

Deep Water Crab

Exploration of the deep water Tanner crab fishery revealed mature animals distributed over a depth range of 400 to 1,500 fathoms. While the size and quality of the crabs were good and acceptable to processors, there were not enough crabs to support a commercial fishery. Much new information on the ecology and morphology of the Tanner crabs was obtained and will serve as a bench mark for reference in subsequent studies.

In other studies, new cryogenic and laser systems for marking Dungeness crabs were developed. These methods are relatively long lasting and do little damage to the animal. Also, a photographic method for quantitative seasonal surveys of green sea anemones was developed along with a suitable tagging method.

Conservation of Reef Fishes

In 1976, Howard Horton and graduate students began studying the reef fish community on one of Oregon's more popular sportfishing reefs. They tagged reef fishes and surveyed party boat catches to calculate the relative abundance of each reef and fish species' population. They studied sex, size and age characteristics to determine how fast each species grows. They also analyzed stomach contents.

The researchers determined that reef fish populations remain strong except for the yelloweye rockfish population in their study area. They found that various reef fish species populations generally do not compete for food and concluded that on reefs where all species populations are strong, there is little competition for food. The implication is that each species can be managed singly, without regard to other species. However, fishing may have to be curtailed in select areas where yelloweye rockfish and lingcod have been depleted. Shallow reefs close to the shore act as nursery areas for rockfish species.

More fishermen than ever angle for reef fish off the Oregon coast. Biologists know little about these fish populations and can not accurately tell if angler effort is overfishing the stocks. Scientists need basic biological and ecological information to assess the health of reef fish populations.

——————————— Howard Horton

List of Projects

1973-75	Assessment of the Tanner Crab as a Potential Fisheries Resource on the Oregon Continental Slope	Carey	R/BR-1
1973	Ecology of Shrimp and Crab Early Life History Stages	Gonor	R/BR-2
1973-76	Prediction of Abundance of Harvestable Dungeness Crab	Horton	R/BR-3
1974	Cryogenic and Laser Marking of Dungeness Crabs	Stroud	R/ES-5
1974	Prediction of Abundance of Harvestable Dungeness Crab: II	Horton	R/ES-6
1975-78	Assessment of the Northern Anchovy Population off Oregon	Richardson	R/OPF-4
1975-78	Subtidal Clam Populations: Ecology, Distribution, Abundance and Management	Hancock	R/EM-9
1976-81	Biology and Conservation of Neritic Reef Fishes	Horton	R/CM-18
1977	Assessment of Oregon Populations of the Green Anemone, for Harvest Potential	Gonor	R/CP-1

Seafood Processing

The goal of the seafood processing program has been to increase the use of food resources from the sea for man and animal. Applied research and direct cooperation with seafood processors were undertaken to realize this goal. Furthermore, the research provided a base for graduate training in marine food science.

Efforts involved a wide variety of seafood processing problems and development opportunities. Researchers evaluated underutilized species for their potential acceptance and considered ways to enhance the commercial development of secondary processing. Investigation of the post-catch and process biochemistry and microbiology of seafood products improved process unit operations and equipment used to improve yield, quality and shelf life. Information on the composition of seafoods promoted public awareness of the nutritional value of seafoods. Better use of waste products was made possible through the evaluation of further processing and animal feed product formulation.

This wide-ranging program, initiated in 1968, has added greatly to knowledge concerning seafood processing. The following examples further describe this effort and provide a measure of its success.

Using Mechanically Minced Fish

Through the mechanical deboning of a wide variety of round groundfish, we were able to increase edible flesh yield from the 27%-35% obtained by hand filleting to 40.4%-54.5%. The minced flesh was shown to be nearly as acceptable as intact fillets, but its frozen shelf life was shorter.

Separated minced flesh was judged to have excellent potential as a major component in mechanically formed mixed food products. Two such products that were evaluated were a mixture which extends high-priced shellfish products and a low-priced carbohydrate commodity which yields a nutritionally balanced product. The latter concept would be an ideal product for large-scale institutional feeding.

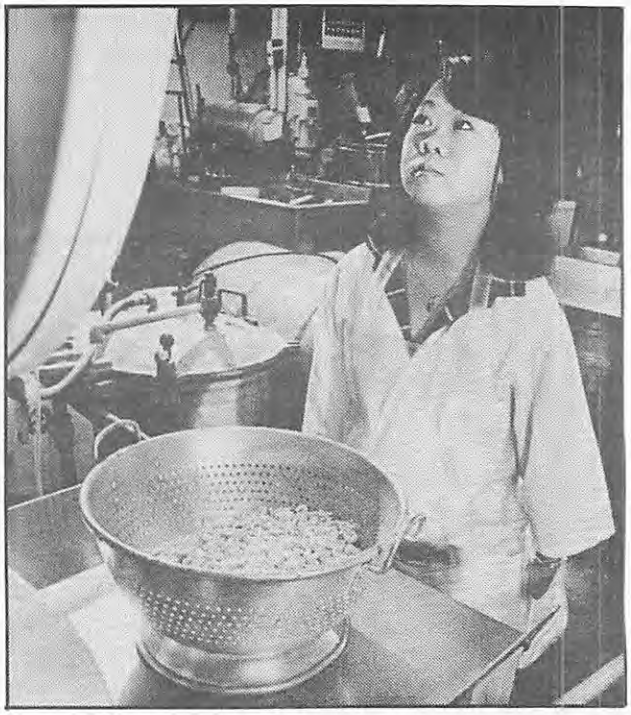
Highly acceptable products having an excellent frozen shelf life (12 months) were developed by combining minced flesh from a variety of groundfish species with small Pacific shrimp and cooked diced potatoes or rice. Both shrimp and carbohydrate products improved public acceptance of the minced fish.

Sea Grant assistance allowed the development of a commercial processing line which could form, batter and bread and freeze the minced groundfish/shrimp product. This produce is currently being produced and marketed under the "Shrimbo" trade name by Pacific Shrimp, Inc., of Warrenton, Oregon.

Finding Uses for Seafood Wastes

Researchers studied ways of processing, upgrading and utilizing seafood processing waste. Extensive chemical characterization of the solid waste of Pacific shrimp processing revealed its low protein nitrogen and its valuable pigment content. A nutritionally balanced, moist pelletized ration containing 40% milled shrimp waste was created to provide a cheap source of dietary pigment for rearing pan-sized salmon with natural pink flesh coloration. Twenty-five thousand pounds of this ration was prepared by the OSU Seafoods Laboratory

Application of phosphates before pre-cooking raises the commercial yield of cooked shrimp meat by approximately 33 percent.



The phosphate procedure was developed at the Seafoods Lab in Astoria and is now widely used by shrimp processors.

and fed by Oregon Aqua-Foods, Inc.

The ration reared fish at a comparable rate, but the degree and uniformity of flesh pigmentation were inferior to those produced by rations containing pigment-rich red crab.

Pigment levels in shrimp waste rations were too low to affect desirable flesh coloration in immature fish. The use of waste in rations could prove very successful if fish are reared to a larger size.

Groundfish carcass waste is an underutilized seafood waste product. Major effort was directed toward upgrading this waste through protein concentration. Much of the work in cooperation with the Oregon Department of Fish and Wildlife was designed to provide a high-quality, moist protein source for the Oregon Moist Pellet system used to rear hatchery fish. Fish meal is presently the major source of protein in this ration system. The supply of meal is becoming limited; commercial quality has been markedly reduced, and costs have increased.

Attempts were made to improve methods of liquefying carcass wastes with enzymes. A procedure was developed for stabilizing deboned liquified fish at ambient room temperature with mineral acid and potassium sorbate. This procedure is now being evaluated by the Oregon Department of Fish and Wildlife.

At present, researchers are evaluating a concentrated fish flesh (CFF) product that is low in ash (5%-6%), and that possesses a reduced moisture content (65%-67%) and a protein concentration of 23%-25%. Its unique physical characteristics allow the formulation of a moist pelletized ration containing 58% CFF, significantly reducing fish meal protein requirements. Investigations are being carried out as a joint venture between the OSU Seafoods Laboratory, the Oregon Department of Fish and Wildlife, and Bio-Products, Inc., of Warrenton, Oregon.

Determining Trace Element and Vitamin Levels

Quantitative determination of the components in Pacific seafoods provided important information concerning the role of seafood products in human nutrition and health. A survey of the mercury content of commercial Oregon groundfish showed little probability of any commercial catch having greater than .50 ppm mercury. The lead and cadmium content of more than 500 samples of 12 different commercial Oregon groundfish showed no more than 0.40 ppm lead and 0.20 ppm cadmium. Most samples contained less than 0.10 ppm lead and 0.05 ppm cadmium.

Seventeen marine species were analyzed for their content of 17 mineral elements. Sixteen percent of the iron in fish was found to be biologically available, an amount which is equivalent to that in red meat. Fish in the diet enhanced the use of iron in foods of low bioavailability (wheat, spinach and soybeans). Thiamine, riboflavin and niacin levels in seafoods were determined, as was the effect of processing and storage on these vitamins.

Determining Biochemical Changes in Processed and Stored Seafood

The investigation of biochemical changes in processed and stored seafoods has helped explain problems of quality and process yield. This information, while not often leading to an elimination of the problems, has provided a basis for controlling the effect of adverse biochemical changes on quality and process yield.

An understanding of the mechanism of oxidative enzyme systems responsible for the blue discoloration in cooked fresh and canned crabmeat enabled us to develop handling and processing procedures which reduced the discoloration. Examination of the decomposition of trimethylamine oxide to formaldehyde and dimethylamine in frozen groundfish and shrimp meat has reinforced the belief that this reaction helps toughen muscle proteins during storage. However, this information has not led to a practical means of retarding the action of this toughening process.

Industrial Engineering

An initial assessment of technological problems in the Oregon seafood processing industry in 1967 indicated the need for engineering research and advisory help. The Industrial Engineering department, through William Engesser, eagerly took on this assignment. The project area was active for eight years, through 1976. Results were of benefit to the national seafood processing industry.

These special projects included time-motion analyses of nearly all processing methods. The myriad steps in handling each product were reduced to micro-second charts using motion picture and video tape techniques. Inefficiencies were pinpointed. Particularly adept processing workers were studied to determine why their methods were more productive. From these studies, a standard efficient method was selected for the handling of each species. Training programs were established, with most Oregon plants participating. Plants in Alaska and other sections of the country also became involved. In later segments of the project, efficiency of supervisory and executive levels were subjected to scrutiny.

The overall effect of this series of projects was to develop modern efficiency standards for processing of most volume seafood products harvested in the northeastern Pacific Ocean. This resulted in monetary savings and in better quality seafood products.

—Bill Wick

The muscles and digestive proteins of shrimp were shown to differ considerably from those of mammals; the proteins exhibited a high level of activity. The unformed connective tissue in shrimp muscle was subject to proteolytic attack and quite sensitive to loss through the washing action

of melting ice during pre-process storage and to heat-induced solubilization during steam precooking. The formed and unformed connective tissue content was directly related to shrimp maturation: small shrimp contained less total connective tissue, and unformed tissue in the muscle was replaced with formed tissue with maturation. The post-catch biochemistry of shrimp produced a marked impact on the quality, processing characteristics and yield of cooked meat.

Improving the Efficiency of Fish Processing

The unit operations of shrimp processing were extensively investigated to improve process efficiency and cooked meat quality and yield. Very fresh shrimp are difficult to peel mechanically, but we discovered that placing them in a weak acid bath just prior to steam precooking led to efficient shell removal. This procedure is not presently in common commercial use, but it has made possible the processing of very fresh shrimp, yielding high-quality cooked meat.

Determination of the sensitivity of the connective tissue in shrimp muscles to heat-induced solubilization led to an evaluation of the relationship between steam precooking time and yield. A survey of commercial operations showed precooking time to range from 90 to 168 seconds. Laboratory evaluation indicated that 90 to 100 seconds was sufficient for producing ready-to-eat shrimp. Indeed, an extension of cooking time from 90 to 168 seconds produced a loss of 31 pounds of cooked meat/1,000 pounds of round shrimp.

Although strict control of precooking times improved cooked meat yield, large quantities of solids were still being lost. Procedures were developed for the application of condensed phosphate to round shrimp just prior to steam precooking. Condensed phosphates penetrated the shell of the shrimp and interacted with the proteins of the shrimp musculature, retarding solubilization and losses during precooking. In addition this treatment formed the cooked shrimp musculature, which reduced mechanical loss during peeling.

Treatment of shrimp at low temperature also proved to be of vital importance. At high temperatures, the condensed phosphate solutions greatly accelerate enzymatic action, breaking down muscle tissue; this action could completely eliminate the yield advantage for the condensed phosphate application.

This phosphate procedure is in wide use by shrimp processors in the Pacific Northwest. Its application has raised the commercial yield of cooked meat from 20-22 pounds to 28-30 pounds of cooked meat/100 pounds of round shrimp.

Dave Crawford at the Seafoods Lab.

Current Research

Present research in seafood processing is directed at determining the action of proteases on the unformed connective tissue of shrimp muscle and their effect on subsequent loss of protein through the washing action of melting ice. Laboratory investigations have revealed a potential for a yield of 35% cooked meat from Pacific shrimp. A system has been developed which allows the substitution of mechanical refrigeration for storage of ice, thus eliminating solids loss by the washing

action of melting ice and unfavorable increases in the moisture content of cooked meat. This system may also extend round shrimp shelf life.

Investigations are under way to examine the unit operations of processing Dungeness crab and to improve the yield, quality and frozen shelflife of cooked meat. Cooking crab in steam rather than water improved meat sensory characteristics. Another highlight of our work is that treatment of raw crab sections in condensed phosphate solution prior to cooking improved cooked meat yield by 2-4 percentage points, based on raw section weight.

Many Sebastes species are marketed as "rockfish," but the species differ considerably in basic quality and handling characteristics. We've examined the characteristics of their connective tissue to determine if species variations were related to commercial quality.

Present investigations seek to determine what characteristics of the connective tissue proteins effect their degree of stability.

Dave Crawford

List of Projects

1968-70	New Species and Product Development		
1968-70	Quality Improvement and Sanitation		
1971-	New Species and Product Development	Crawford	R/S-1
1971	Quality Improvement and Sanitation	Crawford	R/S-2
1973	Seafoods and Heavy Metals	Childs	R/PD-1
1973	Proteolytic Enzymes in Pacific Shrimp	Crawford	R/PD-6
1973	Post-extraction Biochemistry of Trimethylamine Oxide in Pacific Shrimp	Crawford	R/PD-6
1973	Detection and Identification of Spoilage-Flavors of Refrigerated Dungeness Crab Meat	Scanlan	R/PD-7
1973-74	Factors Involved in the "Green and Orange" Discoloration of Albacore Tuna	Babbitt	R/PD-8
1973	Whitening of Rockfish Portions	Childs	R/PD-9
1973-75	Parameters Influencing Utility of Fish Muscle in Frozen Portions and Further Processed Items	Childs	R/PD-10
1973	New Seafood Product Concepts. I. Extension of Shrimp Meat with Minced Fish Flesh	Babbitt	R/PD-11
1973-74	New Seafood Product Concepts. II. Extension of Minced Fish Flesh with Vegetable and Cereal Products	Crawford	R/PD-12

1973	Quality of Minced Fish Flesh Recovered by Machine Separation	Babbitt	R/PD-13
1973	Whole Smelt as a Hot-Processed Smoked Fish	Babbitt	R/PD-14
1973	Intermediate-Moisture Kippered Salmon Products	Childs	R/PD-15
1974	Blueing Discoloration in Dungeness Crab	Babbitt	R/PD-19
1974-75	Decomposition of Trimethylamine Oxide in Pacific Shrimp	Crawford	R/PD-20
1975-77	Seafood Utilization and Process Concept Development	Babbitt	R/PD-25
1975-77	Nutritional Quality of Seafoods	Crawford	R/PD-26
1975-(cont.)	Seafood Science Research Result Applications and Information Transfer	Crawford	A/PD-10
1978-80	Seafood's Role in Human Nutrition	Gordon	R/PD-32
1978-80	Seafood Processing and Utilization	Babbitt	R/PD-33
1981	Seafood Process and Product Improvement	Crawford	R/PD-40

Seafood Microbiology

Microbial hazards unique to seafoods and the effect of microorganisms on the quality of Oregon seafoods have been investigated to provide information on safe and wholesome seafood processing methods. From the earliest phase of this program, researchers sought to provide specific answers to specific problems.

Responding to FDA Concerns

In the late 1960s, the fledgling Oregon shrimp industry was threatened by the Food and Drug Administration's (FDA) seizure of its products because of high staphylococci count. We immediately began to examine standard processing practices and found that a judicious alteration of washing and handling operations could drastically reduce the microbial load. To aid in this study, we also developed a simple isolation and differentiation medium for staphylococci.

The FDA threat prompted the use of a rash of sanitizers and detergents by seafood processors, often with no proper direction. We tested these products and recommended the best of them. After a systematic investigation, our findings and recommendations were published and distributed as a Sea Grant bulletin.

The FDA in 1969 proposed a stringent smoked fish regulation. We undertook educational and research efforts to aid processors. At the same time we investigated the germination and outgrowth characteristics of Clostridium botulinum type E. From this effort we recommended against pasteurization of Dungeness crab meat and averted a regulatory hardship by recommending warning labels for all seafoods packed in hermetically sealed cans that did not receive thermal processing.

Another study was done to find out if Pacific whiting spoiled faster because of unusual microbial action. We found that some bacteria antagonized the growth of seafood spoilage Pseudomonas.

Informing and Educating Processors

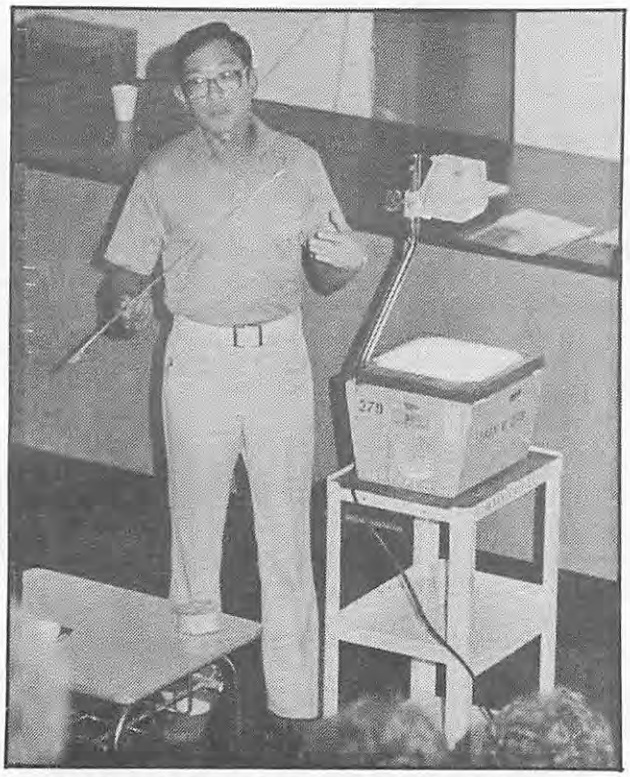
The early 1970s also produced a rash of shellfish-transmitted gastroenteritis across the United States from a particular Vibrio. We investigated the prevalence of this estuarine pathogen among Oregon seafoods and found the risk to be relatively low. Nevertheless, recommendations to safeguard against this bacterium were made to seafood processors.

During this period, we worked closely with the Marine Advisory Program. We participated with agents in trouble-shooting efforts, produced fact sheets and information letters, and held Advisory workshops and seminars to promote seafood plant sanitation.

Breakthroughs from Basic Research

The second phase (FY 74-78) of this program was devoted to the understanding of fundamental microbiological characteristics of Oregon seafoods. During this period, we were able to go back to many questions that had been left unanswered.

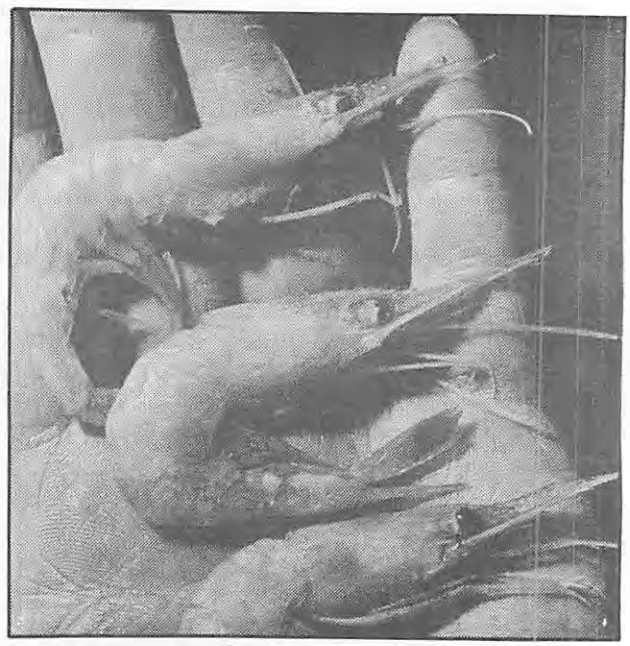
We developed and refined the specialized techniques for the isolation and identification of microorganisms from Oregon seafoods. Microorganisms associated with



Dungeness crab meat and Pacific shrimp were characterized thoroughly. The physiological and environmental factors that contributed to the rise and fall of each microbial group were systematically investigated. The specific role each microbial group played in the degradation of seafoods was studied by inoculating sterile fish muscle with pure cultures of bacteria. This study is considered a major breakthrough.

Shellfish sanitation was another area of our concern. We examined the mechanism by which saxitoxin was bound to clam tissue and studied the microbial population change in oysters subjected to ultraviolet light-treated seawater. When the Food and Drug Administration proposed to withdraw its endorsement of the Oregon Shellfish Sanitation Program in 1977, our efforts in this area were intensified.

We began studying the source of microbial pollutants in Tillamook Bay, developing a fecal source verification model. As a result, Sea Grant was called upon to help the Oregon Health Division and the Department of Environmental Quality (DEQ) to radically redesign the Oregon Shellfish



Jong Lee conducts a seminar for the Pacific Coast Fishermen's Wives on seafood handling (left). Right: a handful of shrimp.

Sanitation Program and provide technical assistance to the DEQ during studies of Oregon estuaries. Sea Grant also assisted shellfish growers in meeting the proposed guidelines on safe harvesting of shellfish, and helped the Soil Conservation Service with its animal waste reduction program.

The pertinent microbiological data obtained during this period were summarized in a ready reference form to be used by the seafood processors.

Phase Three

The third and current phase is devoted to special studies. The first project selected was the Refrigerated Seawater Spray System (RSWS) on board fishing vessels because of its technical complexity and stringent microbiological control requirements. In cooperation with Sea Grant fisheries engineer Ed Kolbe, we designed, built, and tested a workable prototype. The operational specifications of RSWS and the microbiological characteristics of the system are documented for potential users.

The second project was to study the effect of carbon dioxide-modified or

Marine Biomedicinals

The living resources of the ocean provide a tempting array of natural compounds which may have application in the control of disease in other living forms, as insecticides, or for other beneficial uses.

For several years during the early 1970s, the OSU Sea Grant College supported research by the School of Pharmacy through Philip Catalfomo, George Constantine, Lavern Weber and John Block and by James McCauley in the School of Oceanography. These studies were to investigate marine invertebrates and marine fungi for the occurrence and distribution of secondary metabolites. Also examined was how these materials might be used as beneficial medicinal agents or might otherwise be of economic importance.

Results noted biological activities, including those of antimicrobial, tumor-inhibitory, neurotropic, cardiovascular and insecticidal nature. Thirty-three extracts were sent to a commercial company, Zoecon, Inc., for further testing. Other compounds were further analyzed by scientists at Stanford University, Iowa State University, and the University of California at Berkeley.

Although the funding for these projects was terminated in 1974, there are still interest and activity on the part of Constantine and his students. The Ortho Company is currently testing insecticidal activities among the samples developed in 1973 and 1974.

The active research program was halted only as a choice of priorities. At least nine journal articles resulted from the work. ———— Bill Wick

controlled atmosphere storage of seafoods. Due to the potential risk from C. botulinum outgrowth during extended storage, the microbial species found in carbon dioxide-treated seafoods and their influence on C. botulinum are being investigated. The effects of preservatives on microorganisms in seafoods are also receiving our attention. We measured the effectiveness of potassium sorbate on inhibiting microbial growth and have tested a number of chemicals for inhibiting bacteria.

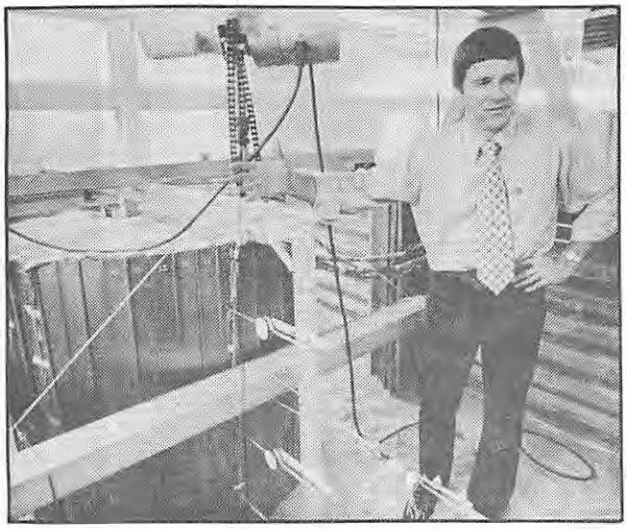
List of Projects

1968-70	Quality Improvement and Sanitation		
1971	New Equipment and Process Development	Lee	R/S-3
1973	Improved Microbial Quality of Seafoods. I. Dungeness Crab	Lee	R/PD-3
1973	Control of Vibrio parahaemolyticus	Lee	R/PD-4
1974-76	Sanitation and Microbial Evaluation of Oregon Seafood Processing	Lee	R/PD-21
1977-79	Microbial Quality Improvement of Seafoods	Lee	R/PD-29
1980-83	Microbiological Impacts of Seafood Process Modification	Lee	R/PD-37

Ocean Engineering

Since the designation of OSU as a Sea Grant College, the coastal environments program has been concerned primarily with coastal and ocean engineering problems. The School of Engineering was a prime mover in establishing the Sea Grant Program at OSU, as well as in developing the Marine Science Center. The initial emphasis in the engineering research supported by Sea Grant was the training of students for a broad range of careers in ocean engineering.

Research was an integral part of the program and was directed towards the development of research facilities and faculty research capabilities. Now, nationally significant ocean engineering research is being produced as a direct result of the careful development of well-founded research programs in the early years of Sea Grant. Current research is more specific and rigorous, responding to the nation's need for improved analysis and design procedures for marine structures. We are training students to make immediate contributions to the ocean industry and are providing industry with useful analysis and design tools.



Lee Schroeder with his innovative circular sheetpile cell.

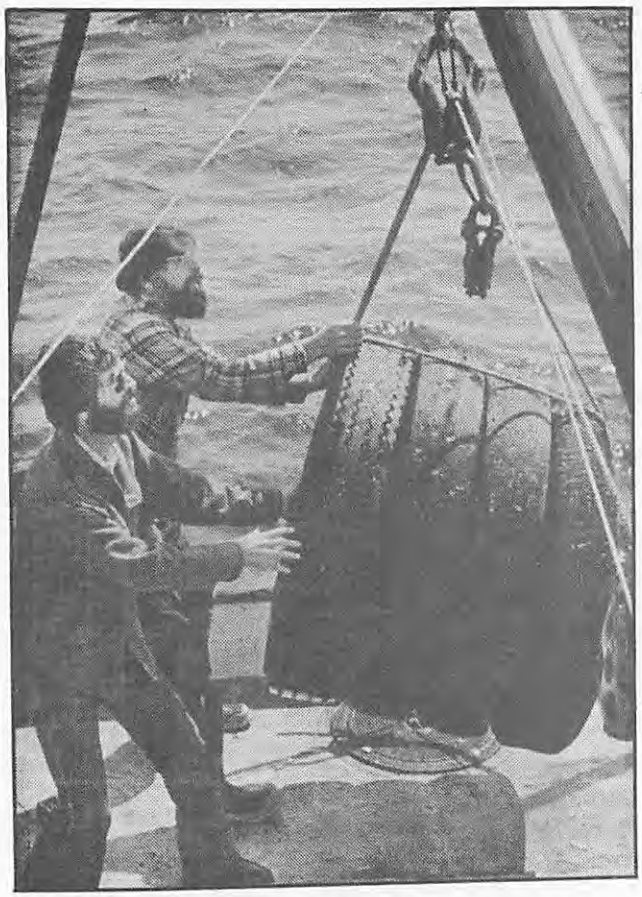
We believe that we are educating better graduates who are being sought by an increasingly sophisticated ocean industry. Our faculty strength has grown significantly, and results of our work have been widely used. Sea Grant has served as a springboard that allows us to develop unique solutions to real problems.

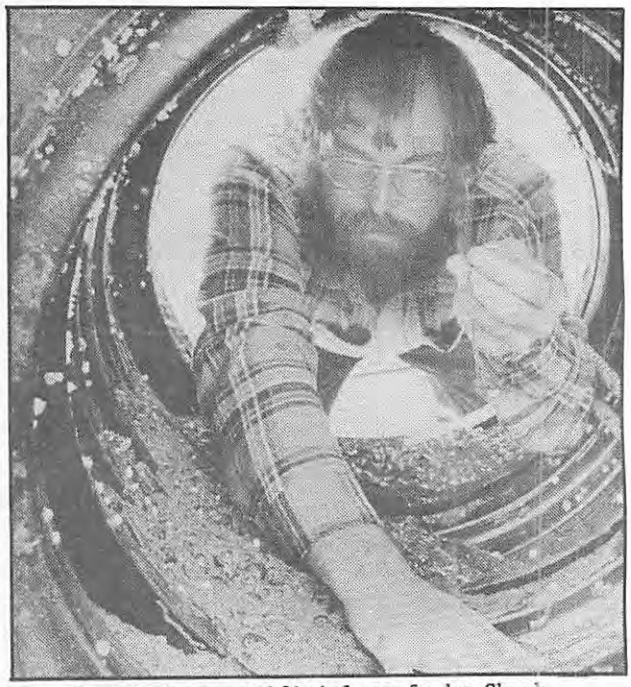
Publications Show Results

The success of the ocean engineering program is best judged by its publications. These attract additional research support, stimulate consultancies for faculty, and facilitate applications of research results. We have grouped them in three major subject areas. Numeric summaries are tabulated below. Details are provided in the list of projects, with reference to project number and title.

Our obvious strength is in the areas of hydraulics, hydrodynamics, and marine structures. Our productivity is directly related to the strength of our faculty in these areas and the problems it perceives in the ocean industry.

The scope and continuity of our efforts are illustrated by the results of projects on submerged and floating bodies. In each case, the principal investigators have drawn from and have built upon previous research results in solving major problems in ocean engineering. Results from projects initiated in response to local needs and concerns (for example, Hancock and Sollitt's





Research in artificial reefs by Chuck Sollitt and Dan Hancock (left) has applications worldwide. Right: Hancock examines marine life growing in a tire; a full-sized reef could attract bottomfish.

study of the feasibility of constructing artificial fish habitat, and Hudspeth's nearshore circulation dynamics work) have significance to global problems in coastal engineering.

Problems

Sea Grant ocean engineering has had its share of problems. For example, it has been a general policy that Sea Grant should not expend its limited resources on the problems of the oil industry. It was reasoned that this industry itself would solve its problems. As engineers, we view this approach as inconsistent with the Sea Grant concept of working on real problems and immediate application of results. The oil industry is the largest industry with the most at stake and the greatest ocean engineering challenges. Here, Sea Grant could make its greatest mark.

On a local level, we have experienced problems communicating the significance of our engineering proposals to review panels with nonengineering backgrounds. Engineering reviews have been few, and promoting our programs has not been an easy task.

Oregon does not have a dominant, high-technology ocean industry as do some other states. We cannot easily integrate our work, in many cases, with the needs of local industry. Yet much of what we do is of national and international import. We feel Sea Grant should view our work in this broader context.

We have developed an especially strong and capable faculty in ocean engineering and are supported by the largest university-owned wave research facility in the world. These two strengths are what we will capitalize on in the future. We have evolved from our beginnings in training and estuarine processes, focused largely on research limited in scope and of largely local impact, to a core research group with strong analytical and experimental capabilities that can solve problems for the country's offshore industries.

Publications Derived from Sea Grant Research
Oregon State University
Ocean Engineering
1968-1983

	Technical Journals	Conference Proceedings	Conference Presentations	Reports
(1) Hydraulics and Hydrodynamics	20	13	19	6
(2) Marine Structures	23	19	17	3
(3) Miscellaneous	6	3	6	7
Totals	49	35	42	16

W.L. Schroeder

List of Projects

1968
1) Applied Hydrodynamics
2) Computer Simulaltion of Ocean and Estuarial Currents
3) Pressure Distributions About Pipelines Exposed to Wave Impact
4) Transport Phenomena in Marine Environments
5) Behavior and Response of Submerged Structure
6) Pollution Control in Marine Waters

1969
-Projects 1 and 2 had commenced. Project 6 was supported from other sources.
-Acoustics (covered in fisheries engineering section) was initiated with limited Sea Grant support.
-Industrial engineering crab and shrimp studies (covered in special section by Engesser).

1970
Sea Grant-supported studies included

1) Applied Marine Hydrodynamics
   a) Forces on Marine Structures
   b) Quantitative Behavior of Estuaries
   c) Instrumentation for Low Velocity Ocean Current Measurement
2) Simulation Research and Related Studies of Marine Productivity
3) Acoustics
4) Industrial Engineering Systems

1971 Applied Marine Hydrodynamics Slotta R/En-1

1971	Simulation Research and Related Studies	Saugen	R/En-2
1973-75	Estuarine Hydraulics	Slotta	R/EM-1
1973	Hydraulic Dredge Spoil Fate	Schroeder	R/EM-2
1973-74	Forces and Responses for Ocean and Nearshore Stuctures	Nath	R/CM-6
1974	Design Criteria for Ocean and Nearshore Structures	Yamamoto	R/CM-9
1974	Wave Interaction with Moored Floating Structures: Phase One	Sollitt	R/EM-4
1974-75	Cellular Bulkhead Wharves	Schroeder	R/EM-5
1975-76	Applications of Nonlinear Random Sea Simulations for Design of Offshore Structures	Hudspeth	R/CM-16
1975	Design Criteria for Ocean and Nearshore Structures	Nath Yamamoto	R/CM-17
1975-76	Hydraulic Characteristics of Marinas: A Case Study of Brookings, Oregon	Slotta	R/EM-10
1975	Wave Interaction with Moored Floating Structures: Phase II	Sollitt	R/EM-12
1976	Deep Water Breaking Waves	Nath	R/CM-23
1977	Design Criteria for Horizontal Plate	Yamamoto	R/CE-1
1977-78	Wave Reflection and Attenuation of Pile Supported Harbor Facilities	Sollitt	R/CE-2
1977-80	Waves and Currents on a Beach in the Presence of a Jetty	Hudspeth	R/CE-4
1978-80	An Evaluation of Coastal Sand and Gravel and Marginal Rock as Construction Materials	Hicks	R/CE-6
1979-81	Submerged Offshore Artificial Reef	Hancock Sollitt	R/CE-7
1979-81	Synthetic Fabric Applications in Ocean and Coastal Engineering	Sollitt	R/CE-8
1979-83	Engineering Roughness of Marine Growths on Structures	Nath	R/CE-9
1981-83	Computer Modeling of Flexible Membrane Interaction with Ocean Waves	Leonard	R/CE-11
1981-83	Geotextile Applications in Ocean and Coastal Engineering	Sollitt	R/CE-12

Fisheries Engineering

Sea Grant fisheries engineering projects undertaken over the last 12 years or so have addressed a number of problems in fishing gear design, methods development, product preservation and handling, equipment maintenance and safety. These projects have been characterized by a heavy emphasis on extension education and demonstration and on research.

For a number of reasons, these projects cannot be seen to follow a single theme or to be directed toward a single overriding objective. First, needs have been defined by a variety of spokesmen within the industry and OSU. Second, the interests of a number of different investigators have varied with their expertise, academic emphasis, graduate student interests and availability. And last, the urgency of needs within different fisheries has varied with the abundance of stocks and vessels, the level of knowledge and expertise of fishermen and processors and management strategies, among other factors.

The success of results varies with the project, the reporter and the definition of the word "success." A summary of projects and their level of success follows. In some cases further contact with industry spokesmen or extension field staff would help to document the effect upon industry change; in other cases, more time is needed to allow the educational benefits of advisory efforts to be realized.

Some Observed Successes

One of the earlier gear projects undertaken during the "Commercial Fishing Methods" project was development and demonstration of the Atlantic-Western combination box trawl. This net was reportedly effective on both flatfish and off-bottom rockfish and is used today on a large number of West Coast draggers.

In collaboration with the Department of Mechanical Engineering, this project also developed and demonstrated an outboard motor-powered hydraulic system that was subsequently used on small dories in the salmon troll fishery. Most Oregon dories today are powered by inboard/outboard drives, so the mechanism is not as commonly seen. However, an East Coast company (Sea Power Pac) based its product upon the project's report and, after a few modifications, began producing the units commercially. Today, the Sea Power Pac is advertised in the fishing industry press.

During the course of two other projects, the principal investigator worked with other Sea Grant investigators in the Department of Food Science and Technology to investigate reported problems with onboard stowage of shrimp in refrigerated seawater spray. Research effort concerning microbial populations, the characteristics of cooling spray and product quality and yield answered many of the questions and led to design and operation advice for industry.

Presumed Successes

It is always difficult to measure a change resulting from a project of an extension advisory nature. "Success" is therefore sometimes defined in terms of production; the major production of such a project is frequently a workshop, written report or industry article. Many such efforts have resulted from activities in

fisheries engineering. The resulting file of printed information in libraries and extension offices represents a potential success to effect ongoing industrial change. Such potential successes include literature on the following subjects:

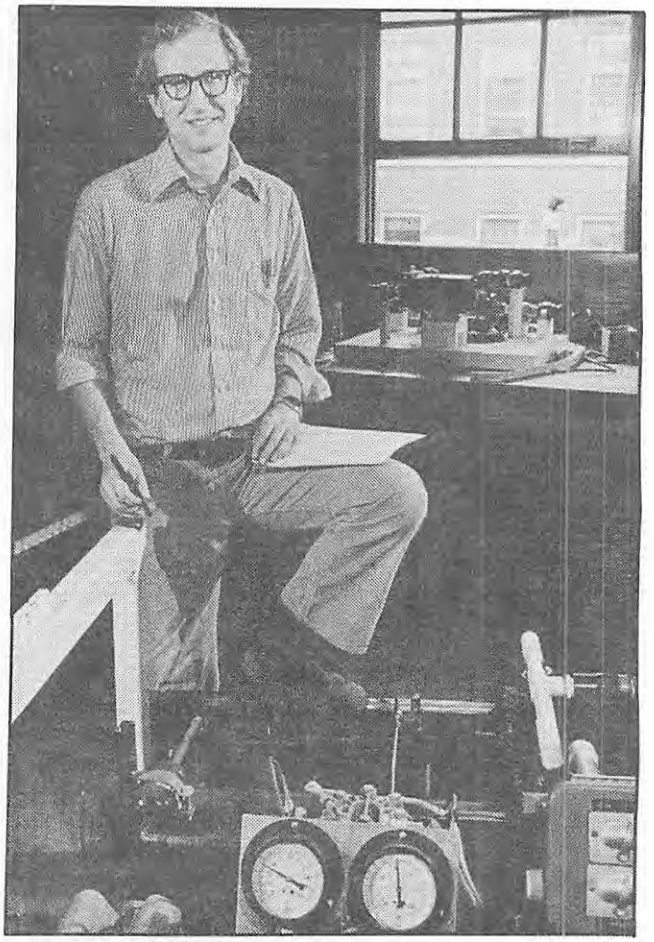
(1) how to rig a long line crab pot system;
(2) plastics for fish hold liners;
(3) marine electrical systems;
(4) troll wire voltage control on salmon trollers;
(5) cathodic protection of boat hulls and fittings;
(6) chilling and freezing of fish and shrimp onboard vessels;
(7) radar reflectors for boats; and
(8) cause and effect of cabin noise onboard fishing vessels.

Most of the written material resulting from these projects has been reproduced several times in the domestic (and in some cases, foreign) industry press.

Questionable Results

A few projects did not produce much industry change for a variety of reasons, although some of these projects did provide graduate students with experience in engineering design. Among these are the development of a portable crab pot pumping system (a system was designed and built, but is not used today), the design and development of a propeller shroud for a gill net boat (the system was built, but I have heard of no resulting industry change) and the design of a hydraulic harvester for bottom-cultured oysters (our influence on the grower's design and development decisions is questionable; the grower continues to strive for a workable harvester).

The results of a few projects are simply unknown. An attempt to measure the cause and effect of underwater boat noise on albacore tuna trolling produced some uncertain research results and a few industry articles. It appeared to raise the awareness of the industry, although it may have demonstrated a correlation that was already assumed by the better fishermen. A second study, on control of corrosion and deterioration of trawl cables, appears to have generated some useful information that is at present being disseminated.



Ed Kolbe gets a leg up on some portable refrigerated seawater equipment, used for cooling seafood.

Problems

Research, its application and extension through advisory methods and its relationship to teaching and graduate education have presented some problems in fisheries engineering--probably not unlike those found in other fields.

(1) There is an inherent conflict in time-scales. Academia's one-to-three-year duration for most projects coincides with proposal objectives, graduate student residence times, marine life cycles and fishing seasons. Industry's needs correspond more closely to a single season or to decisions made within a one-week period. Their requests cannot often be met

neatly within the academic calendar. Furthermore, an academic cannot easily do research and teach while spending time walking the docks to learn industry's needs and to provide advisory education.

(2) There are inherent differences in objectives. Research attempts to develop new (and publishable) knowledge that will contribute to the solution of a problem or to the design of a workable process or machine. Teaching objectives are (among other things) to provide an educational experience for students. Extension objectives might be to advance industry's knowledge and capabilities through demonstration, direct advice and education.

The differences in objectives make it difficult to solicit academic resources in addressing industry's problems.

(3) The logistics of projects involving fishermen and processors are sometimes impossibly difficult. One must often rely on opportunities as they arise, necessitating a much larger time commitment than if experiments could be planned in an orderly fashion.

(4) Finally, a problem relating more specifically to recent activities of extension fisheries engineering is the vast range of subjects which are considered to be areas of responsibility. My attempt to develop broad expertise in all fisheries engineering areas that arise leads to some often superficial results. We need to either narrow our advertised field of expertise or share areas among a greater number of people.

Ed Kolbe

List of Projects

1970	Commercial Fishing Methods	Fisher	
1971	Applied Marine Hydrodynamics; 1b) Mechanization of Fishing Gear	Mingle	R/En-1
1971	Underwater Acoustics for Location of Edible Marine Species	Jensen	R/En-3
1973	Pair Trawling	Fisher	R/ES-3
1974	Fishing Gear and Methods Development	Jacobson	R/ES-4
1974	Gill Net Boat, Propeller Shroud	Kinney	R/ES-2
1975-78	Fishing Gear and Methods Development	Kolbe	R/OPF-2
1978-80	Fisheries Engineering	Kolbe	R/OPF-7
1979-80	Control of Corrosion and Deterioration of Trawl Cables	Kolbe	R/OPF-11
1981-	Seafood Preservation and Handling	Kolbe	R/PD-39

Nearshore Processes

The nearshore processes program has focused on investigations of waves, currents and sand transport on beaches, especially those aspects of the processes that play a role in causing beach erosion. The program has provided a service to the citizens of Oregon whose property has been endangered by the erosion and to the scientific community through articles published in technical journals.

The Lesson of Bayocean Spit

Our initial studies examined jetty construction as a cause of coastal erosion. Our attention was brought to this problem by a major occurrence of erosion at Bayocean Spit, opposite Tillamook Bay on the north Oregon coast. Following jetty construction in 1917, Bayocean Spit underwent progressive erosion culminating in its complete breaching in 1952. In the process, the resort community of Bayocean Park was lost to the erosion. It no longer exists.

Previous studies of the effects of jetties in causing erosion have been in coastal areas such as southern California and the eastern United States, where jetty construction blocked the natural sand movement along the coast (the littoral drift). In contrast, there is no net sand drift along the Oregon coast, the erosion instead resulting from local rearrangements of the shoreline in response to the disrupted equilibrium caused by the new jetties. Prior to our study, it was believed that there would be no coastal erosion problems resulting from jetty construction with no net littoral drift. The loss of Bayocean Park proves otherwise.

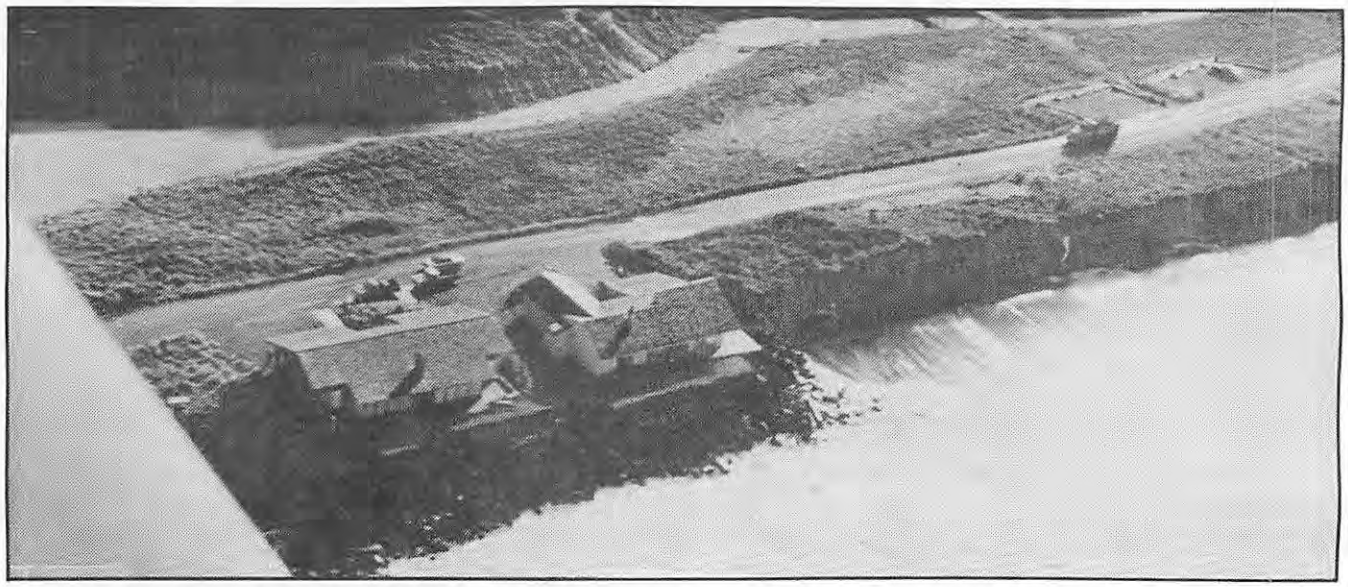
Following our study of the erosion at Bayocean Spit, we expanded our investigation to examine other Oregon jetty systems. All of these were found to follow the same pattern of shoreline changes, reaffirming our conclusions and permitting us to make improved predictions of the effects of jetty construction on the adjacent shorelines. In this connection, we developed a numerical computer model of shoreline changes due to jetties, comparing the model results with actual shoreline changes. Such models now permit detailed predictions of the resulting patterns of shoreline erosion due to jetty construction.

Erosion on Siletz Spit

The severest case of recent erosion on the Oregon coast is at Siletz Spit, an extensively developed area with many homes along its beach edge. Erosion has destroyed one home and threatened many others, which were saved only by the rapid placement of riprap. Our investigations have revealed that the erosion results from a combination of natural processes: rip currents hollowing out embayments into the beach, unusually high storm waves, and high spring tides.

Our study has also shown that the erosion never removes more than about 30 meters of foredunes and that the dunes were naturally rebuilt following the erosion. This indicates that adequate setback lines would have been a more satisfactory defensive measure than the riprap.

Our findings have been of general as well as scientific interest: Paul Komar has served as an advisor to the homeowners on the spit and to various state agencies. At



Paul Komar's research showed that property damage at Siletz Spit in 1972 could have been prevented with more adequate setbacks.

the height of the erosion in December 1972, Komar served on an ad hoc committee to advise then Governor McCall on what should be the state's response in protecting the Spit.

We have similarly studied the erosion of Nestucca Spit and Netarts Spit in order to determine the universality of our findings from Siletz Spit. During an unusual storm in February 1978, Nestucca Spit underwent extensive erosion, which threatened the community of Pacific Shores and led to the breaching of the spit.

Although sand spit erosion is dramatic in that it can be very rapid, the slow but progressive erosion of the sea cliffs along the Oregon coast is actually endangering more homes and property. Most of our coastal communities are built on the marine terraces which are now being eroded back. Because of the significance of this erosion, we have undertaken an investigation to determine cliff retreat rates, the processes of that erosion and the effectiveness of the various defensive measures that are employed.

The "Budget of Beach Sediments"

A useful tool in making planning decisions concerning the welfare of beaches is the so-called "budget of beach sediments," which attempts to evaluate the various sources of sand to the beaches and any losses. In this respect we have undertaken a study of sediments in the Oregon estuaries to determine whether the river sands are able to pass through the estuaries and therefore contribute their volume to the beaches. Our studies indicate that in general they are not, the sand-sized river sediments instead being trapped within the estuaries. The study also has revealed that beach sand is carried into the estuaries by tidal currents so that the estuaries act as sinks for the beach sands. In addition to answering such questions concerning the budget of beach sands, these investigations are also important to our understanding of the sedimentary processes in drowned-river estuaries and the filling and long-term changes of the estuaries.

Publications

Parallel to all of the above studies, we have completed research and published papers on the prediction of wave breaker heights and on the more fundamental aspects of nearshore processes, including the generation and evaluation of longshore currents and the mechanics of sand transport on beaches.

Our present study combines applied and basic research. We are examining the occurrence of edge waves on Oregon coast beaches, their importance in wave swash processes, and their possible role in controlling rip current spacings and hence the centers of maximum beach erosion, such as that found on Siletz Spit. In an earlier study we investigated the related question of whether the choice of spacings of groins installed on a beach to protect it might lead to resonance of the edge waves and ultimately to greater beach erosion.

Altogether, our Sea Grant-sponsored investigations have led to 30 published journal papers, 6 technical reports, and 5 theses. Komar and Robert Holman recently have completed writing chapters for a book dealing with the processes of beach erosion, covering our findings on the erosion of Bayocean and Siletz Spits, the modelling of shoreline changes and the role of edge waves in nearshore processes. The Handbook of Coastal Processes and Erosion will be published in 1984.

Our results also have been used in formulating the goals and guidelines for Oregon's Coastal Zone Management Program. A report to be used by coastal planners, Physical Processes and Geologic Hazards On the Oregon Coast, was written for the Oregon Coastal Zone Managment Association summarizing our present knowledge of Oregon coast processes and erosion problems.

Paul Komar

List of Projects

1970	Coastal Sand Transport	Byrne Komar	
1971	Coastal Sand Transport	Komar	R/O-1
1972-74	Coastal Sand Transport	Komar	R/CM-1
1974	Groin Spacing on Beaches	Komar	R/CM-8
1975-77	Erosion of Netarts Spit, Oregon	Komar	R/CM-15
1977	Sea Cliff Erosion on the Oregon Coast	Komar	R/CP-2
1978-80	Sediment Transport and Deposition in Oregon Estuaries	Komar Scheidegger	R/CP-11
1981-83	Rip Currents, Rhythmic Topography, Edge Waves and Erosion of Beaches	Komar	R/CP-17

Wood in the Marine Environment

The objective of this research is to reduce the maintenance costs of waterfront structures and boats through the improved performance of wood. The need for such research was demonstrated in 1974: a bridge and two docks failed when marine borers attacked supporting piles. In 1977, low streamflow brought salt water far upstream which could have posed a serious problem for wood structures not pressure-treated for marine use. Oregon port and highway officials, meeting with Sea Grant researchers, noted the critical need for information on the identity, salinity and temperature requirements and distribution of marine borers in Oregon estuaries.

Where the Wood Borer Thrives

Inspection of structures along the Oregon coast revealed that decay of piles and sawn timbers was a constant problem. Untreated material frequently is used because of its availability and low initial cost. Pressure-treated members were deteriorating internally, both above and below the water, because of unprotected cuts and bolt holes, inadequate protection of cutoff tops of piles and the use of pointed tongs to lift piles. Inspection of boats revealed few problems in commercial fishing boats which were well maintained but serious problems in pleasure boats where many compartments restricted the circulation of air.

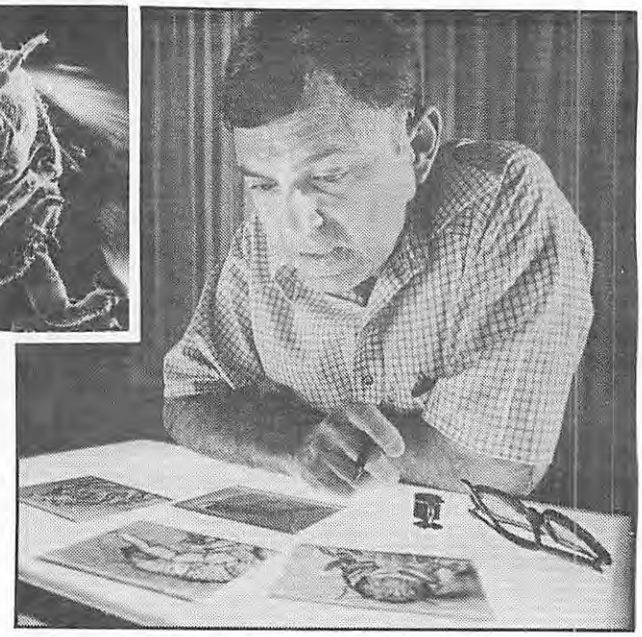
The inspection revealed also the presence in upper Oregon estuaries of Limnoria tripunctata, a marine crustacean that is very destructive to creosoted piles in southern waters. Yet this borer posed no threat to properly creosoted piles in Oregon. Because national standards prohibit the use of creosote above where this borer is present, an engineering firm required a more expensive treatment of piles for a Coast Guard dock.

Bob Graham examines the insidious effects of wood borers.

Research into Preventive Measures

In response to these findings, researchers are evaluating methods for protecting cutoff tops of piles and for stopping their internal deterioration; testing on-site treatments to extend the serviceability of untreated timbers;

Cutting Out the Wood Borer



Gonor encounters Limnoria tripunctata, the gribble.

A savings of about 50 percent in the cost of pressure-treating piling resulted from a change we initiated in national standards for the preservative treatment of piles.

We found high populations of a marine borer in upper Oregon estuaries that attacks creosoted piles in southern waters. National standards require that, where this wood borer is present, piles be treated with high retentions of a copper-arsenic formulation. Because no attack was detected on properly treated piles in Oregon waters, the specifications were revised to require the more expensive treatment only if borer "attack" was present.

By permitting the continued use of creosoted piles, a company that treats piling reports a savings of 50 percent for a 55-foot long pile.

Pressure-Creosoted Bulkhead Piles

Paul Coyne, manager of the Port of Siuslaw, reports that he will save at least $50,000 from the fumigant treatment and capping of internally decaying, four-year-old bulkhead piles as part of our research program.

Because the fumigant and cap have stopped the decay and can be repeated at ten-year or longer intervals, replacement of the 300-foot long bulkhead will not be necessary. An adjacent 500-foot-long bulkhead only a few years older and left untreated will have to be replaced at an estimated cost of $130,000.

We also applied fumigants to untreated Douglas-fir marina piles at Florence. We estimate that by using fumigants and by

preparing maps showing the distribution of marine borers in Oregon waters; and initiating studies to find out why L. tripunctata attacks creosoted wood in some waters but not others.

These studies could lead to more effective treatments to prevent borer attack on wood.

Research Results

National standards were revised to permit the use of more economical creosote in waters where L. tripunctata is present but does not attack creosoted wood, to permit the use of a more economical method for protecting cutoff pile tops, and, soon, to limit the use of pointed tongs or tools to a point near the ends of treated piles.

Internal decay of piles and timbers can be controlled indefinitely by the internal application of fumigants at intervals of ten years or longer--a breakthrough in preserving wood. One electric utility reported annual savings of $2.25 million from the use of a fumigant on its poles.

Capping and treating untreated Douglas-fir marina piles with fumigant

capping, we can double the service life of untreated piles.

Wood Pole Research

An annual savings of $2.5 million in pole investment was reported by the Bonneville Power Administration from the use of fumigants to stop the internal decay of pressure-treated Douglas-fir poles. Annual savings of $1.5 million is anticipated by the New York State Electric and Gas Corp. Nationwide, annual savings must amount to many millions of dollars.

Cooperative research between BPA, the Portland General Electric Co., the Pacific Power and Light Co., the Northwest Public Power Assoc. and the Forest Research Laboratory since the 1960s resulted in this breakthrough for stopping the decay of large wood products in service.

Volatile liquid chemicals are poured into holes in poles. The holes are plugged, and the vapors diffuse throughout the wood for about 8 feet above and below the treating site to eliminate decay fungi and insects for over 12 years. Our latest development is encapsulated fumigants which increase the safety with which these chemicals can be used and permit their application to a greater range of wood products.

The benefits of our wood pole research are many. All users of electricity benefit from utility savings. Because the number of companies using these fumigants is expanding, more jobs are created. Throughout the nation, confidence in the reliability of using large Douglas-fir poles is increasing. Finally, we have improved the utilization of our forest resources.

Export Markets for Douglas-Fir Poles

W. E. Niedermeyer, of Niedermeyer-Marten Co., Portland, is in the process of filling a $1 million order of pressure-treated Douglas-fir poles for shipment to a Middle Eastern country as the result of data submitted showing that pressure-treated Douglas-fir poles were superior to pressure-treated Scotch pine poles from northern Europe.

This cooperative effort opened the entire Middle Eastern market to Douglas-fir with potential sales of $100 million within the next few years.

Loggers, truckers, longshoremen and shippers all benefit. The long-range benefit of worldwide markets will be the increased stability of our forest economy.

———— Bob Graham and Jeff Gonor

---

should increase their average service life from 8 to over 20 years where no marine borers are present.

Hydrographic data can now be used to predict locations where L. tripunctata can be established.

Fact sheets and slide-tapes were prepared to provide information about wood, the wood destroyers in the marine environment, their detection and methods for preventing and controlling the damage they cause to wood structures and boats. A maintenance manual for waterfront structures is being prepared.

Research results and their publication are only half the struggle to improve the serviceability of wood. Research will continue to reveal new information about wood, but only education can dispel the pervasive general ignorance that far too long has discredited wood and placed an incalculable drain on our nation's forest and economy. Somehow we must find better methods for getting our information to architects and engineers who design with and specify wood, to those who erect and manage waterfront structures, and, especially, to those who do the actual construction and maintenance.

List of Projects

1974-78	Improving the Performance of Wooden Waterfront Structures and Boats in Marine Waters	Graham	R/EM-2
1978-81	Preventing and Stopping Deterioration of Wood in the Marine Environment	Graham	R/CP-6
1981	Controlling Biological Deterioration of Wood in the Marine Environment	Graham	R/CP-18

Coastal Weather

The coastal weather program attempted to improve the safety, efficiency and convenience of marine operations for public and private users by providing improved marine weather observations. The OSU program was supported fully and consistently by the U.S. Coast Guard and the National Weather Service (NWS) in a team effort that translated research results into user services.

Initial efforts to install off-shore spar buoys with sensors and telemetering systems were successful from a research standpoint but could not be continued because of high maintenance costs and marginal reliability. The parallel effort to develop sea and surf forecasting techniques was stymied by the lack of reliable and accurate wave measurements; clearly, this problem had to be solved before the program could progress.

Forecasting with a Semi-Automatic System

Following the failure of a conventional pressure sensor system at Newport, Oregon, William Quinn et al. developed and tested a seismic wave measurement system requiring no sensing devices in the ocean. Two years of calibration proved the accuracy and reliability of the approach and furnished data to test the wave forecasting technique which was being developed in a parallel effort. In 1972 the NWS began using the semi-automatic forecasting system and software. At the same time, the measurement network was gradually expanded so that by 1974 seven Coast Guard Stations from Humboldt Bay, California, to Quillayute, Washington, were reporting observations to assist their search and rescue operations as well.

Displays of wave information for CCTV stations were developed later and applied at Westport, Washington, and Newport, Oregon.

Sea surface temperature is an important element in search and rescue operations and fishing; ambient air temperature is important for weather forecasting. Neither had been reported with accuracy, if at all, from the stations in the wave measurement network. Consequently, with partial NWS funding, the program installed quality instruments at all seven stations, and Coast Guard personnel now report the readings to NWS via existing teletype circuits.

Determining Harbor Entrance Visibility

Harbor entrace visibility is important to boat navigation, yet it is difficult to measure by instrument. Quinn et al. developed a radiometer technique for making the measurement from Coast Guard towers and displaying the results on the station's communications panel. It was tested for two years at Newport and prepared for installation at three other stations. A lack of maintenance funds from Sea Grant or the Coast Guard precluded the additional installations. Harbor entrance visibility forecasting is as important as observations; the program developed a forecasting technique for 12- and 24-hour periods, which is applicable to the Oregon coast, at least, and turned it over to the NWS, Portland, Oregon, for use. The method employs only observational data already available to NWS forecasters.

Developing the Tide Sensors

To aid Coast Guard observers and NWS forecasters, the program then developed tide sensors for Coast Guard stations having a floating dock. The system was tested at

Newport for a year, with satisfactory results, and units were then prepared for the other stations in the network. Again, the lack of Sea Grant or Coast Guard funding for installation and maintenance precluded routine use of the systems at locations other than Newport.

The Coast Guard has supported Sea Grant weather research.

Since Coast Guard communications panels do not have a 24-hour live watch, weather reports to the NWS are not made throughout the night—even though sensor outputs are available. To show what could be done to eliminate this problem, the program developed a microcomputer (AIM-65)-based automatic reporting station and tested it using sensors at the Newport Coast Guard Station with excellent results and with little difficulty in training Coast Guard operators in the use of the device. Hardware and software details were documented and transmitted to the Coast Guard and the NWS. Given available sensors, the system would cost about $2,500 per station.

Throughout the decade of its existence, the program provided weather support and compiled data to many Sea Grant projects and to public and private agencies. One result of this activity was a project to compile in report form data useful to aquaculture research. Representative offshore and nearshore data for the area from northern California to northern Washington were collected from several sources and plotted versus time in a format that is easily interpreted by the reader yet reflects upwelling, wind-driven current and estuary conditions clearly.

Although funding ended in FY81, the National Weather Service furnished a grant to OSU for FY82 with the purpose of documenting the reliability of operational wave and temperature measurement systems at the seven Coast Guard stations in the network. The grant also permits a continuing maintenance program for the systems and makes evident the NWS interest in perpetuating the flow of observations from the systems.

—David Zopf

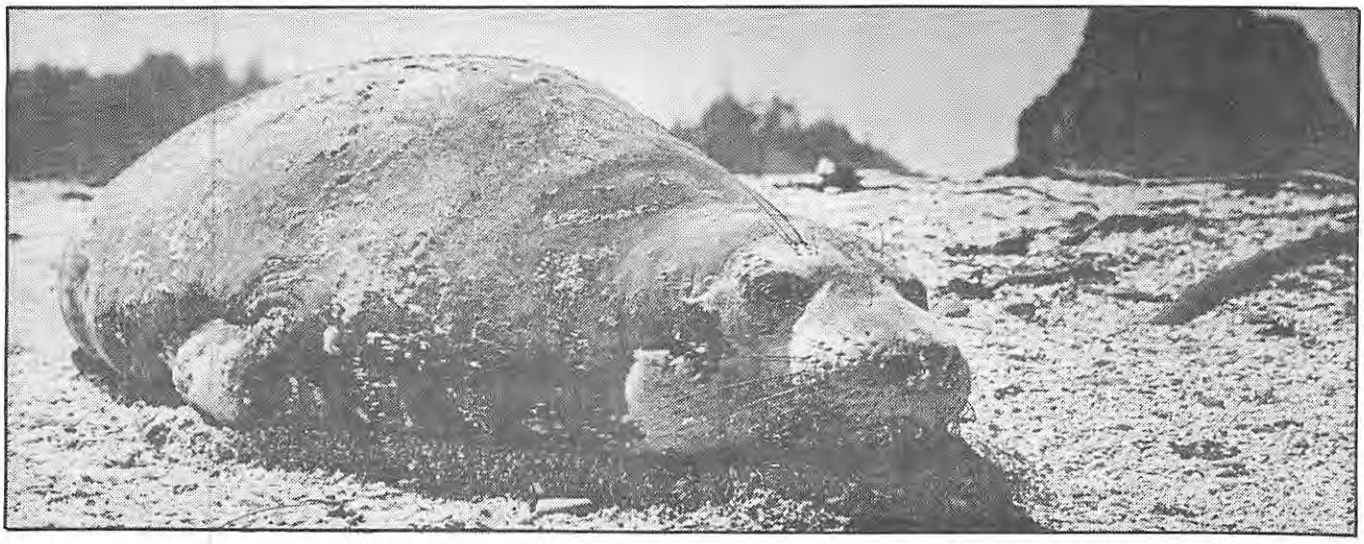
Marine Mammals

The marine mammal research has focused on problems in marine mammal management. The results of this research have provided answers to operational questions posed by the Marine Mammal Protection Act (MMPA), the Endangered Species Act, the Coastal Zone Management Act and the Fishermen's Conservation and Management Act (200-mile limit). These pieces of legislation jointly have affected individual sport and commercial fishermen and the fishing industry at large, the coastal counties in Oregon, state and federal management of marine mammals and the cooperation between states and countries on the management of several specific issues.

Marine Mammals on the Rogue River

Between 1977 and 1979, initial efforts were directed to the Rogue River in southern Oregon, where marine mammals conflicted with sport fishermen in the pursuit of various runs of salmon and steelhead. Residents, guides and visitors to the Rogue River area reported that following the MMPA, marine mammals were appearing where they had not been observed before, and in greater numbers. Population surveys determined that the numbers of animals using the Rogue River followed patterns and that the river was used preferentially during certain seasons of the year. The strongest correlation of pinniped abundance with the presence of anadromous fish in the river occurred during the spring.

We concluded that seals and sea lions have minimal biological impact on the anadromous fish runs. Their largest effect on salmonids amounted to approximately 6% of the summer steelhead run, and this was largely taken after the summer steelhead had



An elephant seal enjoys a rare visit to an Oregon beach.

overwintered and were returning downstream in the spring as seaward migrating smolts. These fish had therefore already moved through the sports fishery during their upriver migration, and only a small fraction of them would be expected to return during a subsequent year for spawning. Little overall impact on the future viability of the species is expected. Runs have not shown any significant decline since enactment of the MMPA which would correlate with the presence of marine mammals.

Another important finding of the Rogue River study was that all three marine mammal species investigated consumed tremendous quantities of lamprey. As adults, lamprey are known to feed on adult fishes during the marine cycle of their life. However, it was unknown how many fish lamprey may consume during their adult life cycle. Furthermore, the composition of that predation would be important in analyzing the overall effect of marine mammals in the river system.

These ramifications were brought to the attention of the U.S. Marine Mammal Commission and to an international meeting of scientists convened by the International Union for the Conservation of Nature. This study provided the only in-depth example of the complex food web relationships that marine mammals have.

Prior to this study, marine mammals were viewed as predators on the catch of fishing boats, but of course fishing boats are highly selective in their prey species, and marine mammals appear to be highly opportunistic. However, the specific composition of prey leaves the question open as to whether marine mammals are detrimental or beneficial to particular target species.

To gain a better understanding of seal behaviors and to protect both salmon and seals, OSU researchers went right to the source. Columbia River fisherman Bill Puustinen shows the problem (left); researcher Robin Brown prepares to examine the cause.

The Rogue River project also analyzed several possible management options, one of which (an acoustic deterrent) has developed into a current Sea Grant-funded project.

A Newsletter about Marine Mammals

During the early development of marine mammal work at OSU, Marine Mammal Information (MMI) was created for exchanging current information about research by marine mammal scientists throughout the world. It is published semi-annually and is

self-supporting. Originally provided free of charge to marine mammal scientists, this newsletter prevented the duplication of work by various investigators and provided an opportunity for investigators performing similar tasks to collaborate and gain greater efficiency by pooling their resources. Also, MMI provides a bulletin board to announce specimens that are sought and available.

Seals vs. Aquaculture

At the OSU experimental chum salmon hatchery (Netarts Bay), aquaculturist Jim Lannan noticed that seal populations appeared to be growing rapidly. Seals were a problem during the return of chum salmon to the hatchery. They boldly entered the river system (and even the fish traps) to feed on returning adult salmon.

An investigation of the seal population at Netarts Bay during FY 79-80 included identification of their home range and the proportion of the animals that might be hauled out at any one time. Innovative techniques involving radio-tagging and feeding habit analysis using feces were developed. The feeding habits of seals in the Netarts area varied radically from those of the seals investigated on the Rogue River, indicating that there were site-specific questions to be dealt with in various geographic areas.

The impact on the aquaculture industry was viewed to be significant. Harbor seal consumption close to the hatchery could account for over 9% of the returning salmon (by conservative estimates). This is a high enough figure to affect the profitability of private and commercial fisheries ventures. Haul-out patterns of seals suggested that the populations in Netarts Bay were at a maximum during the November salmon runs, which is a period of high abundance in nearby Tillamook Bay. Furthermore, animals were tracked moving from Netarts Bay to adjacent bays and back again, confirming that the population of Netarts Bay was not discrete and that seals move reasonably freely from bay to bay.

Because most of the impact on the hatchery occurs near the mouth of the hatchery, it seemed advisable to develop a system to keep seals from this area. The use of acoustics in effectively regulating the distribution of seals began in 1980. The system under development is designed to be portable and useable by individual fishermen to protect their gillnets (which are often robbed of fish by harbor seals in Alaska, Washington, Oregon and California). The system could also be used at the mouth of a hatchery or perhaps provide seasonal relief to river runs of salmonids by preventing upriver movements of pinnipeds.

The development of this device was supported by a number of environmental groups, including the Defenders of Wildlife, as an important contribution of marine mammal management. When certain loud sounds are applied in the area to be "protected" from marine mammals, the marine mammal avoids the area. This, combined with the non-lethal aspects of the system, make it attractive to individuals and groups concerned with the interests of marine mammals. The device will not only save fish from seal predation, but will also save seals (which die in nets) and reduce net damage caused by marine mammals.

Preliminary tests of this unit around salmon have been successful. Further experiments will be carried out on the gillnet fishery of the Columbia River, and on squid, anchovy and herring fisheries.

Bruce Mate puts some final touches on the airplane he used for tracking marine mammals.

Collaborative Efforts in Marine Mammal Research

In the International Sea Grant Project, marine mammal researchers at the Center for Biological Investigations (CIB) in Baja, California, and OSU personnel have shared field research experiences and gained a greater appreciation of important biological as well as managerial questions of international interest. A cooperative research program among the National Marine Fisheries Service's Southwest Fisheries Center, CIB and OSU has allowed researchers from the U.S. to assist Mexican colleagues in the development and use of some of the most recent research techniques and discuss the philosophical, political and practical considerations of marine mammal management. OSU personnel have spent time in Baja, Mexico, giving lectures at the University and exchanging information on field techniques.

Summary

The OSU marine mammal program has identified particularly difficult questions in marine mammal/fisheries conflicts which could be handled through research.

The marine mammal program has attempted to extend its research findings beyond Oregon's own interests by making the information available to federal managerial authorities, such as the National Marine Fisheries Service and the Marine Mammal Commission, as well as international bodies, such as the United Nations Food and Agricultural Organization, the International Union for the Conservation of Nature and Canada and Mexico. The program has further increased communication in marine mammal research results worldwide through the production of Marine Mammal Information. Techniques developed by OSU in capturing and radio-tagging seals are now used in at least one dozen research projects in at least five countries. The skills developed by Sea Grant-funded radio-tagging of seals contributed to the successful creation of a radio-tagging system for large whales and the development of a suitable radio-tag for endangered manatees.

A related documentary film regarding controversies surrounding the management of marine mammals was produced in 1980 by Sea Grant Communications with technical advice and support from OSU marine mammologists. The film has been very successful in educating the public about whales, porpoises, seals and sea lions. It has won several major awards and reached several million viewers through network television.

A second film on whale radio-tagging techniques was produced in 1981 for use by other scientists interested in the research of whale migration patterns.

Bruce Mate

List of Projects

1976	Implications of the Marine Mammal Protection Act in Oregon	Mate	R/CM-19B
1977-79	An Assessment of Sea Lions in the Rogue River Area	Mate	R/CM-19A
1978-81	Population Growth and Feeding Habits of Harbor Seals in an Aquaculturally Enhanced Environment	Mate	R/CP-4
1981	Seal Exclusion Systems	Mate	R/CP-19

Columbia Regional Sea Grant

The Columbia Regional Sea Grant Program was initiated in 1976 as a coordinated effort between the Washington and Oregon Sea Grant Colleges in cooperation with the University of Idaho and Washington State University.

The program addresses the unique problems of interstate marine resources, focusing on the Columbia River and its relation to the Pacific Ocean. These needs change, and so the goals of the program are re-examined, periodically, for their relevance to changing technological, social and economic conditions.

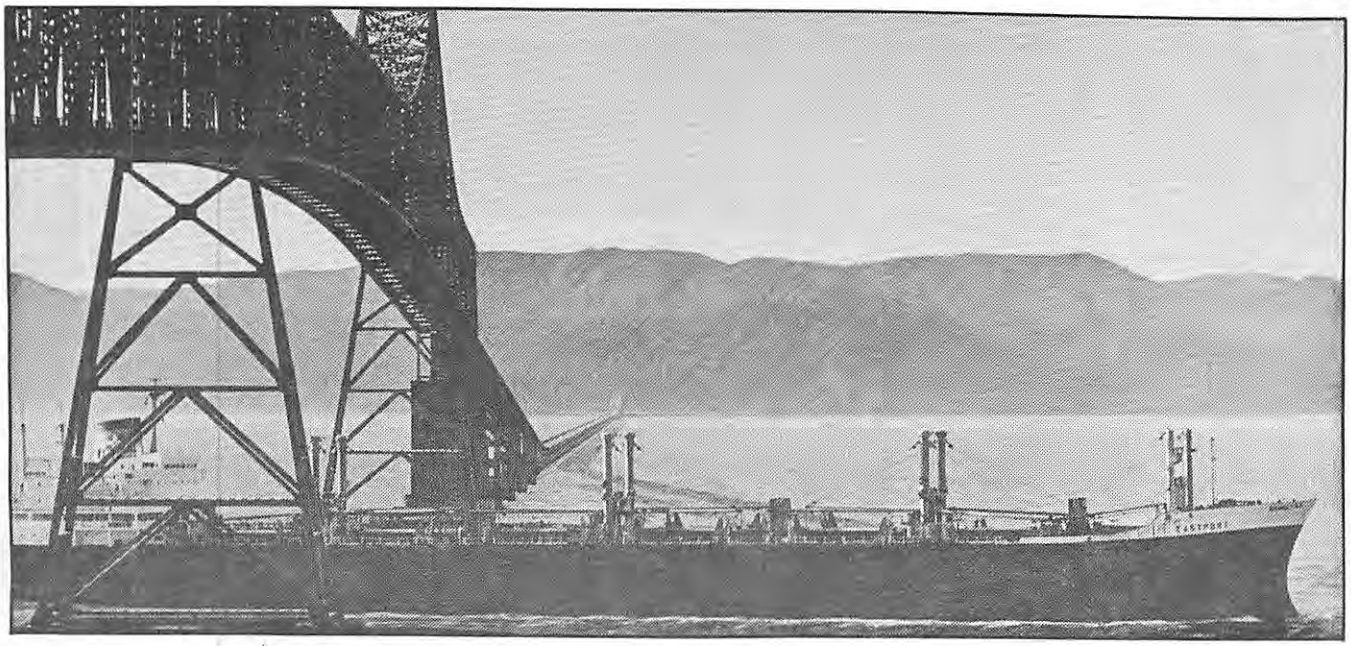
Functionally, the Oregon Sea Grant College supports the regional research projects. The Washington Sea Grant College provides support for the Columbia Marine Advisory Program.

Research projects have emphasized navigation on the Snake-Columbia system in five projects since 1976. A current project investigates the complex management institutions on Columbia River waters. A closely allied project, "Pacific Northwest Anadromous Fish Law," is included here as the Columbia regional project that it is.

The program and projects are solicited, reviewed and selected by an administrative level committee representing all major participant universities. Cooperative relationships are maintained with appropriate state, federal and regional agencies. For example, the recent film Estuary: Columbia's Link with the Sea was a joint production of the US Fish and Wildlife Service and the Oregon Sea Grant College.

Although the Columbia Regional Sea Grant Program is a small element in the Sea Grant system, the work supported is important to the Northwest marine region. It forms an innovative approach toward serving the needs of a multistate, marine-oriented river.

Bill Wick



International Sea Grant

OSU Sea Grant is one of about a dozen Sea Grant programs that conduct an international project. OSU had been involved with the Latin American marine community since the 1960s, and in 1973 relations were formalized with the establishment of the Latin American Oceanography Program. Its goals were to help Latin American institutions improve their oceanography efforts and to develop cooperative research projects between U.S. and Latin American oceanographers. The advent of International Sea Grant funding in 1978 gave continuity, additional breadth and sharper focus to the OSU program.

Today, international ocean research is constrained by the new Law of the Sea Treaty, which has encouraged many countries to adopt absolute-consent requirements. Such requirements are expected to be soon nearly universal. If U.S. scientists expect to do research in the territorial waters of other countries, clear and strong cooperative arrangements will be essential. OSU is fortunate to have long been involved in a program of mutual assistance with Latin America.

The International Sea Grant Program, whose closest ties have been with Mexico and Chile, has sponsored various activities during the five years 1978-83. The program has provided training workshops in fisheries, oceanography and extension methods and has arranged for advanced training, mostly degree-related, for faculty abroad. The program has also provided library assistance and course and curriculum development in the Latin American countries.

Cooperative research, notably in marine microbiology, fisheries and economics, as well as oceanography, has enhanced the understanding of Latin American coastal and ocean resources. Perhaps the program's greatest success has been in its attempts to create a much-needed atmosphere of trust and cooperation between marine scientists in Latin America and the U.S.

Sandy Ridlington

OSU Sea Grant cooperates on research projects at the Instituto Profesional de Osorno hatchery at Lago Rupanco, Chile.

Anthropology

Many Sea Grant research, education and advisory service projects impinge on public policy. Certain projects in anthropology, marine economics and ocean and coastal law, however, have public policy as their primary focus.

Public policy projects in anthropology provide decision makers and the public with information on the performance of social systems. OSU Sea Grant has supported anthropological research on fishermen's behavior, management options, and on the interaction between social and biological aspects of fisheries.

The purpose of marine economics research and training at OSU is to help improve individual and collective decisions regarding use of the ocean. It is directed at improving human welfare through more rational allocation and use of ocean resources and through improved performance of individuals, businesses and public agencies.

OSU Sea Grant has also supported projects at the Ocean and Coastal Law Center (OCLC) at the University of Oregon which emphasize legal education, research and public information.

The combination of legal research, anthropological information on the performance of social systems and marine economics research directed towards improved decision making results in a distinct public policy component with significant value to both public and private decision makers.

Beginning Public Policy Work

Public policy work in anthropology began in 1972 with an investigation of limited entry for the salmon fishery. The limited entry study showed how fishermen historically sought to limit entry by obtaining favorable legislation or privately constraining entry into the fishery. The most common tool used was the initiative petition. The history of these petitions was summarized by C. Smith in a Sea Grant research report published before the 1974 initiative petition election to make steelhead trout a game fish.

At the time, 1972-73, neither fishermen nor the Oregon Legislature were ready for this management alternative. Largely because of pressure from the Pacific Fishery Management Council--a regional fishery management agency established in 1977--a moratorium on shrimp, salmon troll and gillnet licenses was instituted in 1979. Data from the 1972-73 study were not used in determining this policy.

The second research activity was on the different types of fishing involvements and the kinds of benefits individual fishermen derived. In the early 1970s fishermen were perceived as a relatively homogeneous group. Initial research showed considerable variability in interests and reasons for fishing. These observations were further documented, and differences between various types of anglers, sport-commercial trollers, part-timers and professional fishermen were identified.

After these projects developed data about Oregon fisheries, the next study tried to summarize the operation of fisheries. The primary method for doing this was computer simulation. This work also sought to develop data on fishing behaviors worldwide.

The simulations were developed in close cooperation with fishery biologists, resource economists, an ecosystems modeler and a cultural anthropologist. The objective was to integrate concepts across disciplines to provide a more holistic description of how fisheries operate and evolve.

NOGERO and TRAWL

This project resulted in the development and use of two simulations—NOGERO and TRAWL. NOGERO shows the interaction between a mythical hunting and gathering society and its clam, halibut and salmon resources. The simulation illustrates to introductory anthropology students the interdependence of human cultures and their natural resource base, and it shows how cultural values affect decisions made in promoting NOGERO survival.

Smith and applied mathematician Robert McKelvey are investigating some of the problems raised by the TRAWL simulation. One focus of this work is determining how fishermen adjust to natural and market variability in a fishery. Our research indicates that a mix of behaviors--where some fishermen specialize in one type of fishing while others perfect skills of switching between fisheries --is the way fishermen have traditionally dealt with this problem.

Management rules can discriminate against the behavior of specialists by shortening seasons and against the behavior of generalists by imposing limits on entry into a fishery. Our objective is to suggest what mix of these behaviors might be most adaptive.

A film, Salmon Struggle, is popular with historical societies, service clubs, schools and extension groups. It is a silent, 12-minute, black and white film. It is also sometimes integrated with a slide lecture and has been presented in many Oregon

Court Smith's TRAWL computer study offered new insights into fishing decisions.

locations. During 1975 and 1976, it was shown also several times at Woods Hole, Massachusetts, with good results.

The most difficult impact to dtermine is the number of people informed by general interest publications. It is also difficult to know the nature of the impact of this information. Any influence it has had appears to be subtle and not dramatic. Portions have appeared in a Japanese television program, in local newspapers, and in other media reports. Requests for publications have come from Europe, Japan, Australia, Canada and throughout the United States.

The trawler-landing simulation, TRAWL, focuses on the effect changes in fishing effort have on a fishing community. TRAWL consists of biological models developed from Albert Tyler's work in the Sea Grant pleuronectid project that simulate the impact of natural and fishing mortality on three sole populations, plus a Pacific whiting model developed by David R. Bernard. The behaviors of up to 50 fishing units are simulated. Each fishing unit is capable of making decisions regarding the optimum fishing strategy. The economic effects of these decisions and various management options on a local fishing community are evaluated using the simulation.

Information for general audiences has resulted from these three research activities. Associated with this has been curriculum development that makes students taking introductory anthropology courses more aware of their fishing heritage. Finally, selected scientific reports and articles have provided data on economic equity, types and attitudes of fishermen, and the integration of biological and socioeconomic data and concepts.

Over 100 students per term get information on Oregon's fishing heritage in introductory anthropology. A like number use the NOGERO simulation.

TRAWL, which integrates a biological model of several groundfish species, economic decision making by fishermen, fishing behaviors, market conditions and the impact of a fishery on a coastal community, has been less successful.

A simulation model like TRAWL requires considerable socioeconomic data, although parameters to run the model can be estimated.

Court Smith

List of Projects

1972	The Impacts of Limited Entry	C. Smith	R/PPA-
1973	Innovations and the Oregon Fish Harvest Systems: Fishermen's Organization and Communications Patterns	C. Smith	R/PPA-3
1974	Social Well-being Distributions in Allocation of Marine Resources	C. Smith	R/PPA-5
1977	A Model of the Interactions between the Oregon Ground Fishery and the Coastal Community	C. Smith	R/PPA-8
1978	(New title) NETS--Northwest Educational Trawler Simulation	C. Smith	R/PPA-8
1981	The Evolution of Multipurpose Fisheries	Stander C. Smith McKelvey	R/PPA-18

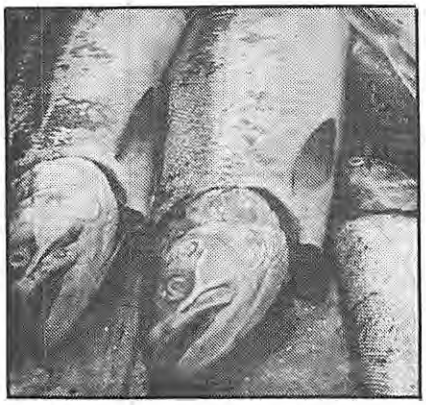
Marine Economics

OSU Sea Grant has supported interdisciplinary marine economics research. Economists have worked closely with biologists, engineers, oceanographers, statisticians and anthropologists at OSU as well as professionals from other academic and government institutions. This research has focused on the economics of the seafood industry. Because of the special interests and talents of the staff and because of industry needs, this research has included demand, prices and marketing of seafood products, economics of marine firms, and public policy in marine economics.

Research in the economics of coastal areas, and the economics of recreation and marine transportation has been less comprehensive and less well integrated but has nonetheless produced some significant results.

Demand, Prices and Marketing

Research in demand, prices and marketing of seafoods focused initially on estimating demand relationships for groundfish and salmon. This kind of research requires a long-term investment, and it continues today. It has made it possible to predict ex-vessel and wholesale prices relative to inventories, exchange rates, income levels and competition from other foods. Significant advances in prediction techniques have been made and are receiving attention nationwide.



This research has also improved our understanding of economic relationships within the seafood marketing system. For example, market concentration in some seafoods has been found to be much greater than in others. Also, the institutional inability of the processor to control his product mix was found to be a major factor in ex-vessel-to-wholesale price spreads. This type of information is used by decisionmakers in the industry and to some extent by regulatory agencies.

More recently the work in demand, prices and marketing has led to extensive cooperation among colleagues in Asia, Europe, South America, Canada and the other Pacific Coast states. This is opening up new sources of data and will make it possible to better understand the international aspects of seafood marketing.

Back at the local level, research on consumer tastes for seafood and responsiveness to promotion have revealed valuable information and behavior patterns. For example, while it was found that "advertising pays" for most seafoods, for others it doesn't pay at all.

Economics of Marine Firms

Research on the economics of marine firms has produced detailed cost and earnings data on fishing operations from Alaska to

California and on oyster producing operations in Washington and Oregon. These results are used extensively by people in the industry for business management decisions, by credit institutions and by regulatory agencies. The research technique pioneered at OSU is now widely used. For example, economists in South Carolina, Hawaii, Florida, Louisiana and Alaska have used the technique.

Research in the economics of marine firms has helped determine the economic feasibility of fish meal processing, pollock processing, cooperative fish plants, oyster seed hatcheries and six other types of seafood businesses. Not only do these studies identify the important feasibility factors; they demonstrate several methods that are now being used by private industry.

Unplanned research in this area includes an estimate of fishing fleet fuel consumption to meet the 1973 fuel crisis. The estimate was so accurate that it was used by Washington and Alaska for their fishing industry.

Research in public policy has been closely integrated with the previous areas mentioned. Staff have been intimately involved with fishery management bodies and have been on foreign assignments relating to public policy. Research on valuation of salmon harvested by different groups and on economic impacts of the fishing industry appears frequently in fishery management plans. A comparison of fishery management policies among several countries has resulted in several analytical reports which have received acclaim.

From Fishery to Fishery

Just as research on problems in the fishing industry has been modified to address the most important problems encountered by the industry, so have contemporaneous events facing public bodies altered policy studies. One project initially intended to improve techniques for estimating capacity was modified to examine multiple fishery participation and what causes fishermen to shift from fishery to fishery. The finding that economic factors

Sea Grant market research aids industry decision-makers.

are far more influential in guiding new entry than movement from specific fishery to specific fishery, which is very consistent with work in marine anthropology, will be of great value in predicting undesirable consequences of some currently debated forms of limited entry. Another project initially intended to reveal economic interrelationships between hatchery and wild salmon was modified to develop a methodology for public agencies to weigh important policy consequences (such as harvest levels and protection for wild spawners), even though no economic information is available for some of the consequences. Not only did agency biologists contribute heavily to the analysis, but they have also used the analysis to clarify their understanding of the impacts of policy choice upon affected user groups.

Other Public Service

Other public service activities include Bruce Rettig's participation on the

Scientific and Statistical Committees of the Pacific Fisheries Management Council and the Northwest Power Planning Council, Fred Smith's numerous involvements both here and abroad to bring economics to fishery management groups with a heavy biological orientation.

Another area in which the department has had substantial research and public service involvement is aquaculture. When the Sea Grant program was initiated, little was known about the extent and outlook for aquaculture for the region. Several analytical and descriptive studies have changed that. The department has also conducted research in coastal development, recreational activities (boating, camping and fishing) and coastal ports.

While the research, advisory, teaching and public service programs dealing with the commercial seafood industry have operated at a critical mass level and have received wide recognition, other research thrusts have tended to be relatively isolated and not organized into a comprehensive program. In most instances, such as the early work on coastal areas and the project on the boating service industry, study results have led to improved extension programs both within and outside of Oregon. In some instances public policies appear to have been improved on the basis of study results. In other areas research thrusts operated at such a small level as to have only minor impacts.

Underachievement

Perhaps the most frustrating areas of underachievement have related to two of the most famous economic studies ever to come out of Oregon State University. William Brown's valuation of the Oregon salmon and steelhead fishery in the mid-1960s is recognized as a pioneering achievement. Brown updated that study using funds primarily from the now defunct Northwest Regional Commission. A small portion of Sea Grant funds in 1977-1978 supported an investigation of possible new statistical methodology, but that portion of Brown's work has never been seriously integrated into modest-sized studies conducted by others during the last decade. Marine recreation is thus an area that has involved several small projects but no major program thrust.

The second famous study dealt with the policy impact of controlling environmental quality in the Yaquina estuary. Sea Grant did support expanded publication of work done under the auspices of the Water Pollution Control Administration in the mid-1960s and supported an unrelated study of coastal economic-environmental links in the early 1970s, but this area has been largely neglected since that time.

———Richard Johnston, Bruce Rettig and Fred Smith

List of Projects

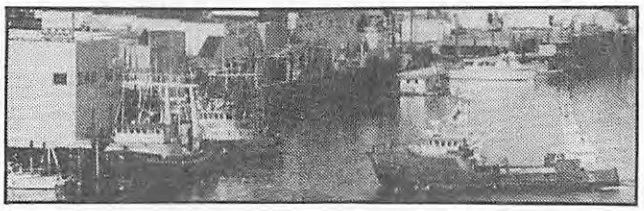
1968 Research was proposed in several areas: multiple use of marine resources, to include food and waste disposal, recreation, and transportation.

1969
- -Demand, prices and marketing
- -Economics of coastal areas
- -Public policy in the seafood industries

According to the proposal, "The economics of marine resources is, for the most part, a neglected field of inquiry. Although a few isolated studies have been conducted, there is nothing approaching a comprehensive literature on the subject."

1971 Demand, Prices and Marketing — Johnston — R/CE-1

1971	Public Policies in the Marine Resources Industries	Stevens	R/CE-2
1971	Economics of Coastal Areas (1973	Stoevener Rettig	R/CE-3 R/CM-7)
1971-75	Economics of Marine Firms (1973	F. Smith	R/Ec-4 R/PD-17)
1971	Marine Economics E&T (1973	Castle Rettig)	E/Ec-1
1973	Economic Feasibility of Selected Aquaculture Projects in the Pacific Northwest	Youde	R/Aq-20



1973-75	Processed Salmon Market, U.S. and Canada	Johnston	R/PD-16
1973-75	Economic Impact of a Moratorium on Entry in Oregon's Dungeness Crab Fishery	Stevens	R/PPA-4
1974	Economic Benefits from an Improvement in Environmental Quality in an Estuary: Recreation	Rettig	R/CM-10
1974-75	An Economic Study of the Relationship between Public and Private Outdoor Recreational Facilities on the Oregon Coast	Stoevener	R/CM-11
1974-75	Economic Information for the Marine Industry	F. Smith	R/EM-6
1974-76	Public Service Pricing in Oregon Coastal Development	Vars	R/CM-13
1975-77	Feasibility of the Production and Marketing of Seafoods Reared by Aquaculture	Johnston	R/Aq-27
1975-76	Economic Analysis of Extended Jurisdiction by the U.S. over Coastal Resources: Fisheries from Washington to California	Rettig	R/OPF-3
1975-77	Seafood Market Structure and Performance	Johnston	R/PD-24
1975-77	The Demand for Recreational Boat Moorage and Storage	Vars	R/EM-8

1976	The Demand for Overnight Camping Facilities on the Oregon Coast	Stoevener	R/CM-22
1977	Small Ports Advisory Program	Schmisseur	A/CM-12
1977-80	Refining Calculations in Fishery Management Plans: Capacity and Optimum Yield	Rettig	R/PPA-7
1978-81	Relationships between Institutional Arrangements and Aquacultural Development	Johnston	R/Aq-36
1978-81	Economic Implications of the International Marketing of Pacific Coast Seafoods	Johnston	R/PD-34
1979-82	Economic Analysis of the Interrelationships between Wild and Hatchery Salmon	Rettig	R/PPA-12
1980-82	Economics of the Boating Service Industry	F. Smith	R/PPA-14
1981-83	The Application of Computer Technology in Marine Economics	F. Smith	A/PPA-15
1982-85	Market Analysis for Pacific Groundfish	Rettig	R/PD-41

1977	T/T-5 and E/M-1 continued.		
	Management-oriented Aquaculture Training (Master of Agriculture in Aquaculture)	Bond	E/Aq-1
	Graduate Curriculum in Marine Extension	Klein	E/Ex-1
	Marine Education (proposed but not approved)		E/MEd-1
	Sea Grant Fellowship (proposed but not approved)	Wick	E/Fel-1
1978	T/T-5, E/M-1, E/Aq-1 and E/Ex-1 continued		
	Education for Effective Management of Marine Resources	Neal	E/MRM-2
1979	T/T-5, E/M-1, E/Aq-1, E/Ex-1, E/MRM-2 continued.		
	Marine Education Materials Identification, Preparation, and Implementation for Classroom Use	Thiess (ODE)	E/MEd-3
	Development Program for Professional Fishermen (Clatsop)	Phillips (Lodge)	E/PT-1
1980	T/T-5, E/M-1, E/Aq-1, E/Ex-1, E/MRM-2, E/MEd-3 and E/PT-1 continued.		
1981	E/Aq-1, E/PT-1 continued.		
	Marine Education Materials Inservice Program	Thiess (ODE)	E/MEd-4
	Education Programs for South Slough Estuarine Sanctuary	Gartland (Coos ESD)	E/MEd-5
	Marine and Maritime Studies Certificate Program	Copek	E/M-2

currently one of the most economically depressed areas in the state.

This project is increasing educational use of the sanctuary by students in grades 4-12, involving the public in productive educational experiences at the sanctuary, and developing a program of workshops and credited courses for teachers' in-service needs.

———— John McMahon, David Phillips, Ray Thiess

Education - Chronological Summary and Projects

1969 Thirteen graduate students had received support as Sea Grant trainees —extraordinary interest, course development proceeding at rapid pace, additional key staff had been hired, instrumentation and materials had been acquired or were in process, interdepartment and interschool cooperation was noted.

Summary Marine biology, 1 SG trainee; marine economics, 1 SG trainee, authorization of Ph.D. in resource economics; marine fisheries, 2 SG trainees, two new courses (fish genetics, and exploitation of fish and shellfish); food science, 2 SG trainees; mineral resources, 1 SG trainee; Oceanography (biological), 2 SG trainees; ocean engineering, M. of OcEng degree initiated, 2 SG trainees, five new courses, another course, Ocean Systems Designs, under development; oceanographic tech training, 25 students, 3 new courses; UO Law School, seminar in ocean resources law.

1970 Continued education and training as separate from research projects. Requested support for 23 assistants in oceanography, 2 of which were to work on hydrothermal deposits; 12 new courses had been developed in ocean engineering, 19 students in OcE, 4 SG trainees.

1971 Numbered education projects. Four technican training projects active at Clatsop: oceanographic, fisheries, marine, and a marine engineering (pilot).

1973 Graduate students treated as GRA's on most projects, exceptions in economics E/Ec-1, law E/L-1, and 3 tech training projects at Clatsop. Oceanography technican training had become independent of Sea Grant support.

1974 T/T-2, commercial fishing technican training, and T/T-3, marine technician training, were supported at Clatsop, E/L-1 law at U of O. A new curriculum, E/MRM-1 professional training in marine resource management was initiated in oceanography.

1975 Continuation of T/T-2, T/T-3, E/L-1, and E/MRM-1.

1976 T/T-2 and T/T-3, E/L-1, and E/MRM-1 continued.

Maritime Training Materials Development	(Clatsop)	Flickinger	T/T-5
Marine and Maritime Studies Program		Astro	E/M-1

requests for proposals and direct requests for assistance. The primary purpose of CIFAD is to assist developing countries and provide representatives of the member universities the opportunity to participate in such assignments. A non-profit organization, CIFAD has been involved in projects in such developing nations as Zaire, Costa Rica, the Philippines, Rwanda and Indonesia.

Staff have served as evaluators of project proposals, consultants and reviewers of courses to be offered in developing countries.

Maritime Studies

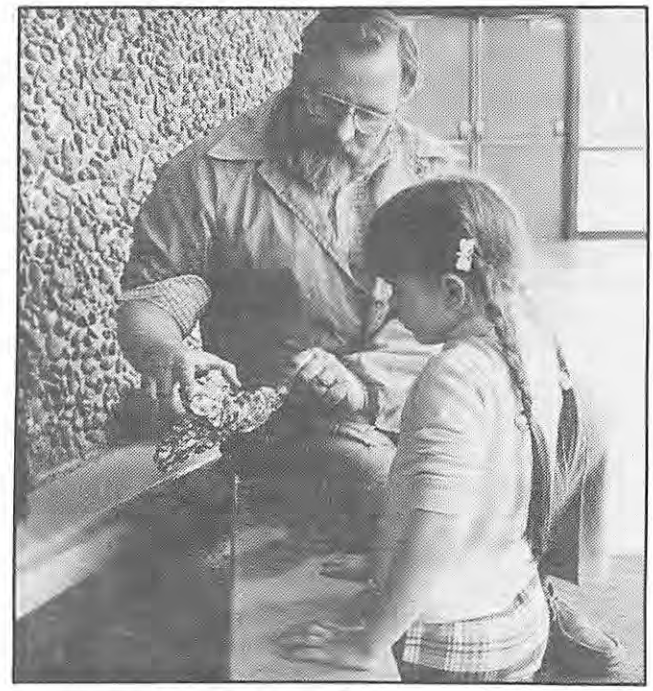
The Marine and Maritime Studies Program was inaugurated in 1976 with a new course on literature and the sea. Since then additional courses have been developed in such subjects as maritime history, maritime art, values and ocean technology, and Latin America and the sea. A certificate in Marine and Maritime Studies has been approved by the College of Liberal Arts. Regular program activities have included workshops, conferences and public lectures as well as courses. In addition, this broad array of courses offers graduate students in marine disciplines a wide selection of cultural and policy-oriented courses to supplement technical work in their fields.

Marine Education Materials

The Marine Education Materials Program was a cooperative effort with the Oregon Department of Education, which used a three-phase approach: materials identification, adaptation and dissemination.

During the ongoing dissemination phase, the Oregon Department of Education is providing in-service programs to disseminate information to teachers and administrators about available materials and is suggesting methods for infusing marine materials into the existing curriculum.

This program has resulted in increased communication among marine educators, sharing of materials and requests for materials. More importantly, the Oregon Department of Education is now perceived as a responsive agency by marine educators. The marine education materials collection at the Oregon Department of Education is considered an educational resource throughout the Northwest.



Marine education specialist Don Giles introduces a young visitor to a resident of the Hatfield Center's touching pool.

This project is especially timely and responsive to local needs. The adapt-and-adopt approach to curriculum development used here requires a substantially shorter lead time than the traditional curriculum writing approach.

South Slough

The Education Program for the South Slough Estuarine Sanctuary reflects a unique opportunity in a unique site. South Slough was the nation's first estuarine sanctuary. The sanctuary's advisory committee placed high priority on developing the educational program. The Coos County Educational Service District also wished to develop educational programs at the sanctuary. Sea Grant funding serves as a catalyst for these two local agencies to work together for the benefit of the local community, which is

in the private sector and in local, state and federal government positions. Examples include seafood marketing and processing, fisheries development, marine extension, private consulting, pollution control, coastal planning and teaching.

The program has also gained regional, national and international attention. The Western Interstate Commission on Higher Education considers it "unique." The International Oceanographic Commission and Tinker Foundation support foreign student fellowships for the program. Foreign students have always been an important part of the student population, lending diversity to the program.

Sea Grant's role has been primarily that of a catalyst by providing limited funding and by linking training in marine resource management with the Marine Advisory Program for identification of and experience with real world resources management problems.

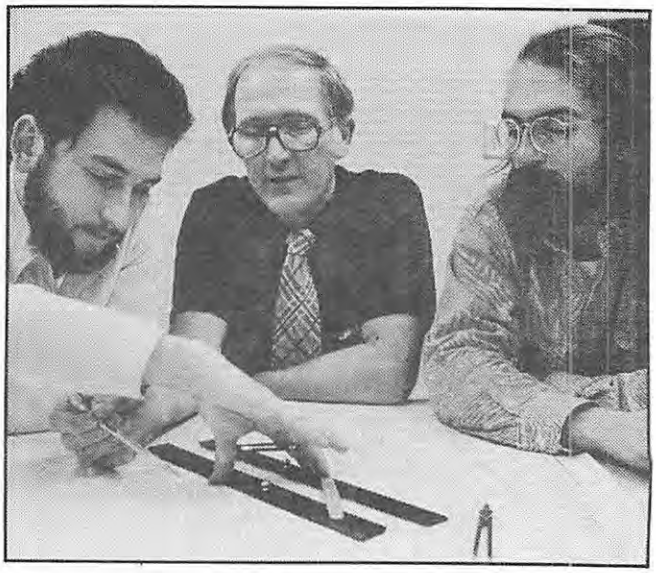
A related project is the Graduate Curriculum in Marine Extension, which is a program for academic training for individuals preparing for Marine Advisory careers in the Sea Grant network. A secondary effort was in-service training for current Marine Advisory staff. This program is in cooperation with the OSU School of Education.

The program has resulted in a series of courses in extension methods, program planning, international extension and marine extension, and in extension internships. The courses have all been approved as graduate, minor courses by OSU. The extension minor is available to graduate students in fisheries, marine economics, oceanography, ocean engineering, marine resource management, seafood technology, marine education and other fields. Ten students have completed graduate degrees with minors in extension, and other students' degrees are in progress. In addition, some courses meet the needs of students with interests in other extension programs.

The OSU Link

The link with the OSU School of Education is significant because it legitimizes extension as a formal discipline. The extension minor is potentially very useful to graduate students in adult and community college education.

EM 515, International Extension Methods, has been offered for four years under the leadership of W. L. Andersen. Jointly sponsored by Sea Grant and the School of Education, this course is an example of the good cooperation that has been shown across campus for the extension minor. Administrators in education, agriculture and oceanography have lent their support and counsel.



Ed Condon (center) with Marine Resource Management students.

CIFAD

The Consortium for International Fisheries and Aquaculture Development (CIFAD) is headquartered at OSU. Other participating universities are the University of Arkansas at Pine Bluff, the University of Hawaii, the University of Michigan, and Michigan State University.

Under the leadership of executive director Harvey Moore, CIFAD responds to

Graduates of the Marine Technician Training program include charter boat skippers, tow boat deckhands and tow boat captains. Others are employed in related areas such as marine supply stores, shipyards and maritime insurance. The program has also complemented oceanography and commercial fishing programs, by providing a core of seamanship and navigation courses.

The Maritime Training Materials Development project has produced instructional materials that have been of great value to the college's marine programs. Commercially produced relevant instructional materials, particularly in the commercial fishing area, have been scarce to non existent. Audio and visual materials, primarily in the video format, have been developed, which would not have been possible without Sea Grant's funding.

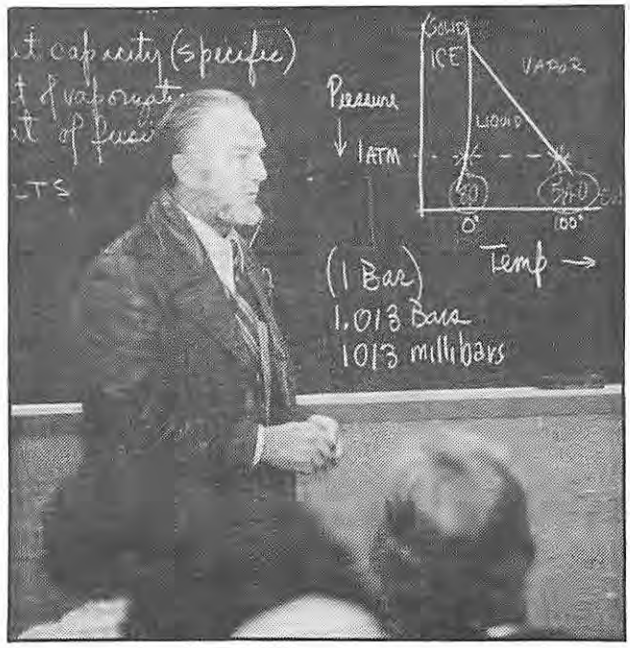
One of the most exciting and widely acclaimed projects has been the Development Program for Professional Fishermen. This project received national press coverage and the enthusiastic support of the commercial fishing and marine electronics industries. Commercial fishing captains from the West Coast and Alaska have attended one-week workshops on Fish Finding Systems and Fisheries Technology. This effort was made possible by Sea Grant's finanacial support.

There had been doubt that a highly qualified instructor could be hired and that American fishermen would want to learn proven European technology. With Sea Grant's aid, Dennis Lodge provided widely accepted workshops until June 30, 1983.

Marine Resource Management

Another major Sea Grant education effort has been interdisciplinary graduate training for effective management of marine resources.

Initiated in 1974 with four students, the School of Oceanography's Marine Resource Management M.S. program has grown to be a successful, stable part of the university's offerings in marine education. Forty-one students have completed the program, with 16 currently enrolled. Support from Sea Grant has been vital in developing a curriculum



One strength of Sea Grant is in the cross-fertilizing of research and teaching. Pictured is oceanography professor Steve Neshyba.

and an internship program, in providing field experience in commercial fisheries and student projects, and in advising.

Sea Grant has supported the development of new course work in estuarine processes, marine transportation, marine and coastal law, marine resources, coastal zone management and port projects, and of seminars on the exploitation of living resources.

Internships, a valued principal component of the Marine Resource Management program, have been developed using Sea Grant monies. These internships with private industry and local, state and federal agencies have added an important, practical experience to the students' education.

Several field experiences and projects have been Sea Grant supported, such as commercial fishing field trips and small port planning and development assistance.

Program Success

The success of the education program is indicated by the employment of its graduates

The national Sea Grant program provides an excellent framework for interdisciplinary training for marine resource development. Marine education and training have always been a part of OSU Sea Grant. In addition, marine education for school children and the general public has been considered an investment in the future understanding of marine resources.

For most areas of study we had a history of training, but Sea Grant also promoted new programs in law (the University of Oregon), engineering, economics and technican training (Clatsop College).

Ocean Engineering

In ocean engineering, the initial emphasis was to train students for ocean engineering careers. Now, research has increased in sophistication and has become the principal thrust of the program. Students still participate in the research, and the program directors "believe that better graduates have gone into an increasingly sophisticated ocean industry, that our faculty strength has grown in a major way, that results of our work have been widely used, and that Sea Grant has been the constant backbone of support that holds our ocean engineering program together."

Since 1969, Sea Grant support has resulted in 70 ocean engineering publications in technical journals, reports and conference proceedings as well as 39 conference presentations. This widespread dissemination of results attracts attention for additional research support, stimulates application of results, develops consultancies for faculty and attracts better graduate students.

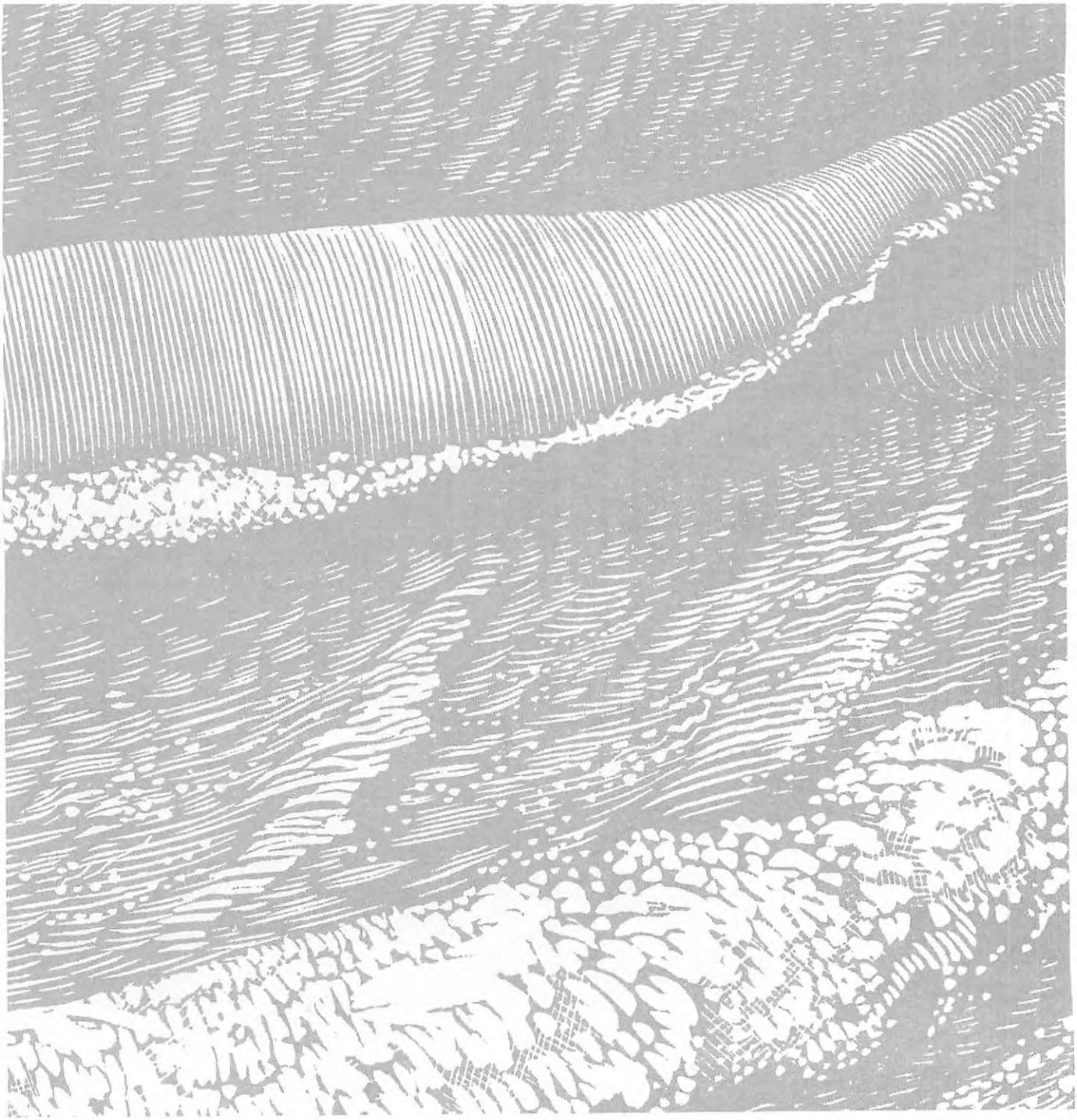
Technical Training

Marine technical training at Clatsop Community College has been a major effort of OSU Sea Grant since 1969. The primary purpose has been to prepare men and women for job entry employment in marine occupations and to upgrade the skills of those already employed. Sea Grant's role has been that of providing seed money and serving as the catalyst for program development.

American commercial fishing has changed from a low- to a high-technology industry in the past two decades. In addition to having basic fishing, net mending and seamanship skills, today's commercial fisherman needs to know how to troubleshoot and sometimes repair a boat's electrical, hydraulic and refrigeration systems. In addition, the fisherman needs to know the proper use of electronic gear such as sonar, radar, loran C, echo sounders, net sounders and fish lupes. Furthermore, he must understand the theory of fishing gear behavior, the behavior of fish, meteorology, fish preservation and economics.

When it started, Clatsop's Commercial Fishing Technician Training program was not widely accepted by fishermen. At the same time, however, most fishermen had difficulty finding reliable, experienced help. With Sea Grant's financial support of staff and materials, the college was able to devote its limited resources to purchasing a suitable floating classroom, the F. V. Forerunner, in 1974. It is a fully equipped commercial fishing boat. Today, the program has a good reputation and relationship with the commercial fishing industry.

Education



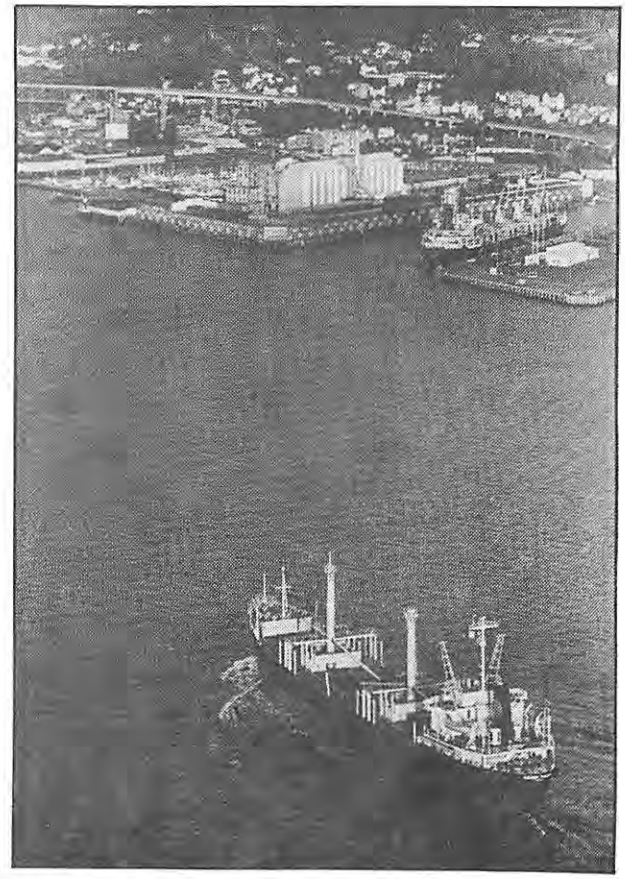
1971	Ocean Law	Jacobson	R/L-1
1973-75	Research and Publication in Ocean Law	Jacobson	R/PPA-1
1973-77	Advisory Services in Ocean Law	Jacobson 1975 became -	R/PPA-2 A/PPA-2
1974-77	Professional Training in Ocean Law	Jacobson	E/L-1
1976	Developments in Northwest Ocean Law and Coastal Law	Jacobson	R/CM-21
1977-79	Current Developments in Ocean Law: Pacific NW and Alaska	Jacobson	R/PPA=6
1979-80	Implementation of the Fisheries Conservation and Management Act in the Pacific Northwest: Legal Information and Education Services	Jacobson Hildreth	R/PPA-13
1981	New Developments in the Law of the Sea and Coastal Management of Significance to the Northwest and Alaska	Jacobson Hildreth	R/PPA-17

Jacobson has lectured on ocean law in South America on behalf of the United States Information Service; he has been a member of the State Department's Public Advisory Committee on the Law of the Sea since 1977; he had advised the State of Alaska's Law of the Sea Commission; and he has served on the Advisory Panel for the North Pacific Fishery Management Council.

Hildreth supervised the preparation of a seven-part report on outer continental shelf oil and gas for the Oregon Land Conservation and Development Commission, moderated several panels at the Oregon Coastal Zone Management Association's (OCZMA) National Coastal Zone Management Conference in 1979, spoke at several OCZMA meetings and OSU Sea Grant workshops, and testified with Swan before the Oregon Legislature concerning liquified natural gas terminals.

Research assistant Don Hornstein researched and wrote a bulletin, Salmon Ranching in Oregon: State and Federal Regulations, on behalf of the Oregon Fish and Wildlife Department. Jacobson and research assistant Kevin Davis edited Federal Fisheries Management: A Guidebook to the Fishery Conservation and Management Act. Hildreth and Ralph Johnson of the University of Washington edited Ocean and Coastal Law, a law school casebook.

— Jon Jacobson and Richard Hildreth



A program goal is to keep legal information up to speed with changes in ocean and coastal use.

List of Projects

1968	Depicted as a year of organization; to survey legal bibliography and research materials; to begin to improve library holdings, etc.
1969	Ocean Resources Law: Sub-projects in teaching and research in ocean resources law and law periodical
1970	Results in areas of (1) leasing of submerged lands, (2) coastal shift on ocean boundaries, (3) man-made structures in ocean zones, (4) changing concepts in territorial sea, (5) federal jurisdiction, (6) hard mineral mining

Ocean and Coastal Law

The Ocean and Coastal Law Center at the University of Oregon Law School has been conducting research and providing both professional education and public information on ocean and coastal law issues that affect the Pacific Northwest.

The faculty investigators have, over the years, conducted several significant research projects on ocean and coastal law topics. They have been aided in these efforts by student research assistants.

In addition, Sea Grant sponsorship has enabled the development of the Ocean and Coastal Law Library, now considered to be one of the finest collections of its type in the world. A half-time professional librarian is in charge.

Professional education activities have occurred at the University of Oregon Law School. Two courses have been added to the Law School's curriculum: Law of the Sea (formerly Ocean Resources Law), taught by Jon Jacobson; and Ocean and Coastal Law, taught by Richard Hildreth. Further professional training has been made available to those Oregon law students appointed as research assistants in the Ocean and Coastal Law Center (OCLC).

The professional education available at the Oregon Law School was enhanced by the creation of a "Statement of Completion" program, awarded to graduating law students who received training in ocean and coastal law through curriculum programs and special research assignments. Law students who participate in the Ocean and Coastal Law Program have, as a consequence, been placed in ocean and coastal law-related positions in federal and state governments and in private practice.

Professional education by the OCLC is also now provided to nonlaw students at Oregon State University. Jacobson, Hildreth and Peter Swan have taught the Marine and Coastal Law course to OSU students in alternate years for the past eight years.

Public Information

Public information (not legal advice) has been one of the emphases of the OCLC. Much of our research has supported publications, conferences, workshops, and speeches done for the purpose of enhancing the general public's understanding of ocean and coastal law developments. The primary example is our series of Ocean Law Memos and Coastal Law Memos on current topics.

The OCLC has also sponsored conferences at the law school on coastal zone management and on mariculture laws, and in Portland on the Law of the Sea and the Exclusive Economic Zone.

Further, the OCLC has organized and participated in public workshops. For example, a series of workshops on antitrust laws and the fishing industry was conducted in several locations along the West Coast.

The faculty investigators and the research assistants associated with the OCLC have over the years given many speeches and talks on ocean and coastal law topics to interested members of the public.

Other Achievements

Finally, the OCLC has been active in support of governmental activities related to ocean and coastal law. For example,

Administration

Sea Grant at OSU is part of the office of the Dean of Research and, as such, is part of university administration. This administrative position enables Sea Grant to deal easily with the various departments, schools and colleges of OSU and with other universities. Incorporation into the administration implies commitment to Sea Grant as a permanent, broadly-based program of the university.

The Sea Grant director serves at the pleasure of the OSU president. An internal executive committee and an external advisory council provide guidance and policy advice. Programs are developed on the basis of the best advice from all relevant sources. These focus on several factors, including (1) our best estimates of future trends; (2) the expressed and implied needs of marine resource users in Oregon, the Northwest, and the nation; (3) the available talent base in the region augmented, if necessary, by the members of the Sea Grant network; and (4) available funding from federal, state, local, and industrial sources.

Program proposals are prepared on a biennial basis. Each program contains some new elements using faculty from a broad array of disciplines. At the same time, the core of our program reflects the core strength of our institutional base. We

continue to support proven performers—researchers, educators, and advisors. These professionals are helping Sea Grant build a name and an image in Oregon and across the nation.

Bill Wick

Communications

Professional communicators have performed an essential role within the Oregon State University Sea Grant College Program since its beginning. For a decade the information staff has provided Sea Grant researchers and administrators with communications support, and has published and distributed technical information for other marine scientists and various interested groups and individuals. The staff also disseminates information to the general public.

Tools of the trade include technical reports, special reports, annual reports, news stories, features, magazine articles, radio and television public service spots, public television programs, slide/tape programs, newsletters, public displays, and group meetings.

As the Sea Grant College Program matured, communications staff members built upon the successes of the past. For example, in the early 70s the success of Wisconsin Sea Grant's radio program, Earthwatch, encouraged our staff to begin a similar series in Oregon. Coastwatch, a marine-related radio news and feature program, was started in 1975 and remains an important and reliable part of our public information program. In succeeding years, staff members built an effective system for producing and distributing technical reports--a system which remains essentially unchanged today.

More recently, through the use of increasingly effective news and feature writing, radio news reports and public service television production, we are reaching a wider audience than ever before. For example, in the last few years we have produced two television documentaries which were broadcast on the public broadcasting systems western stations, and are currently producing The Blue Revolution, a film on world aquaculture, for broadcast on the science series NOVA.

Within OSU Sea Grant, the Marine Advisory Program maintains its own communications office, housed and administered through the Department of Agricultural Communications in the College of Agricultural Sciences. While the two offices are physically and institutionally separate, we act in concert on many projects and regularly keep each other informed of the other's activities.

To give a sense of the scope of Sea Grant Communications' public information work, here's a simple listing of those activities during 1982-83. We:

--A. wrote 60 or more stories for newspapers and magazines, half of which were used on state, regional, or national wire services.
--B. produced 30 radio stories and made them available to stations desiring them.
--C. produced 96 Coastwatch radio public service spots used regularly by 38 stations in the Northwest.
--D. published two special sections in the Corvallis newspaper, the Gazette Times, and one section of the Oregon State University alumni newspaper, the Oregon Stater.
--E. published five technical reports and six special reports.
--F. produced and distributed Estuary, a 29-minute documentary used on the National Public Broadcasting Network.
--G. produced Gray Whale, an 8-minute filmed research report.

—H. produced a 3-minute informational television spot used regionally at basketball halftime.

--I. produced a 20-minute slide/tape program for the Oregon State University Hatfield Marine Science Center in Newport.

--J. assisted the CBS producers of Walter Cronkite's Universe with the production of "Why Whales Strand," a segment aired in 1982.

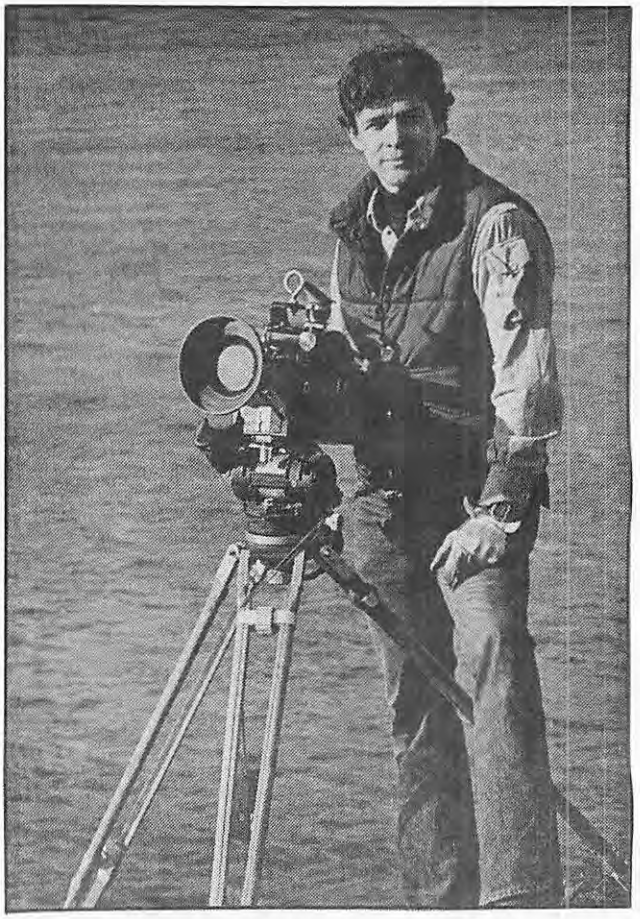
--K. assisted the Australian Broadcasting Network with their production Stranded, an internationally broadcast special on whale strandings.

--L. produced the biennial Sea Grant proposal and two annual reports.

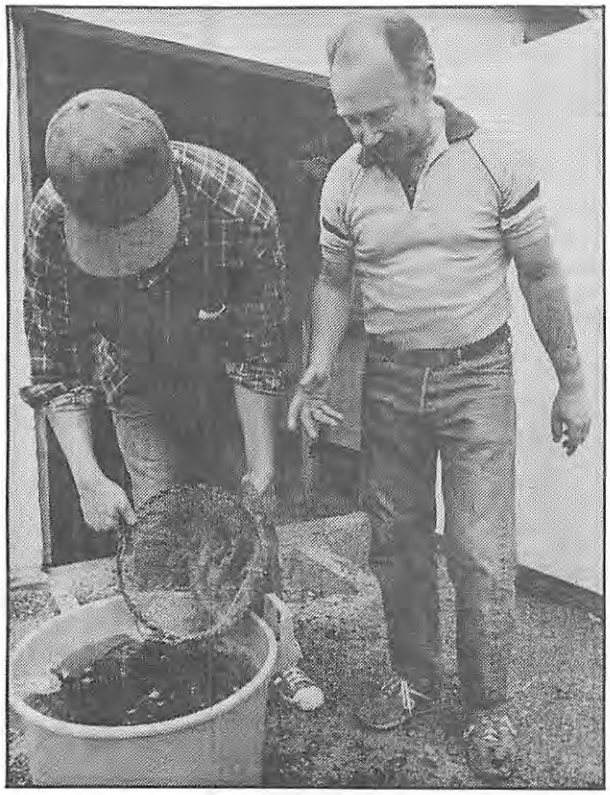
--M. responded to more than 1400 requests for marine information and distributed 2400 publications to those requesting them.

--N. published four editions of Marine Mammal Information and three of the Sea Grant newsletter, Currents.

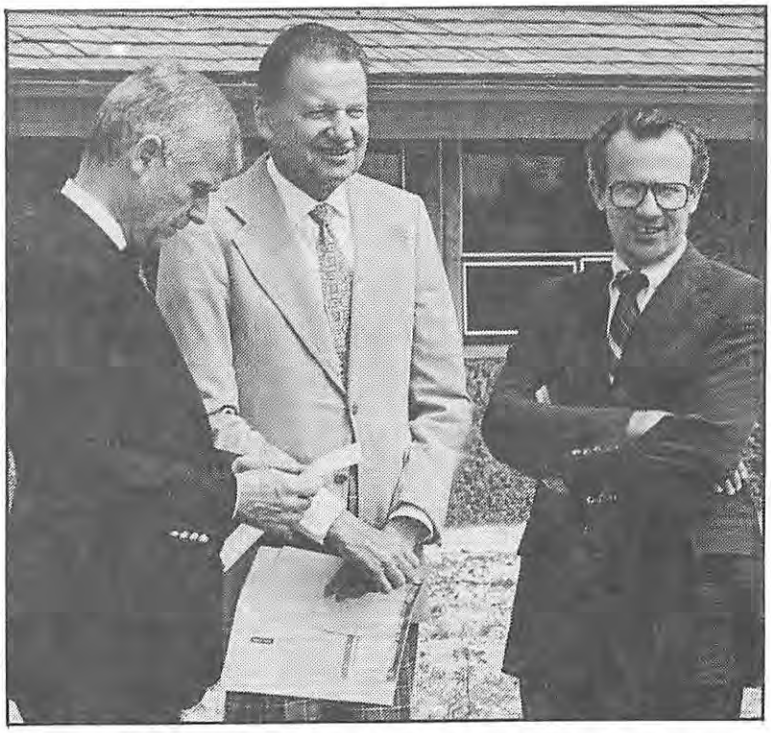
Sea Grant Communications has received a number of national awards in recent years, notably for films by Jim Larison. Some of the awards were: CINE Golden Eagle (for both Mammals of the Sea and Estuary: Columbia's Link with the Sea), a Grand Award from CASE, the Council for the Advancement and Support of Education, for Estuary. Coastwatch, Sea Grant's radio program, also received a CASE award for exceptional achievement, for programs produced in 1983-84.



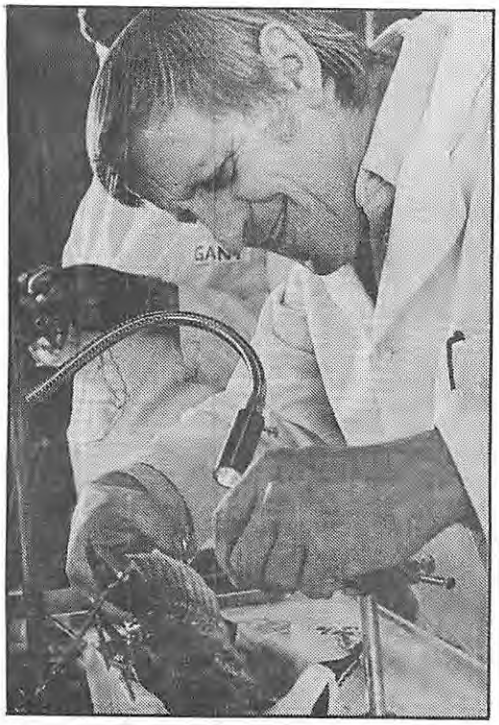
Film maker and Communications director Jim Larison.



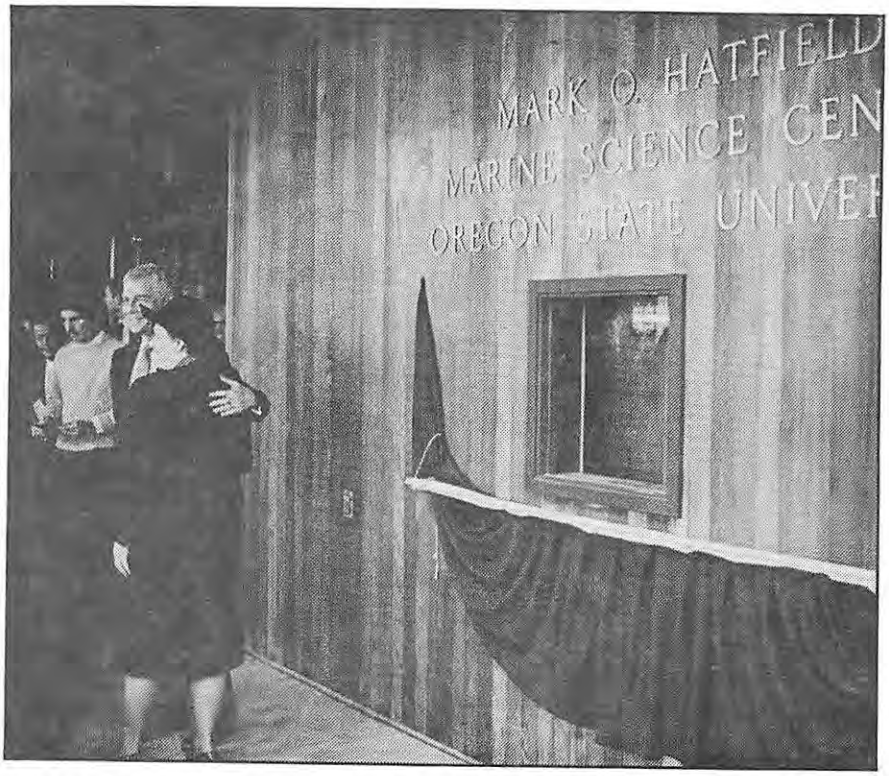
Howard Horton, Marine Advisory Program leader since 1980.



Mark Hatfield, a long-time supporter of marine research, joins Robert MacVicar and John Byrne for ceremonies at the Marine Science Center, 1982.



Marine Science Center director LaVern Weber.



Mark and Antoinette Hatfield at the dedication ceremony, 1983.

Sea Grant Students

EMPLOYMENT PROFILE OF STUDENTS SUPPORTED BY

OSU SEA GRANT COLLEGE PROGRAM

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
AGRICULTURAL & RESOURCE ECONOMICS			
ABBAS, Leon	1975	PhD	Sea Grant Program, N. Carolina State Univ.
BOYLE, Kevin	1982	MS	PhD student at Univ. Wisconsin, Ag & Res Econ
CARTER, Christopher	1982	PhD	Oregon Dept. of Fish & Wildlife, Portland, OR
CHONG, Kee Chai	1979	PhD	Researcher, International Center for Living Aquatic Resources Management, Philippines
EARLEY, Jim	**	MS	Current graduate student
EMAMI, Ali	**	PhD	Current graduate student
FERRARA, Pamela			Withdrew from school
FORD, Donald	1976	MS	Unknown
FRISBIE, Thomas	**	MS	Current graduate student
HANNA, Susan	1982	PhD	Research Associate, OSU, Ag & Resource Econ
HERRICK, Samuel	1980	PhD	National Marine Fisheries Service, LaJolla, CA
JENSEN, William	1975	PhD	Lewis & Clark College, faculty, Portland, CA
LENT, Rebecca	1983	PhD	Post doctoral research in marine economics, Marine Biology Lab, Concaneau, France
LIN, Bling Hwan	1983	PhD	Faculty, Univ. of Alaska
MARTIN, John V.	1978	MS	Vice president, fishing company, Anchorage, AK
McINTYRE, Daniel		MS	Withdrew
QUEIROLO, Lewis	1977	MS	National Marine Fisheries Service, Juneau, AK
REILING, Stephen	1976	PhD	Faculty, University of Maine, Ag & Res Econ
ROBERTS, Kenneth	1973	PhD	Extension Service, Louisiana State Univ., Baton Rouge
ROGERS, Larry O.	1980	PhD	University of Arkansas, Pine Bluff, on IPA to NOAA, Washington, D.C.
SASS, Mary Ellen	1978	MS	Unknown
SAVAGE, John	1979	MS	Unknown
SIAWAY, Arthur	**	PhD	Current graduate student
SWARTZ, A. Nelson	1979	PhD	National Marine Fisheries Service, Seattle
VIETH, Gary	1976	PhD	Asst Prof, Univ of Hawaii, Ag & Res Econ
WALKER, Kevin	1982	MS	PhD student, Univ Missouri
WANG, Stanley D.	1976	PhD	Faculty, Univ of Minnesota, Economics
WILSON, James	**	PhD	Inactive student. NMFS, Juneau, Alaska
AGRICULTURAL ECONOMICS - WASHINGTON STATE UNIVERSITY			
LOGSDON, Charles			
ANIMAL SCIENCE			
SHQUEIR, Adnan Ali	1982	PhD	Faculty, at university in Jerusalem
VANDEBERG, Kenneth		MS	Withdrew
WU, Yea-Ching	**	PhD	Current graduate student

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
ANTHROPOLOGY			
HATLEY, Thomas	1976	MAIS	Special Programs Coordinator, Linn-Benton Community Services Consortium, Albany, OR
HILGEMAN, Charles	1974	MA	4-H Youth Counselor, Agricultural Extension, Humboldt State University, Eureka, CA
STEPHENSON, Garry	1980	MAIS	Current graduate student
YATES, Dean	1975	MA	Management trainee, Pacific Power & Light, Wapato, Washington
BIOCHEMISTRY/BIOPHYSICS			
RAMBERG, Donald	1977	PhD	MAYO Clinic, resident MD in neurosurgery (received MD from U of O)
BOTANY AND PLANT PATHOLOGY			
DeBOER, James	1975	PhD	Faculty, Univ of Texas, Marine Science Institute, Port Aransas, TX
GILL, Gary	1971	MA	Research technician in marine biochemistry, Bedford Institute, Halifax, Nova Scotia
KARENTZ, D.	1976	MS	Current graduate student in Botany, URI
WULFF, Barry	1970	PhD	Associate professor, Eastern Connecticut State College, Willimantic
BUSINESS ADMINISTRATION			
BOWMAN, Kenneth	1974	MBA	Major, U.S. Army
HOBSON, Perry	1970	MBA	Unknown
NORDLING, John B.	1971	MBA	Unknown
CHEMISTRY			
GHANNAM, Lina	1981	MS	Current graduate student
KRAUS, Robert Henry Jr.	**	PhD	Current graduate student
OERTEL, Christopher	1981	MS	Rockwell International, Boulder, CO
CROP SCIENCE (Agronomic)			
ALDRICH, J.	1972	MS	Unknown
EDUCATION			
McMAHON, John	**	PhD	Current graduate student
SCOTT, Robert A.	1975	MS	Unknown (degree in Science Education)
ENGINEERING - AGRICULTURAL			
COREY, Philip	1983	PhD	Faculty, Univ California, Davis
ERNST, Douglas	1983	MAg	Teaching OSU, MSC.
GEISELMAN, James	**	MS	Current graduate student
WATTEN, Barnaby	1981	MAg	Research Assistant, OSU, Ag Eng'g

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
ENGINEERING - CHEMICAL			
DARDEL, Brice	1981	MS	IBM France
ENGINEERING - CIVIL			
ADAMS, Burton	1971	MS	Norconsult A.S., Hovik, Norway
ARNESON, Robert	1975	MOcE	Wharton School of Business, U. of Penn
ASKREN, David	1978	MOcE	Oceanographer, Portland District Corps of Engineers
BALIGA, Ravidranath	1978	MOcE	Engineer, San Francisco, CA
BARNES, B.L.	1975	MS	Unknown
BOLEY, Scott	1973	MOcE	Self-employed fishermen, Brookings, OR
BOYCE, Allen R.	1977	MS	Department of Ag Engineering, Purdue Univ.
CAPILLON, Patrick	1982	MS	
	**	PhD	Current graduate student
CHAN, Yan (Thomas)			Transferred to MBA program
CHANG, Chen	1981	MS	Microflect, Inc., Salem, OR
CHASSE, James P.	1972	MS	Unknown (was with EPA, Corvallis)
CHEN, Min-Chu	1980	PhD	Brown & Root, Inc., Houston, TX
CHINTAKOVID, Vanit	1979	MS	Thailand Highway Department
CHOI, Byungho	1976	MOcE	Korea Institute of Science & Technology
CLEMMONS, Gregory	1981	MS	U.S. Forest Service, Olympic National Forest
DIBBLE, T.	1981	MS	Unknown
DODSON, Timothy	**	MS	Current graduate student
DOMINGUEZ, Richard	1970	PhD	Chairman, Civil Eng'g, U. of Maine, Orono
DUMMER, Jerry	1981	MOcE	C.E. Lab, Port Hueneme, CA
EVANS, Gary L.	1981	MS	Oregon Department of Transportation, Eugene
FINNIGAN, Timothy			Transferred to University of Houston
GOODWIN, Carl R.	1974	PhD	USGS, Jacksonville, Florida
GRECCO, Michael	1977	MS/OE	Marathon Oil Company, Houston, TX
HAFEN, Blaine	1976	MOcE	Civil Engineer, Naval Construction Battal. Center, Port-Hueneme, CA
HUANG, Min-Chih	1981	MOcE	Faculty position in Taiwan
HSU, Ming-Kuang	**	PhD	Current graduate student
KIM, Tae-In	1982	MS	Current graduate student
LEACH, Patrick	**	MS	Current graduate student
LEE, Jaw-Fang	**	PhD	Current graduate student
LIN, Cheng-Wen	1981	PhD	Operations Research, Silver Springs, MD
LO, Alain	**	PhD	Current graduate student
LUNDY, Dan	1973	MS	Unknown
MAITLAND, James	1978	PhD	Willamette Geotechnical Consulting Firm Corvallis, OR
MALLOCH, Robert			Withdrew
McDOUGAL, William	1981	PhD	Assistant Prof., Civil Engineering, OSU
McKENZIE, David	1975	MOcE	Bay Area Rapid Transit, Oakland, CA
MUELLENHOFF, W.	1977	PhD	Undersea Science & Technology Office, NOAA, Washington, D.C.
MULLARKEY, Thomas	1982	PhD	Faculty, School of Engineering, University College, Galway, Ireland

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
ENGINEERING - CIVIL, cont'd.			
PONG, Shio-Jin	1981	MS	Conservtech, Inc., Vernon, CA
PRATT, Robert			Transferred to Colorado State University
PRESTEDGE, Gordon	1977	MS	Engineer, Sir William Halcraw & Partners, South Africa
PYLES, Marvin	1975	MS	Assistant Professor, Forest Engineering, OSU, (PhD from UC, Berkeley)
SPAW, Robert		MS	Withdrew. President, ATIS, Inc., Cypress, TX
TANG, Shirly	1977	MOcE	Tetra-Tech Engineering, Pasadena, CA
TENG, Chung-Chu	**	PhD	Current graduate student
THIELEN, David	**	MS	Inactive. Dames and Moore, Portland
TSENG, Ying-Chuan	1974	MS	Returned to Taiwan
UTT, Michael	1974	MS	Union 76 Oil Company, Los Angeles, CA
WANKMULLER, Richard	**	MS	Current graduate student
WRIGHT, James	1976	MOcE	NAVFAC, Ocean Project Officer, Navy Yard, Washington, D.C.
ENGINEERING - ELECTRICAL			
EGHBALI, Hassan	1976	PhD	Electrical & Computer Engineering, Pahlavi University, Shiraz, Iran
KOLAR, Michael	1970	MOcE	Naval Undersea Center, San Diego, CA
ENGINEERING - INDUSTRIAL			
CHAKRAVARTY, Jyotirmoy	1976	MS	Texas Instruments, Dallas, TX
CHEN, Kuei-Lin	1976	PhD	Research Institute, University of Dayton, OH
CHEUNG, Chi Ming	1976	MS	Unknown
CHOLVANICH, Viravat		PhD	Withdrew from OSU
CONRADS, Randal G.		MS	Withdrew from OSU
FARAQUI, Siahuddin	1975	MS	Tetronix, Inc., Beaverton, OR
GHAFFARI, Ebrahim	1970	MS	Unknown
JAIN, Pravin	1976	MS	Tektronix, Inc., Beaverton, OR
MERCER, William	1975	MS	Industrial Engineer, Tektronix, Inc., Beaverton, OR
RAWAL, Subhash	1970	MS	Canadian Pacific Railway, Toronto, Canada
WALLS, Bobby Jack	1976	PhD	Owner, Polar Cryogenics, Inc., Corvallis, OR
WILLIS, George P.	1975	MS	Corps of Engineers, Portland, OR
ENGINEERING - MECHANICAL			
BARLOW, Dwight	1970	MS	Unknown
BROWNLOW, R. W.	1976	PhD	School of Engineering, Gonzaga Univ., Spokane, WA
CHANG, Terrill John	1974	MS	CH2M Hill, Bellevue, WA
CYVAS, Matthew K.	1976	MS	Unknown
LADD, Daniel	1975	MS	Naval Undersea Center, San Diego, CA
LAMOTTE, Nicole	1971	MS	Unknown
LeFEBVRE, Patrick	1974	MS	CH2M-Hill, Portland, OR
MARSHALL, Charles A.	1971	MS	US Forest Service

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
ENGINEERING - MECHANICAL, cont'd.			
RAUW, Charles.	1975	MS	Dames & Moore, Environmental Consultants, Los Angeles, CA
RUPE, Robert C.	1973	MS	Bell Telephone Laboratories, Boulder, CO
SLACK, David P.		MS	Withdrew from OSU to enter Medical School
TAVOLACCI, Don	1974	MS	Developer, Corvallis, OR
ENGLISH			
MACKAMAN, Julie	1976	MS	Unknown
FISHERIES AND WILDLIFE			
ARMSTRONG, David A.	1974	MS	Dept. of Water Science and Engineering, University of California, Davis
COOMBS, Candia	1979	MS	NSE Regional Ag Assoc., Ketchikan, AK
COYKENDALL, Robert L.	1973	MS	Yuba County Mosquito District, Yuba City, CA
CROOK, Amy	**	MS	Inactive student
DEMOTT, Glenn	1983	MS	Assistant Store Manager, Waremart, Oregon
EMADI, Hossein	1974	PhD	Director, Iranian Fisheries Research, Institute, Bandar Pahlevi, Iran
FITZPATRICK, Martin	**	MS	Current graduate student
GABRIEL, Wendy	1979	MS	Department of Fisheries & Wildlife, University of Massachusetts, Amherst
HAEFNER, James	1975	PhD	Faculty, Dept Fisheries & Wildlife, Utah State Univ.
HAYDEN, Thomas	**	MS	Inactive student. Fisherman in Alaska.
HAYMAN, Robert	1978	MS	Unknown
HENDERSON, Bruce	1983	MS	ODFW, Newport, Oregon
HUTTON, Mark I.	1973	MS	Dames & Moore, Juneau, AK
JOHNSON, William C.			Transferred to University of Rhode Island for PhD
JONASSON, Brian C.	1983	MS	ODFW
KAPUSCINSKI, Anne Renne	1981	MS	
	**	PhD	Current graduate student
KEPSHIRE, Bernard	1976	PhD	Regional fish culturist, Alaska Department Fish & Game, Anchorage, AK
KREUZ, Keith	1979	MS	High Desert Brine Shrimp Co., Lakeview, OR
KRUSE, Gordon	1981	MS	
	**	PhD	Current graduate student
KRYGIER, Earl E.	1974	MS	Working in Alaska
LISS, William	1977	PhD	Assistant professor, Fisheries & Wildlife
MALOUF, Robert	1977	PhD	Assistant professor, SUNY, Stony Brook, NY
McBRIDE, Margaret	**	MS	Inactive student. Working at Woods Hole
McCLURE, Robert	1982	MS	Private consultant in fisheries development
MURANAKA, Michael	1981	MS	Unknown
OBERBILLIG, David	**	MS	Current graduate student
OTT, Alvin	1975	PhD	Alaska Fish & Game, Fairbanks, AK
PATINO, Reynaldo	1983	MS	
	**	PhD	Current graduate student
PEQUENO, German	**	PhD	Current graduate student
POON, Derek	1977	PhD	NSE Reg. Ag. Assoc., Sitka, AK
PRIMBS, Edward	1969	MS	Unknown
PRING, Cynthia	**	MS	Current graduate student
REDDING, Michael	1983	PhD	Post doctoral research in France

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
FISHERIES AND WILDLIFE, cont'd.			
REHNBERG, Bradley	**	PhD	Current graduate student
ROBINSON, William I.		MS	Withdrew from OSU. ODFW, Beaverton, OR
ROWAN, Gerald	1975	MS	Anadromous, Inc., Deer Island, OR
SHAUL, Warrent		MS	Withdrew from OSU. Washington Department of Fisheries, Shellfish Lab, Brinnon
SMOKER, William	1982	PhD	Assistant Professor, Fisheries, University of Alaska, Juneau
STAEGER, William	1974	MS	Self-employed consultant
STEFFERUD, Jerome	1975	MS	USFS, Albuquerque, NM
STEINER, Richard	1978	MS	Marine Extension Agent, Kotzebue, AK
THOMPSON, Grant	1981	MS	
	**	PhD	Current graduate student
TONER, Margaret	1978	MS	Unknown
WASHINGTON, Betsy	1982	MS	Institute for Environmental Studies, Seattle, Washington
WATKINS, Bruce	1976	MS	Unknown
WILLIAMS, Steven F.	1975	PhD	Faculty, Biological Science, St. Cloud State College, MN
FOOD SCIENCE AND TECHNOLOGY			
AKEL, Phillips	1981	MS	Technical sales representative, Rohm Co. (juice & wine producers)
ARGAIZ, Alvaro	1976	MS	Professor, Escuela de Cinecias Maritimas y Tecnologia de Alimentos, Cuaymas, Mexico
BOYKO, Alayne L.	1975	MS	Food analyst, Micro-Chem Labs, Seattle, WA
BUCHER, J. A.		MS	Withdrew from OSU to enter dental school
CRAPO, Charles A.	**	MS	Current graduate student
CULBERTSON, Jeffrey	1978	MS	Current graduate student at University of WA
DECKER, Carl	1974	PhD	Food chemist, Ralston-Purina Co., St. Louis
de ROSENZQEIG, Lorenzo	1978	MS	Food scientist, Fisheries Department of Mexico, Mexico City
ERICKSON, Marilyn C.	1981	MS	
	**	PhD	Current graduate student
FLORES, Sergio	1973	MS	Technologico de Monterrey, Guaymas, Mexico
GEIST, Gary	1973	MS	Turkey processing division, Land O'Lakes, Inc., Albert Lea, MN
GULAN, Michael P.	1973	MS	Carnation Company, Van Nuys, CA
KELCH, William	1977	MS	Veterinary Officer, U.S. Army, Veterinary Div., Dept. of State, Belgrade, Yugoslavia
LEIB, Andrew	1973	MS	Oregon Fruit Products, Salem, OR
MA, H.		MS	Transferred to MBA program in 1977
MADERO, Carlos	1978	MS	Current graduate student at Texas A&M Univ., Seafood quality/technological section
PARKER, R.	1981	PhD	Assistant professor, Department of Nutrition, Cornell University
PRICE, Robert	1972	PhD	Department of Food Science, University of California, Davis
STEEL, Ronald E.	1971	MS	Director of Research, Consolidated Flavor Corp., Bridgeton, MO

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
FOOD SCIENCE AND TECHNOLOGY, cont'd.			
TOLEDO-FLORES, Luis J.	1982	MS	Current graduate student at Cornell Univ. Food Science Department
WHITING, Richard C.	1974	PhD	USDA/ARS, Philadelphia, PA
GENERAL SCIENCE			
PANSHIN, Daniel	1971	PhD	Assistant Administrator, Extension Service, USDA, Washington, D.C.
PRIBBLE, Howard J.	1972	MS	Project leader, Carp Study, Australian government, Melbourne
RILEY, Ronald	1979	PhD	Toxicology and Biological Constituents, Russell Research Center, Athens, GA
GEOGRAPHY			
HARTSOOK, Thomas	1978	PhD	Senior systems analyst, Computer Center, OSU
TERICH, Thomas	1974	PhD	Assoc. professor, Department of Geography, Western Washington State College, Bellingham, WA
LAW - LEWIS & CLARK LAW SCHOOL			
BENNETT, Laurie	**	JD	Current graduate student
CARLSON, Cynthia	1982	JD	LL.M. 1983, U. of Virginia; Law Associate (Specialty: natural resource management ocean and land base)
COLE, Dan	**	JD	Current graduate student
DOD, Barry	1982	JD	Unknown
HARTMAN, Debbie	1983	JD	Unknown
JOHNSON, Brad	1980	JD	Captain, Judge Advocate General Consul, U.S. Army
McCHESNEY, Francis	1980	JD	Associate editor, Environmental Law Report, Washington, D.C.
MITTLE, Rob	1982	JD	Unknown
OWLETT, Steve	**	JD	Current graduate student
LAW - UNIVERSITY OF OREGON			
ARMSTRONG, James J.	1977	JD	Unknown
BALAGNA, Steven	1980	JD	Unknown
BARKELEY, James	1981	JD	Unknown
BENNER, Richard	1975	JD	1000 Friends of Oregon, Portland
BERGER, Matthew	1979	JD	Unknown
BERMAN, Carol	1978	JD	NOAA
BUCK, James	1979	JD	Unknown
BUNNENBERG, Ann	1980	JD	Unknown
BRADLEY, Ralph	1979	JD	Unknown
CALLAHAN, Dan	1978	JD	Alaska Legal Service, Fairbanks, AK
CAMERON, Douglas	1977	JD	Kirkland, Campbell, and Keating, New York, NY
CARTER, Derb	1980	JD	National Wildlife Federation, Carolina Wetlands Project, Raleigh, NC
CLARKE, Mary	1977	JD	Unknown

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
LAW - UNIVERSITY OF OREGON, cont'd.			
COLE, Warren	1979	JD	Unknown
CONNER, Dan	**	JD	Current graduate student
COOK, Greg	1978	JD	Alaska Department of Fish & Game, Juneau
DAVIS, Kevin	1982	JD	Judicial clerk, Judge Skopil, U.S. Court of Appeals, 9th Circuit federal level, Portland, OR (specialty: Columbia River)
DEVINE, William	1981	JD	Unknown
DIALS, William	1977	JD	Unknown
DZIEMAN, Thomas	1976	JD	Jackson County Courthouse, Medford, OR
EKLUND, Bill	1978	JD	Christensen, O'Connor, Johnson & Kindness, Bellevue, WA
EVANS, Martha	1980	JD	Unknown
GRUBER, Robert	1976	JD	Unknown
GUTCHES, Meredith	**	JD	Current graduate student
HERMANN, Chris	1981	JD	Deckert, Price & Rhoads, Denver, CO
HORNSTEIN, Don	1981	JD	Judicial clerk, D.C. circuit
HOLT, Mary Gray	**	JD	Current graduate student
HRIBERNICK, Paul	1980	JD	Sea Grant legal program, Louisiana State University, Baton Rouge
JACKSON, Charlie	1983	JD	Prudential Insurance, sales, Portland
JOCHENS, Ann	1977	JD	Unknown
JOHANSEN, Kenneth	1980	JD	Carlton, Fields, Ward, Emmanuel, Smith & Cotter; FL
JOHNSON, Jeff	1979	JD	Cong. James Jeffords, VT, Washington, D.C.
KAHN, Gary	1981	JD	U.S. Department of Agriculture, Washington, D.C.
KERR, Joanne	1977	JD	Unknown
LANTON, Ed	1978	JD	Unknown
LEEDS, Michael	1979	JD	Unknown
McMILLAN, Hollis	1975	JD	Public defender, Portland, OR
MURAKAMI, Stephen	1979	JD	Unknown
NYE, Dan	1980	JD	Clerk for Judge Belloni
ORMSBY, Marybeth	1979	JD	Unknown
PARRISH, Richard	1980	JD	Nuclear Regulatory Commission, Washington, D.C.
PENFIELD, John	1982	JD	Unknown
PICKFORD, Jo	1975	JD	Attorney for Boise Cascade Corp., Boise, Idaho
REEVES, Marty	1981	JD	Unknown
REEVES, Meg	1981	JD	Judicial clerk, Corvallis, OR
REICH, David	1978	JD	Unknown
SCHROTH, Deborah	1979	JD	Unknown
SEITZ, Michael	1981	JD	Unknown
SHUPE, Steven	1982	JD	National Resource Division, Attorney General, Denver, CO
SPRINGER, Richard	1977	JD	Unknown
STARK, Robert	1979	JD	Unknown
STEFFENS, Claire	1981	JD	State Capitol, Juneau, AK
TAYLOR, Robert	1978	JD	Unknown

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
LAW - UNIVERSITY OF OREGON, cont'd.			
THOMPSON, Glen	1982	JD	Gorlich and Maynard, Norfolk, VA
TOZER, Robert	**	JD	Current graduate student
TITUS, Sue	1979	JD	Unknown
UTTINGER, Louis	1980	JD	Nevada Indian Legal Service, Inc., Caron City, NV
WESTPHALL, Warren	1982	JD	Dickson, Evans, and Esch, Anchorage, AK
WILBURN, Gary	1977	JD	Unknown
WILK, Mark	1981	JD	Unknown
WOLNEY, Mary	1977	JD	Unknown
ZACKHEIM, Ivan	1976	JD	Unknown
MICROBIOLOGY			
GOULD, Rowan	1977	PhD	National Fisheries Research Center, Naval Support Activity, Seattle, WA
GROBERG, Warren	1982	PhD	Fish pathologist, ODFW
HUANG, Manley	**	PhD	Current graduate student
McMICHAEL, John	1974	PhD	Associate professor, Department of Biology, Edinboro State College, Edinboro, PA
NELSON, Jim Steel	1983	PhD	Post doctoral research in Japan
NISHIBUCHI, Mitsuaki	1983	PhD	Post doctoral research, Univ. of Maryland
RANSOM, David	1979	PhD	Oregon Aquafoods, Inc., Springfield, OR
WINTON, James Robert	1981	PhD	Assistant professor, Microbiology, OSU
ZALDIVAR, Mercedes	**	MS	Current graduate student
OCEANOGRAPHY			
AGUILAR, Nicolas	1977	MS	Comandancia General de la Marine Correo Naval, Venezuela
BABA, Jumpei	1980	MS	
	**	PhD	Current graduate student
BARMEIER, Judy		MS	Withdrew from OSU
BATCHELDER, Harold	1980	MS	Current graduate student
BERTRAND, Gerald	1971	PhD	Council on Environmental Quality, Washington, D.C.
BODVARSSON, Gundrun	1975	MS	Working in Taiwan for U.S. government
BRODEUR, Richard	**	MS	Current graduate student
BROOME, Robert	1979	MS	Unknown
BROWN, Robin	1981	MS	Research Assistant for Bruce Mate at MSC, Newport
BUTTLEMAN, Kim			Withdrew from OSU
BUSCH, William	1980	PhD	Unknown
CAPLAN, Ronald			Withdrew from OSU
CARNEY, Robert	1977	PhD	U.S. National Museum, Div. of Echinoderms, Washington, D.C.
CHUNG, Alton	**	MS	Current graduate student
CONNER, Daniel	1981	MS	1000 Friends of Oregon, Portland, OR
CROOM, Miles	1980	MS	NOAA Ship Surveyor, Air Corp, Seattle, WA
DEASON, Elizabeth E.	1975	MS	Graduate School of Oceanography, U. of Rhode Island, Kingston

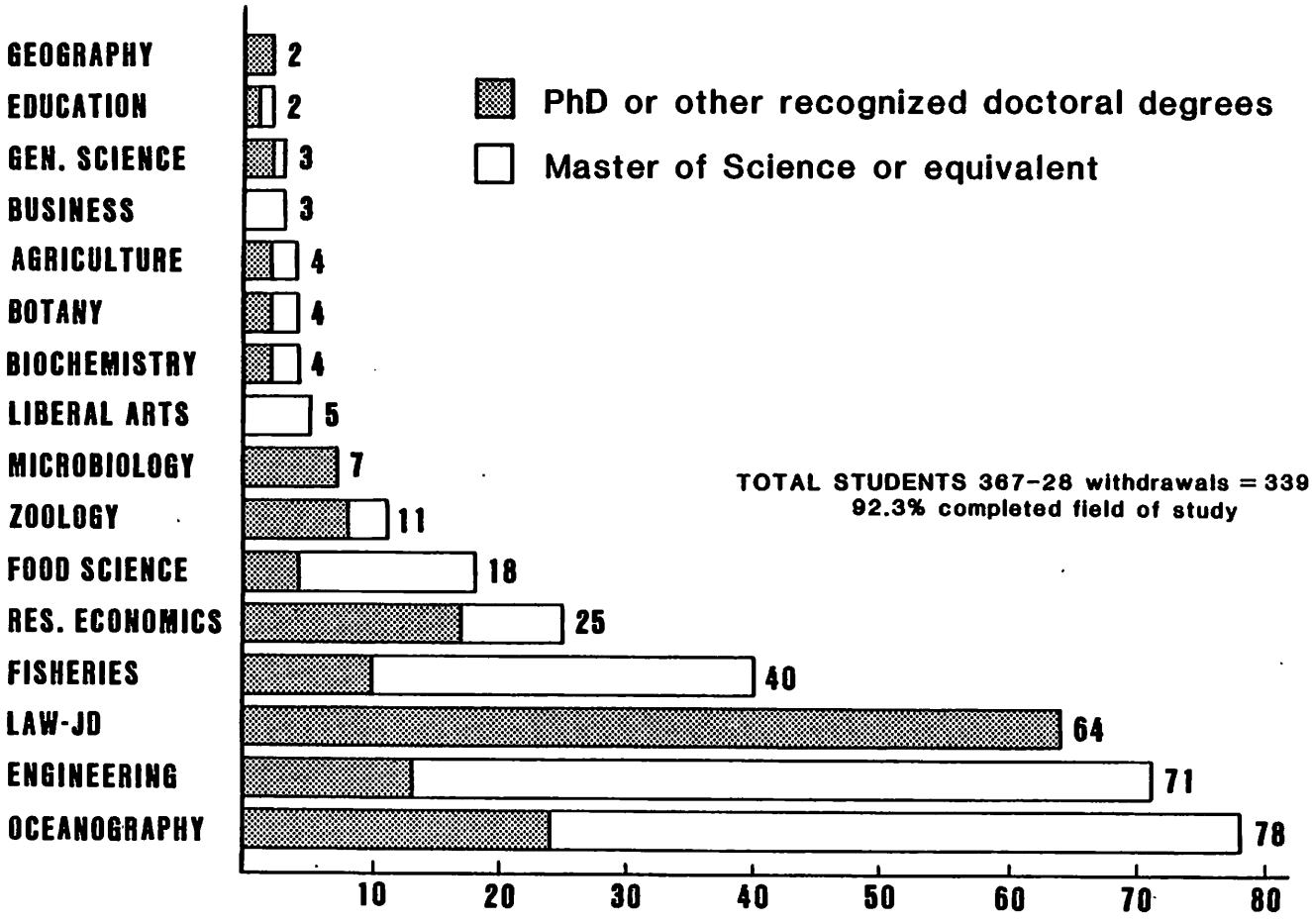
NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
OCEANOGRAPHY			
DeMANCHE, J. Michael	1975	MS	Pacific Marine Environmental Lab, NOAA, Seattle
DEXTER, Barbara	1977	MS	
	1982	PhD	Post doctoral research, SUNY, Stony Brook
DICKINSON, John	1977	PhD	National Marine Fisheries Service, Woods Hole, MA
DONAGHAY, Percy L.	1975	MS	Graduate School of Oceanograhy, U. of Rhode Island, Kingston, RI
ELVIN, David	1975	PhD	Department of Zoology, University of Vermont, Burlington, VT
ELWELL, Terry	1980	MS	Trident Seafoods Corp., Seattle, WA
FARRELL, Joseph	1980	MS	NMFS, Fisheries Development, Terminal Island,
FEDERMAN, Alan	**	PhD	Current graduate student
FREY, John	1974	MS	Unknown
GABRIEL, Wendy	1979	MS	Dept of Fish & Wildlife, University of Massachusetts, Amherst, MA
GADOMSKI, Dena	**	MS	Current graduate student
GARROW, Holly	**	MS	Current graduate student
GAUGHAN, Michael	1976	PhD	Faculty, CICESE, Ensenada, Mexico
GUNTHER, Fred	1972	PhD	Computer Sciences Corp., NASA-GSFC, Greenbelt, MD
GUSHEE, Dean	1983	MS	Current graduate student
HAMMANN, Mark	1981	MS	Universidad Autonoma de Baja California, Ensenada, Mexico
HENDERSON, Curtis	1983	MS	Unknown
HEWITT, Gary	1980	MS	Unknown
HOCHBERG, Ann	1981	MS	Fisheries specialist, New England Management Council, Cambridge, MA
HOGUE, Everett	1982	PhD	Unknown
HOLDEN, Robert	1976	MS	Working in South America for U.S. government
JEFFERTS, Katherine	1977	MS	Unknown
JOHNSON, J. Ken	1981	PhD	Pacific Marine Fisheries Commission, Portland,
KAISER, Rodney	1983	MS	Unknown
KASKAN, Lisa			Withdrew from OSU
KEENE, Donald	1974	PhD	Pacific OCS Office, BLM, Los Angeles, CA
KEMP, Paul	**	PhD	Current graduate student
KIRK, Deborah	1973	MS	Unknown
LAU, Sergio A.	**	MS	Current graduate student
LIZARRAGA, Jose A.	1976	MS	Escuela Superior de Ciencias Marinas, Ensenada, Mexico
LOUGH, Robert	1975	PhD	NMFS, Northeast Fisheries Center, Woods Hole,
MARGULES, Gerturde		PhD	Withdrew from OSU
McDONALD, John	**	MS	Current graduate student
McEWEN, Gail	1979	MS	Tillamook Estuary, Oregon
McFADIEN, Margaret		PhD	Withdrew from OSU
McKAY, Janet	1981	MS	Lane County Planning Commission, Eugene, OR
McKENNEY, Barbara	1977	MS	Current graduate student
McMANUS, John	1978	MS	Unknown

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
SOIL SCIENCE			
COSTA, Robert	1978	MS	County Extension Chairman, Morrow County, Heppner, OR
ZOOLOGY			
ALFORD, David	1974	MS	Current graduate student at University of Hawaii in aquaculture program
ALSPACH, George	1972	PhD	Assoc. Professor, Zoology, University of Western Maryland, Westminster
BREED, Gail	1976	MS	Assistant to the head of Biology, Portland State University
BURRESON, Eugene	1975	PhD	Faculty, VIMS
HANSON, Alfred	1973	PhD	Faculty, Whittier College, Biology, Whittier, CA
HARTMAN, Michael	1972	PhD	Faculty, Florida Technological University, Orlando, FL
MILLER, R. L.	1977	PhD	Unknown
MORRISON, Norman	1974	PhD	Unknown
ROSEBERRY, Eliza	1971	MS	Unknown
ROTHLISBERG, Peter	1975	PhD	Research scientist, Australian CSIRO, Brisbane, Australia
TAKAHASHI, F. T.	1974	PhD	Unknown

**Current student.

NAME	YEAR GRANTED	DEGREE	POSITION/LOCATION
OCEANOGRAPHY, cont'd.			
McMURRAY, Greg	1977	PhD	VTN Oregon, Beaverton, OR
MERRICK, Richard	**	MS	Current graduate student
MILLER, Martin C.	1978	PhD	Science Applications, Inc., Raleigh, NC
MUEHLBERG, Gary	1971	MS	Clatsop Community College, Astoria, OR
MUNDY, Bruce	**	MS	Current graduate student
O'CONNORS, Harold	1973	PhD	Marine Science Research Center, SUNY, Stony Brook
OGLE, Damon		MS	Withdrew from OSU
OLIVER, Brian	1976	MS	Unknown
ORNAF, Gabriel		MS	Withdrew from OSU
PARMENTER, Lytitia	**	MS	Current graduate student
PETERSON, Curt	1983	PhD	Research associate, Oceanography, OSU
PETERSON, Robert	1978	PhD	Science Applications Inc., Boulder, CO
PETERSON, William	1980	PhD	Marine Science Research Center, SUNY, Stony Brook
PINEDA, Elpidio		MS	Withdrew
PISIAS, Niklas	1974	MS	Assistant professor, OSU, Oceanography
RATTI, Frank	1978	MS	ODFW, Charleston, OR
REA, Campbell	1975	MS	Department of Environmental Sciences, University of Virginia
REID, Jack W.			Withdrew from OSU
REIMERS, Claire	1981	PhD	Marine Biology Research Division, Scripps Institute of Oceanography, LaJolla, CA
ROFFE, Tom	1980	PhD	Student, Veterinary Medicine, Washington State
ROGERS, Martin C.			Deceased
ROGERS, Robert	1979	MS	Ball Bros Seafood Inc., Anchorage, AK
ROHRBERG, Vicki	1980	MS	Tetra-Tech, Corvallis, OR
ROSE, Robert	**	MS	Current graduate student
ROSENBERG, Andrew	1980	MS	Unknown
ROUSH, Robert	1970	MS	NOAA-MESA, SUNY, Stony Brook, NY
SCHONZEIT, Michael	1973	MS	Scripps Institution of Oceanography, LaJolla, CA
SHENKER, Jonathan	**	PhD	Current graduate student
SMITH, Scott E.	1983	MS	Oregon Department of Energy
SOLON, Edwin Mark	**	MS	Current graduate student
SUELZE, Kim	1978	MS	Northern Icicle Seafoods, Petersburg, AK
SULLIVAN, Barbara	1977	PhD	Harbor Branch Foundation, Ft. Pierce, FL
TEMTE, Jonathan	**	MS	Current graduate student
TESTER, Patricia	1976	MS	Unknown
THOMPSON, Michael	1981	MS	Unemployed
TURNER, James	**	MS	Current graduate student
VANDERHART, Archie	1976	MS	Enrolled in theological seminary
WAKEFIELD, W. Waldo	**	MS	Current graduate student
ZAKAR, Karen		PhD	Withdrew from OSU
ZIMMERMAN, Steve	1972	PhD	NMFS Research Lab, Auke Bay, AK

OSU Sea Grant College Program 1968–82
Students Supported by Area of Study



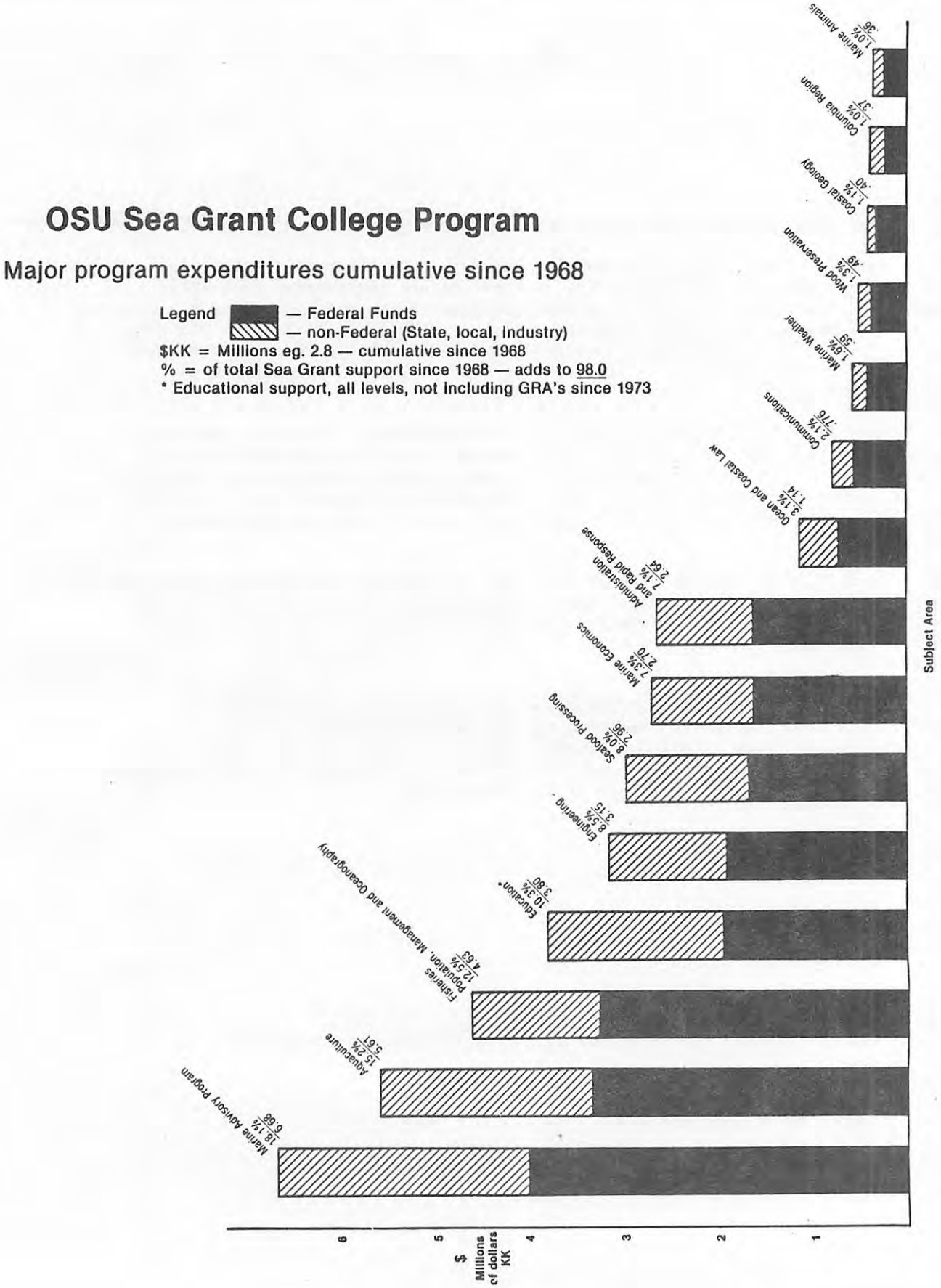
Publications

Sea Grant has always encouraged its investigators to publish their Sea Grant-sponsored work in professional journals before considering some other avenue of publication. Besides lending prestige to the research, journals reach more professional colleagues than do most other kinds of publication. In the past 15 years, our researchers have published nearly 500 journal articles about their Sea Grant-funded work. In most cases, Sea Grant has assumed the page charges and bought and distributed reprints.

Occasions arise in which a journal is not the most appropriate vehicle for publishing research. A full description of the research may be too long for inclusion in a journal. A paper may be an interim report--significant enough to go to press, but too inconclusive for publication in a journal. Or, it may be desirable to disseminate research results more quickly than is possible in a journal.

In such cases, Sea Grant Communications publishes the information in a form most appropriate to the material and the intended audience. Since the program began, we have produced 230 works in various formats—for example, technical reports, handbooks, bibliographies, leaflets, proceedings, and teacher's manuals.

Some works, aimed at a very limited audience, have a small press run. Others, such as the 89 technical and special reports we have produced, are distributed far more widely (we usually print 300 to 400 copies). Still others, such as teacher's manuals, although written for a few readers, ultimately bring to many people a keener awareness of the marine world.


OSU Sea Grant College Program
Major program expenditures cumulative since 1968
Legend
— Federal Funds
— non-Federal (State, local, industry)
$KK = Millions eg. 2.8 — cumulative since 1968
% = of total Sea Grant support since 1968 — adds to 98.0
* Educational support, all levels, not including GRA's since 1973
Marine Advisory Program
16.1%
6.68
Aquaculture
15.2%
5.61
Fisheries Population, Management and Oceanography
12.5%
4.63
Education*
10.3%
3.80
Engineering
8.5%
3.15
Seafood Processing
8.0%
2.96
Marine Economics
7.3%
2.70
Administration and Rapid Response
7.1%
2.64
Ocean and Coastal Law
3.1%
1.14
Communications
2.1%
.776
Marine Weather
1.6%
.59
Wood Preservation
1.3%
.49
Coastal Geology
1.1%
.40
Columbia Region
1.0%
.37
Marine Animals
1.0%
.36
Subject Area
$ Millions of dollars KK
6
5
4
3
2
1