WASHINGTON SEA GRANT PROGRAM

WSG-PM 75-1

A REPORT ON THE WASHINGTON SEA GRANT PROGRAM
FOR JANUARY 1, 1974 - DECEMBER 31, 1974

DIVISION OF MARINE RESOURCES
UNIVERSITY OF WASHINGTON 98195

Prepared under the
National Sea Grant Program

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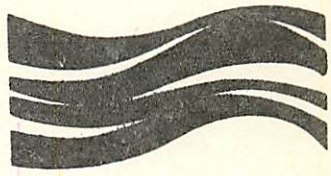

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WASHINGTON SEA GRANT PROGRAM

Director	Stanley R. Murphy, Director Division of Marine Resources
Assistant Directors	John Dermody, Assistant Director for Operations
	Alyn C. Duxbury, Assistant Director for New Programs
Advisory Services	Robert E. Harris, Manager Marine Advisory Program

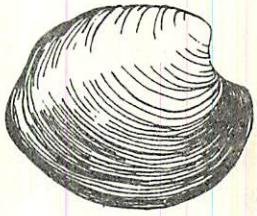
Editor, 1974 annual report	Patricia Peyton, Communications Coordinator

In 1974, Washington Sea Grant was supported by grant number 04-3-158-42 from the National Oceanic and Atmospheric Administration and by matching funds from State of Washington sources.

The University And The Marine Community

With its passage of the National Sea Grant College and Program Act of 1966, Congress initiated a united effort to develop the nation's marine resources by establishing a unique partnership involving educational institutions, federal and state governments, and industry. Provisions of the Act called for the creation of Sea Grant colleges, and in September 1971, the University of Washington was designated one of the first four Sea Grant Colleges in the nation.

In Washington, a state-wide Sea Grant program administered by the University serves the marine community through programs in research and development, education and training, and advisory services. As a recipient of Sea Grant support, the Washington Sea Grant Program must match federal funds it receives from the National Oceanic and Atmospheric Administration on a one for two basis. This calls for coordination with other programs on state, academic, and industrial levels, and requires the active involvement of many people in the planning and operational processes.



The resulting combination of effort is one of the unique aspects of Sea Grant and is an approach to marine resource development which is making a significant impact upon the needs of the marine community. In the chapters which follow, those needs which were addressed by Washington Sea Grant in 1974 are outlined and results reported.

CONTENTS

Providing Useful Information For The Marine Community

- *Where do citizens and legislators go for reliable information about the environmental or economic effects of pending marine legislation?*
- *How can a small commercial seafood processor be certain that temperatures of frozen fish shipments remain constant?*
- *Can the nutrition needs of low-income citizens provide new markets for commercial fishermen?*

On a day-to-day basis, these are the kinds of practical questions confronting Washington's marine business community, the state's elected officials, and its private citizens. Answers may be available at the University of Washington. After all, most people in Washington have heard that the university has some of the world's best known marine experts on its faculty and staff.

But practically speaking, how does a Bellingham seafood processor or a concerned resident of that port city find "the" expert in that large and complex university 90 miles south in Seattle? Even if "the" expert can be found, how can he take time from his or her ongoing teaching and research to provide answers which require appreciable time and effort?

A good place to begin such an inquiry is with Washington Sea Grant's marine advisory program. That program doesn't guarantee answers to all the questions which come its way. There is just so much that four marine advisory specialists and field agents, a part-time economist, and one information specialist can do in days that are 24 hours long. Nevertheless, this competent and enthusiastic group does promise to listen and acknowledge the questions which come their way and to provide ready answers when possible. If ready answers are not possible, they usually know whom to contact and can help determine if questions will require in-depth studies.

Moreover, members of the marine advisory staff (now located in offices in the University's Division of Marine Resources, at Grays Harbor College, at Clover Park Education Center, and in 1975 to be located at Bellingham Vocational-Technical Institute as well) can and do provide answers from a growing store of professional knowledge and expertise and from useful advisory publications. Questions requiring expertise outside the specializations of the field team require more time than those related to seafood processing, aquaculture, marine economics, and commercial fishing. But again, Sea Grant's marine advisory staff, as well as its University personnel, are prepared to help seek answers and, where feasible and appropriate, to stimulate practical research projects designed to answer the important, tougher questions. Some of the questions they tackled in 1974 are described in this chapter.

For Fish Farmers

Pen-reared fish are subject to a variety of profit-eating diseases, and during the 1973-74 season, commercial salmon growers in Washington suffered heavy disease losses. In the past, scientists in the University's College of Fisheries had provided information about efficient stocking rates and diets, so once again the growers turned to the University for help. Because a rapid response was needed to the disease problem, Sea Grant personnel in the College of Fisheries and the Division of Marine Resources decided to bring growers together to discuss their problem with the best available people doing research.

So, in April, 1974, Dr. Ernest Brannon, associate professor of fisheries, and Terry Nosho, aquaculture field specialist, organized a workshop to do just that. From across the country, they brought in researchers from universities and federal laboratories to listen to Washington salmon growers and to give them the latest information on preventing and reducing diseases in cultured fish. Representatives from ten salmon farms attended the workshop and had the opportunity to "quiz the experts."

# # #

During the workshop, an interesting thing happened. A number of the growers and researchers expressed their views concerning the benefits to be derived from having an organization of salmon growers. Nosho surveyed the group quickly and learned that there was indeed an interest among salmon-farming companies in Washington in forming an association that would permit ongoing exchanges, deal with federal regulations, and help effect needed legislation. The outcome? Nosho continued to work with the growers, providing liaison, so that their network ultimately resulted in the formation of the American Salmon Growers Association.

Later in 1974, Rep. Rick Smith of Kitsap County attended a meeting of the salmon growers to discuss his legislative bill to permit ocean ranching by private enterprises in Washington State. Subsequently, Rick Smith met with commercial and sports fishing groups to gain citizen input to the ocean-ranching bill, with help from Nosho in arranging these meetings.

Discussions on the ocean-ranching bill immediately brought to light opposition. Commercial fishermen, plagued by poor fish runs and judicial decisions which they felt had an adverse effect on their share of those runs, viewed ocean ranching as yet another threat to their livelihood. The fishermen had many questions about the potential effects of ocean ranching on fish runs and fish markets.

As a tax-supported organization, Sea Grant could not be an advocate for or against the proposed legislation. However, Sea Grant was in a unique position to provide technical and scientific information which the concerned parties could use in reaching a decision on the scope and language of the ocean-ranching bill. Once again, a workshop bringing together the public groups concerned about the issue and the best available University and agency personnel seemed a logical response. Before the workshop, Nosho contacted commercial and sports fishing groups and asked them to outline their concerns so that these could be addressed effectively during the workshop scheduled for mid-December. With the fishermen's input in hand, and help from Dr. Ernest Salo, a professor in the College of Fisheries, a panel of experts was lined up to respond to the questions raised. Then invitations to the workshop were sent to all public groups and officials known to have a stake in the ocean-ranching bill. To ensure an even greater public awareness of the ocean-ranching issue, Sea Grant communications staff helped the team set up a press conference in connection with the workshop.

More than 60 interested people came to the all-day meeting on the University campus. Pointed questions were raised about the potential effects of the bill, and Rep. Smith, who observed the entire proceedings, came away having heard the intensity of the opposition's arguments, and the fishermen left in the knowledge that they had been heard.

Tangible results of the workshop would be hard to quantify. However, it seems clear there was a need for information exchange among these groups. Although the 1975 legislature adjourned with the ocean-ranching bill still in the House Rules Committee, its supporters feel certain a similar bill will be introduced at the next session and are optimistic about chances for passage.

In any event, passage or rejection of this bill was not the aim of the workshop. The purpose was to provide a forum where parties concerned about pending marine legislation could express their views,

get answers to their questions, and provide input for pending legislation. Sea Grant provided that opportunity and at the same time drew public attention to the issues.

In 1974, Terry Nosho also continued to coordinate a cooperative field study he initiated in 1973 to identify the cause of oyster mortalities in Willapa Harbor. Orginally, local oystermen suspected that their losses might be caused by leachate and lignin from a debarking mill at Raymond. But study results indicate that the cause is probably related to bacterial pathogens instead.

Beside providing the oystermen with information about the causes of the Willapa oyster mortalities, the study also produced water quality data that can be used by Pacific County's Department of Public Works and the Washington Department of Ecology.

The study was jointly conducted by Sea Grant personnel in the marine advisory program, in the University's College of Fisheries, and at Grays Harbor College. Also cooperating were members of the Willapa Harbor Oyster Growers Association, the Washington Department of Fisheries, and the Pacific County Department of Public Works.

In a second field study, the aquaculture field specialist helped a group of Lopez Island residents plan and conduct studies of the growth and survival rates for Manila clam seed planted on the island in 1973. The study showed that 15 percent of the clams planted at about 3 mm survived. Because a higher survival rate is desired, Nosho has recommended that larger seed be used in future plantings. However, he cautions that the cost of larger seed should be equated against survival and growth expectations before purchase.

For Seafood Processors

Because a mistake by even one food processor can have serious consequences for the entire industry, most large seafood processing firms employ professionally trained personnel to ensure quality products and compliance with regulations governing the industry. However, small processing plants frequently cannot afford this kind of talent.

To help overcome this deficiency, Sea Grant's seafood processing specialist, Robert Palmateer, personally visited most of the smaller plants in Washington to learn first-hand what their needs are. Subsequently, Palmateer developed individual guides for those needing information concerning smoked fish processing and conducted preliminary investigations on control techniques for determining temperature fluctuations in frozen fish shipments.

To extend these individual efforts to the industry as a whole, Palmateer participated in industry-wide workshops on can-seam evaluations, retorting, smoked fish, and plant sanitation. He also assisted the Cooperative Extension Service in presenting workshops for homemakers on techniques for canning seafood safely.

Not infrequently, seafood processors need to build or remodel production facilities to comply with FDA regulations. In the past, the kind of design expertise needed to plan these modifications has not been readily available--even to large processors. In 1974, Palmateer spent considerable time consulting with processors on plans for plant construction. Moreover, Palmateer and an architecture student, Rick Brown, provided major assistance in developing construction plans for the Hydaburg Fish Plant and the Skokomish Fish Plant and did preliminary planning work with the Kotzebue Fish Cooperative. They also assisted the Oregon State University marine advisory program in an evaluation of a Charleston, Oregon, Plant.

# # #

In addition to working with the processors, Palmateer met regularly with representatives of the Food and Drug Administration, the Environmental Protection Agency, the National Marine Fisheries Service, the Occupational Safety and Health Administration, and other industry-related agencies. He also met with industry groups such as the National Canners Association, the Puget Sound Smoked Fish Producers, and fish canner labor unions, thereby establishing an effective communications network between the agencies and the industry--a network which has led to improved relationships among these diverse but related organizations.

For Marine Businesses And Industries

Because the industries with which Sea Grant works require economic information as well as scientific and technical data, the program makes available the services of a marine economist, Dr. James Bray, who divides his efforts among a variety of Sea Grant projects.

At the aggregate industry level, Dr. Bray spent part of 1974 developing and analyzing primary data on Washington's fisheries. The data and analyses will be used by the Washington State Department of Commerce and Economic Development to produce a computerized Washington State input-output model on which state government can frame economic policies appropriate to its resources. Moreover, Dr. Bray performed economic evaluations of industrial and governmental studies on several of the state's marine-related industries and policies: recreation, fisheries, aquaculture, and coastal zone management. At the individual firm and entrepreneurial level, Bray worked with industry to determine the economic feasibility of various proposed private ventures, including possible pen-reared salmon and raft-cultured oyster operations. He also provided ongoing economic expertise for a variety of Sea Grant's educational, advisory, and research efforts.

For Commercial Fishermen

Last year, the National Marine Fisheries Service (NMFS) was asked by the National Advisory Committee for Oceans and Atmosphere (NACOA) to develop recommendations for a national fisheries plan which could be adapted by the federal government to reverse depletion of U.S. fish stocks and to ensure a viable and healthy commercial fishing industry. On the West Coast, NMFS turned to Sea Grant marine advisory programs for help in obtaining input to the plan from industry and others who would be affected.

In Washington, Sea Grant's marine advisory program manager, Robert Harris, and two marine agents, Donald Samuelson, stationed at Grays Harbor College, and Scott Harrington, at Clover Park Education Center, organized meetings with commercial fishermen in five ports: Ilwaco, Aberdeen, Port Angeles, Bellingham, and Seattle. Nearly 400 commercial fishermen and representatives of their industry associations attended those meetings and commented upon a draft outline of a national fisheries plan prepared by NMFS. To facilitate commentary at these meetings, Sea Grant Communications earlier provided copies of pertinent sections of the plan to the National Federation of Fishermen for distribution to the federation's regional members.

Commentary at the meetings was summarized and transmitted to NMFS for consideration in their draft plan. . . Another example of the Sea Grant network in action.

# # #

For several years, Clover Park Education Center near Tacoma has provided an advisory program for Washington's commercial fishing fleet. To provide better service to that fleet last year, field instructor Scott Harrington met with advisory groups in four major port districts--Olympic Peninsula, South Bend, Seattle, and Bellingham--to seek suggestions about topics for short courses, seminars, and workshops.

At those meetings, fishermen told Harrington what their needs were, and in response, he organized ten short courses on requested topics. These courses ranged from fishboat refrigeration to income tax preparation and were presented to the 263 fishermen who enrolled.

Four town hall meetings were set up in the same manner to provide commercial fishermen with information in which they had expressed interest. These meetings were attended by 423 interested individuals--primarily commercial fishermen.

During the 1974 energy crisis, Harrington and the Clover Park staff provided fact sheets designed to help commercial fishermen obtain

fuel necessary to run their boats. They also met with fishing groups to discuss their fuel allocation status and methods of meeting energy regulations to secure fuel allotments.

For Coastal Communities

At Grays Harbor College in Aberdeen, Sea Grant has established a marine advisory center which serves Washington's Pacific Coast communities. Directed by Dr. John M. Smith, the 1974 program offered those communities a wide variety of advisory services.

Marine field agent Eugene Johnson and his successor Donald Samuelson coordinated workshops and short courses attended by representatives of the area's marine industries. They also worked with the area's small marine business firms to help solve problems, improve methods, and develop better communications between marine resource users and University of Washington researchers.

One of the most exciting projects undertaken by the Grays Harbor staff last year was to assist the local Community Action Program in obtaining underutilized species of bottomfish for its senior citizen nutrition programs. Not only were those citizens provided with tasty, high protein meals at low cost, but local commercial fishermen were also provided with a potential market for heretofore unsalable catches.

To assist in the program's communications effort, staff information specialist Pansy Bray continued to produce *Harbor Tides*, a Sea Grant newsletter for commercial fisheries people in the area. Through *Harbor Tides*, fishermen and others regularly received pertinent information on local, state, and national marine events that were significant to the community.

Another cooperative project undertaken by Pansy Bray was helping the Cooperative Extension Service develop two marine science oriented 4-H camps. If measured by the enthusiasm of the camp staff and the campers themselves, this venture was an especially rewarding one.

For The Public

At the Pacific Science Center in Seattle, a working scale tidal model of Puget Sound designed by University of Washington oceanographer John Lincoln is the main feature of an exhibit designed to increase public awareness of the marine sciences and their application to environmental and marine resource problems. During the summer of 1974, when more than 120,000 people visited the Center, approximately 300 demonstrations were presented. These 15-minute demonstrations centered on the dispersion of heated water from proposed thermal power plants and, by means of dye injected into

the model, showed visitors how thermal effluent at various sites might be dispersed and transported in the Sound by tidal currents.

In response to the public's interest in Puget Sound and the model, countless informal demonstrations were also given, as were formal lessons for school classes visiting the Center. The staff also presented programs to local sailing enthusiasts, and a group of graduate students from the University used the model in conjunction with a site evaluation study of super ports in Washington.

In order to make information about uses of the model as an analytical tool widely available, Lincoln produced a short film entitled *Oceanography and the Puget Sound Model*. In it, he explained how oceanographers can use the model to predict the movement of materials discharged under various tidal conditions in Puget Sound. To produce the film, Lincoln assembled an assortment of both black and white and color footage from University film files. Despite its "low budget" format, the film has frequently been requested by environmental planning agencies and schools across the nation. Heavy usage of this film has necessitated several prints to meet the demand.

Developing Manpower To Meet National Needs

A renewed concern for the nation's marine and coastal resources has created a need for men and women with educational backgrounds in marine sciences and related social sciences and technologies. To help meet these national and regional manpower needs, Washington Sea Grant supports development of necessary career-related courses at the University of Washington, at four of the state's community colleges, and at one of its vocational-technical institutes.

. . . At The University Of Washington

Fisheries Management

Effective management of the nation's fisheries requires resource agencies with personnel competent to assess the size and distribution of aquatic stocks. At the University's College of Fisheries, Professor Ole Mathisen offers a course on methods of assessing fish stocks. In his graduate course, Dr. Mathisen trains students in the use of echo soundings and other acoustic tools and techniques for estimating the size, distribution, and identification of fish stocks.

In addition to this innovative university course, Sea Grant also supports short courses and extension courses for professional personnel in fisheries management agencies. In October, 1974, some 40 participants from Washington, Alaska, and British Columbia assembled at the University's Lake Wilderness conference center for a two-day course on the economics of salmon management.

And in February, a one-week extension course on salmon nutrition was given for hatchery personnel of the State of Washington Department of Fisheries. This extension course is the first of a series spanning three years, which will cover various topics related to hatchery operations.

An annual highlight of Sea Grant activities in the College of Fisheries is a series of guest lectures by internationally prominent scientists in the field of fish populations. The 1974 lectures were presented by Dr. W.E. Ricker, former editor of the *Journal of the Fisheries Research Board of Canada*, whose series was appropriately entitled: "Footnotes on Population Dynamics."

Marine Resources Economics

Because there has long been a need for a course dealing in depth with economic problems in the development and management of marine resources which would be open to students from disciplines other than economics, Dr. James A. Crutchfield, professor of economics and public affairs, and Robert M. Stokes, lecturer in the Institute of Marine Studies, developed just such a course and taught it for the first time last year.

The new course is designed to meet the needs of three groups:

--graduate students in fields other than economics who need some basic economic concepts and techniques to apply to their own resource management problems

--senior students in a number of marine-related disciplines

--government officials with scientific or engineering backgrounds who are directly concerned with marine resource management

Primary emphasis is on giving students basic technical economic capability required to deal with important issues in public policy in marine affairs. The first quarter of the course provides a detailed examination, at a sophisticated level, of basic micro-economic theory related to uses of the sea. The remainder of the course utilizes these tools to deal with a series of important public policy areas. In 1975, these included national and international marine fisheries, offshore oil, marine-based recreation, and coastal zone management.

Response to the first offering was excellent--19 students registered, from various disciplines including law, economics, engineering, fisheries, and oceanography.

During the course it became apparent, however, that the necessary depth and range of coverage could not be achieved in one quarter. Accordingly, Crutchfield and Stokes are developing course outlines, syllabi, and reading materials for a two-quarter course which will expand the introductory theoretical section and increase the depth and number of case studies considered.

Ocean Systems Design

Design of modern marine facilities inevitably involves the work not only of engineers but also of economists, planners, and systems specialists. To help students acquire the skills needed to achieve design goals while working with experts from diverse fields, Sea Grant supports an ocean systems design course in which students annually produce a new preliminary design for a marine facility.

Last year, Professor Karl Vesper charged his class with designing a recreational boating facility compatible with its environment yet flexible enough to adapt to sites not suited for conventional marinas. The students responded with a preliminary design for a floating modular marina which provides not only moorage and launching facilities, but also living quarters, shops, parks, and other recreational spaces. Their plan also included ancillary services such as parking (inside the floating modules), sewage treatment, and other utilities.

According to Dr. Vesper, the student-planned system could provide additional recreational boating moorage for an area running short of such capacity and would be suited to unconventional deep-water sites. Because the floating modules do not restrict flow of currents underneath, there is less tendency for siltation and less interference with fish migrations which follow the shore and better flushing than in conventional marina designs. Another plus for the student design is that the marina can be simply moved to another site in contrast to conventional marinas which are permanent installations.

Results of the students' work were compiled into a report of preliminary design concepts and quantitative analysis, including cost data and were presented in a public meeting.

Law and Marine Affairs

The legal framework needed for continued development of marine resources with due regard for preservation of the marine environment requires the services of lawyers whose training includes both relevant legal subjects and knowledge of the marine environment. Graduates of the Law and Marine Affairs course of study in the University's School of Law are helping provide those services.

In June, 1974, five of the six students receiving LL.M. degrees from this program did so with Sea Grant support. Two of these graduates are now working in the office of the General Counsel, NOAA; two are serving as research consultants on a research project funded by the U.S. Department of State; one is Special Counsel for the Washington State Council on Environmental Policy; and one is continuing graduate work at Cambridge University in England.

Sea Grant support for this emerging program did not stop with these student assistantships, however. Because this is a relatively new field, teaching materials must be developed, so last year funding was provided for a new course on the law of the coastal zone. This work was performed by two lawyers doing graduate work in Law and Marine Affairs and by one undergraduate who will continue his studies as a graduate student in 1975-76. The course, which addresses the legal background of an increasingly important public interest, was created under the guidance of Professor Ralph Johnson and will be taught by him for the first time in 1975.

Professor Johnson does not limit his expertise in coastal zone matters to his classroom. Since May, 1974, he has chaired a Sea Grant planning committee which is attempting to give direction and to bring coordination to coastal zone research projects throughout the University.

Teaching materials for another course, "International Law of the Sea," previously developed by Professor William Burke, were revised and updated by him to take into account developments at the 1974 Caracas session and the spring 1975 Geneva session of the Law of the Sea Conference. The 1973 edition of these materials has now been authorized for use in other law schools including the University of Miami, the College of William and Mary, Gonzaga University, and the University of California (Berkeley). Professors Johnson and Burke have also continued to serve actively as adjunct faculty members of the University's Institute for Marine Studies. The Institute curriculum is an interdisciplinary one providing course work in marine science, fisheries, international relations and other subjects essential to students pursuing graduate degrees in Law and Marine Affairs. Last year, Sea Grant support was made available through the School of Law program for student assistance on two interdisciplinary course development projects in the Institute--one in engineering and one in fisheries.

Program In Marine Affairs

In a two-quarter marine affairs seminar offered by Professor Edward Wenk, Jr., director of the University's Program in Social Management of Technology, students are guided in studying and analyzing typical policy assessment which must be made by marine resource planning and management agencies and which require a basic understanding of related technologies.

Although the primary aim of this Sea Grant-supported seminar is an educational one, student analyses and critiques result in some important public service contributions that can be used by public planning agencies. Last year, individual students not only produced in-depth policy-oriented research reports on a marine issue of their choice, but they also produced a class report on the implications of this state's decision-making capabilities related to possible expansion

of petroleum handling facilities in Puget Sound and coastal Washington. Their findings were presented at a public meeting attended by representatives of the various public and private interests concerned.

Another student report, "Washington Harbors and Regional Facilities (WHARF)," written by the 1973 class, was presented last year to the annual meeting of the American Society of Civil Engineers and was subsequently introduced into the official record of a subcommittee of the Washington House of Representatives. Students from the class also provided testimony for this record.

Moreover, a student report on the Intergovernmental Oceanographic Commission was published by Sea Grant and is being marketed by the University of Washington Press. This report is being used for educational purposes at several other universities and has also been selected for use as a background document by an advisory committee to the Department of State.

Other reports on implementation of the Washington State Shoreline Management Act, citizen participation in shoreline planning, policy formulation for deepsea mineral development, and marine affairs in the United Nations system were completed and transmitted to academic units and public and private agencies with interests in the subject areas. A comprehensive analysis of leasing policy for outer continental shelf lands was initiated as a group project, and it is expected that reports generated in this effort will be submitted to the National Ocean Policy Study and the Congressional Office of Technology Assessment in conjunction with the advisory activities of Professor Wenk.

. . . In Washington's Community Colleges And Vocational Schools

Commercial Divers

Applicants from all over the country now seek admission to the two-year commercial diving and engineering program offered by Highline Community College in Midway. The growing demand for this expanding program is a direct result of the competence of students who complete the program and their success in securing jobs.

Of the 26 graduates in 1974, 25 landed commercial diving jobs and are now located all over North America--from Alaska to Louisiana to New Brunswick. Two are working on a salvage project on the Suez Canal and another on a North Sea operation. Even the sole graduate working outside the diving field got a job--"working on the railroad!"

Peter Williams, master diver and coordinator of the program is convinced that in order to get jobs, people must have the ability to perform these jobs. He views diving as a means of "getting to work," and emphasizes the importance of underwater working skills.

To ensure the dual capacity for diving and working, the first year of classroom training at Highline includes subjects from English and engineering to math and oceanography. Subsequently, specific courses taught at Highline's Redondo Beach pier include basic rigging, hard-hat and lightweight diving, salvage techniques, underwater welding, blasting techniques, mixed-gas diving and diving bell operations.

Although the emphasis of this training program is on producing trained commercial divers, instructors and students last year cooperated as subjects and console operators for a hyperbaric research program conducted at Seattle's Virginia Mason Research Center. They also established a plan to provide for use of Highline's Sea Grant funded diving bell and ancillary facilities for work on deep-ocean, cosmic ray experiments at the University.

Marine Technicians

Worldwide concern for preservation of the environment has created a demand for technicians capable of gathering reliable data on the marine environment and of subsequently analyzing those data in laboratories aboard ship and ashore. In response to this demand, Shoreline Community College in Seattle is training oceanographic and marine biology technicians to fill jobs in a growing marine industrial-regulatory-research complex.

Last year, 24 students completed their marine technician training at Shoreline; of these, 22 found related employment, and two entered college. Furthermore, John C. Serwold, director of the program, reports that more than 100 students were placed "on-the-job" with researchers from NOAA, the University, Seattle's Metro, the Environmental Protection Agency, and private industry.

In addition to taking basic classroom courses, students gain valuable research experience in Shoreline's field courses. In 1974, 30 students were actively involved in a benthic baseline study of Puget Sound. Results of this effort were presented at a regional marine estuary conference at Oregon State University. Subsequently, the Corps of Engineers contracted with Shoreline's marine staff and technicians to conduct a baseline study of Elliott Bay, and similar contracts have been made with Metro and the University.

Vessel Operators

Training engine-room personnel for sea-going vessels is the main thrust of an industry-applauded technician program offered by Seattle Central Community College in a shipboard and classroom facility located on Salmon Bay.

Last year instructors Donald Smith and Kenneth Dahlgren also instituted five extra deck seamenship classes for ordinary seamen who wanted to reach able-bodied seaman status. Smith and Dahlgren recognize that such specialized training not only enables individuals to upgrade themselves but also helps meet industry's immediate needs. Nearly 100 students were enrolled in these upgrading classes which enabled the men to obtain their A.B. endorsements and to sit for lifeboatmen's tickets as issued by the U.S. Coast Guard.

Until 1974, the engines used for the diesel training program were acquired exclusively with Sea Grant funds. But success of the program attracted industry attention and last year six technical engines classes were offered to 72 students for which industry provided not only a specific make (General Motor or Caterpillar) of diesel engines but a factory instructor as well.

Smith and Dahlgren consider these classes of enormous benefit because they cover operating instructions for equipment students are likely to find aboard vessels. They also encourage involvement

of equipment suppliers, maritime unions, and employers in a training program which needs to be responsive to industry's manpower needs.

Keeping an eye on those needs, the instructors have laid groundwork for an oil tankermen training program. Employment prospects are promising for trainees in this area because of increased movement of oil anticipated from the Alyeska pipeline. First classes are scheduled for fall 1975 and will be open initially only to people already employed in the industry.

Overall employment prospects for students completing the full-day associate-degree program remain good. Although the fishing industry looks spotty, qualified students are finding employment. Manpower needs of the tugboat segment are being met mainly though SCC's upgrading classes and the expanding state ferry system in Washington and Alaska are continuing to offer opportunities for this program's students.

Grays Harbor Investigations

Investigations supported by Sea Grant at Grays Harbor College serve a dual purpose--to gather and analyze relevant data on significant local marine problems while providing students with meaningful training and field experience. Co-investigators John M. Smith and Louis Messmer pool their expertise in accepting projects and designing programs whose completion will have a measurable value to the local community, partcipating students, and other researchers.

Major 1974 investigations involved the completion of an oyster mortality study, the continuation of baseline water quality data collections, and the initiation of a salmon-rearing project.

Undertaken at the request of, and partially financed by, Willapa Bay oyster growers, the oyster mortality study attempted to find causes of perennial oyster kills in the bay. Specific water quality parameters of the upper bay were measured on a regular basis by eight student technicians who recorded their data and helped investigators analyze the interrelationships observed. This effort complemented that of Sea Grant's advisory service study on oyster mortality.

Student technicians also conducted weekly baseline data surveys at two estuarine and three ocean stations. Information collected by the students aids local users including the Washington Department of Fisheries, the Port of Grays Harbor, and the Corps of Engineers. The data are routinely transmitted to NOAA's National Oceanographic Data Center where they are readily available to others.

Commercial Fishermen

At Clover Park Vocational-Technical Institute in Lakewood Center near Tacoma, Sea Grant provides equipment needed in a class designed to give student skills required to become viable crew members aboard commercial fishing vessels.

In that course, field instructor Scott Harrington offers practical instruction in the five basic fishing techniques used on the West Coast: trolling, purse seining, dragging (otter trawling), long-lining, and pot fishing. Success of the course can be measured by the fact that all students who completed this course last year found jobs in the commercial fishing industry.

A problem which hampered this program earlier was lack of actual fishing experience for students. The problem was solved during the 1973-74 school year when Clover Park leased a 58-foot commercial fishing vessel for seven months and actually fished, and with students as crew. Income earned by the boat was re-invested by the class. The class is divided into three groups, with each group spending every third week aboard the vessel actually fishing. This vocational approach to training provided each student with classroom instruction, laboratory time for fishing-gear construction and repair, and actual "hands-on" experience.

. . . the depletion of the ocean's resources

. . . the degradation of the marine environment

The phrases are familiar ones. Not a day passes without a news story or television commentary covering some aspect of these alarming results of overexploitation and pollution. What evidence Americans do not read or hear about they can offtimes see for themselves.

As for most problems of such magnitude, solutions are complex, long-term, and have many beginnings. This chapter tells about such a beginning.

Assessing The Ocean's Resources

Effective management and preservation of marine resources begins with an assessment of those resources. Since the early 1930's, fisheries biologists and oceanographers at the University of Washington have been routinely collecting and cataloging environmental data which are now providing resource management agencies with the baseline information necessary to long-term planning. With the advent of the Sea Grant program at the University in the late 1960's, funds became available to expand that data collection in several instances; to publish much of it in the form of indexes, atlases, and checklists; and to develop improved methods for data collection and analysis.

# # #

Assessing the ocean's fishery resources is a formidable task, but one which has been greatly facilitated by breakthroughs of Washington Sea Grant's Marine Acoustics Program. Although sonic instruments have been used to detect schools of fish for nearly 40 years, it was not until the decline of world fish populations was recognized in the mid-1960's that the full potential of hydroacoustic assessment was recognized. At that point, scientists began to examine acoustic methods not only as a means of detecting fish but of measuring their abundance as well. Their aim was to provide the population data

needed to formulate rational schemes for preserving stocks at levels which had previously permitted annual world catches of around 65 million metric tons.

The first instruments developed in response to this pressing problem provided a preliminary measure of success; however, they had their limitations. One, a pulse counter developed in the United Kingdom, worked well for assessing individual targets but not the biomass. Another, a Norwegian analog integrator, gave a measure of the biomass, but it proved difficult to calibrate. Though still in use, it is limited to operation on only two depth channels.

When a Sea Grant program was instituted at the University of Washington in the late 1960's, funding became available for further development. Under the Sea Grant umbrella, an interdisciplinary marine acoustics team was organized which linked long-standing expertise in hydroacoustic engineering at the University's Applied Physics Laboratory with that in fisheries assessment and management in its Fisheries Research Institute.

Taking advantage of mini-computers just entering the market, the team quickly produced an improved and economical instrumentation system for acquiring and processing acoustic data. The system now has the capacity to determine not only the density and depth of a population but also the size distribution of individual acoustic targets--an aid in determining size of fish within a target.

Last year, the team continued both theoretical studies and field assessment work with these results:

- Dr. John Ehrenberg and Dr. William Acker initiated a study in the Applied Physics Laboratory on acoustic scattering in high density fish populations. Their purpose is to provide techniques for acoustically estimating the abundance of very high density fish populations. One potential application may be determining efficient daily food rations for stocks raised in aquaculture projects.

- Acoustic surveys of herring stocks in Puget Sound conducted by Dr. Richard Thorne and his associates from the Fisheries Research Institute will be the principal basis for herring-fishing quotas set this year by the State of Washington Department of Fisheries. Last year, this fishery had an ex-vessel value of about $2 million. The surveys indicated that the largest concentrations of herring were to be found in four areas: The Gulf of Georgia, 27 million pounds; Carr Inlet, 12 million pounds; lower Hood Canal, 15 million pounds; and Protection Island, 11 million pounds.

- An interesting side aspect of these herring studies has been the documentation of a fourfold increase in the nuisance dogfish population of southern Puget Sound during the past three years.

- Since 1969 acoustic surveys have been conducted annually on the hake population in Port Susan and vicinity. A hake biomass of 62.2 million pounds, including 19.0 million pounds in Port Susan, was observed during the survey in February, 1974. This population was the largest observed since 1971 and relieved fear of a population decline of this resource.

- Since 1971, Dr. Thorne's team has cooperated with biologists from the Alaska Department of Fish and Game (ADF&G) on surveys of herring throughout southeastern Alaska. Last year, surveys were conducted in twelve areas, and indicated that the largest herring population--11 million pounds--was located in Lisianski Inlet.

- Besides helping ADF&G with the herring survey, the marine acoustics team built a second acoustic assessment system for installation aboard that Department's research vessel *Montague*.

- Because of many dwindling salmon runs, increasing effort is being devoted to enchancement programs for these stocks. For sockeye salmon in Bristol Bay, these programs might take the form of increasing fry production by hatchery operations or in spawning channels. However, any increase in juvenile stocks must be matched against the production potentials of the nursery areas. Last year, Dr. Ole Mathisen, professor in the Fisheries Research Institute, directed acoustic surveys of the nekton population in four lakes in Bristol Bay. The acoustic estimates which resulted have provided ADF&G with a ranking of four major sockeye nursery areas. This work has formed a basis for future rational enchancement programs where the investment is measured in millions of dollars compared with a $10,000 cost of acoustic surveys.

- Equipment developed by marine acoustics experts at the Applied Physics Laboratory program is being used by scientists studying coastal upwelling off Baja California and Northwest Africa. This study is sponsored by the National Science Foundation as part of the Coastal Upwelling Ecosystem Analysis (CUEA) segment of the International Decade of Ocean Exploration.

# # #

For many years, the sockeye salmon run in Lake Washington has provided significant catches for sportsmen and Indian gillnetters, but during the last decade this run has varied tremendously--between 135,000 and 560,000 sockeye annually. Dr. Robert Burgner, director of the Fisheries Research Institute, and Dr. Stephen Mathews, are directing an assessment study whereby long-range forecasts of this and other Pacific salmon runs can be made to enable improved stock management and allocation of catch to stabilize the population.

To achieve this goal, investigators "count" the lake's juvenile smolt population by means of midwater net hauls which are correlated with data from simultaneous echo soundings. The smolt estimates, now conducted for six years, plus measurements of marine survival provide a means of forecasting adult sockeye runs two years in advance. The Washington Department of Fisheries relies on this information as one basis for deciding how this salmon resource will be allocated. The study also contributes useful information for regional planning of the water resources of the Lake Washington drainage basin.

Another goal of this project is to develop a management model in which catch levels and economic returns for each lake fishery can be simulated under varying fishing efforts and spawning population levels. Toward this end, investigators last year compiled economic data on the harvestable stocks. Results of the study will be reported in a dissertation scheduled for completion in 1975.

# # #

Producing a useful and detailed reference book on Puget Sound fishes has been a life-long ambition of Dr. Allan C. DeLacy, professor emeritus of fisheries. With the careful assistance of Dr. Bruce Miller and the financial support of Sea Grant, that ambition is nearing fruition. The published work, which is expected to parallel the landmark, *Fishes of the Gulf of Maine,* will include information on the identification, distribution, relative abundance, basic ecology, and ecological life history, and the importance of each species of Puget Sound fish.

Because information of this type is in such great demand, Drs. DeLacy and Miller have already made a good deal of preliminary data available to the public. In 1972, they prepared a *Checklist of Puget Sound Fishes,* which was published by Sea Grant and for which there continues to be a steady demand.

Last year, this team compiled a detailed atlas of Puget Sound fishes which includes for each of the 215 species a distribution map showing the location of each record for that fish and a separate listing of every available record--both published and unpublished--which they were able to uncover. The atlas is available to users in the reference

library of the State of Washington Department of Ecology and in the University's Fisheries-Oceanography Library. The two have also completed and published reports on nearshore fish surveys conducted for the Washington Department of Ecology and the Municipality of Metropolitan Seattle (METRO--local sewage treatment agency). These field studies are useful in assessing the importance of the biological populations of the nearshore environment where effects of man's activities are particularly noticeable.

# # #

Since the early 1930's, oceanographers at the University of Washington have been routinely gathering and cataloging data on the marine environment of Puget Sound. With support from Sea Grant, Eugene Collias, Noel McGary, and Dr. Clifford Barnes of the University's Department of Oceanography have compiled a large body of physical and chemical oceanographic data on Puget Sound and its approaches to produce an atlas which was published last year by Sea Grant and marketed by the University of Washington Press.

The atlas displays graphically six water-quality parameters along eight vertical profiles through Puget Sound and is providing useful information for agencies making decisions which require an understanding of the physical and chemical characteristics of Puget Sound.

With the completion of the atlas, the oceanography investigators redirected their efforts to a study of the effect of meteorological conditions upon water levels. Purposes of the study are twofold: (1) to determine the changes in water level caused by the long-period changes in weather patterns, and (2) to determine the short-term effects of storms and the associated abrupt changes in excess of predicted tide heights.

A long-period change in mean sea level occurs that is directly associated with the seasonal changes of coastal winds. The storm effects have been shown to cause a change of as much as three feet over predicted heights. This information, coupled with wave height data, will be especially useful in the design of seawalls for protection of beaches and for installation of piers.

# # #

Garrison Bay is a small bay in the San Juan Archipelago--part of which is a national historical monument called English Camp. When the National Park Service bought the land from private owners, there were significant clam stocks present. However, unrestricted public use depleted those stocks.

Dr. Vincent Gallucci, an assistant professor of fisheries, undertook a project which has already aided in the partial recovery of clam

stocks on Garrison Bay beaches. Because public cooperation was a must if the work was to succeed, Dr. Galluci and his associates provided the San Juan Island newspaper with information about the life histories of clams. Through the paper, they also suggested proper digging techniques and explained the reasons behind regulated closings of beach areas. Further, they helped the National Park Services prepare an illustrated leaflet on Garrison Bay clams and ways to dig them with minimal damage. The leaflet is being distributed to park visitors.

Dr. Gallucci also cooperated with personnel from the Department of Fisheries in sampling clam beds before and after they were dug by the public. On the basis of this sampling, he assisted the Department in making decisions about selective closures of areas to prevent overharvesting.

Futher, Dr. Gallucci studied growth rates of the Garrison Bay clams, compared seasonal survival rates, and developed a more efficient clam-sampling technique which may be applied to other beaches. His findings and this new technique have been the subjects of several soon-to-be published scientific journal articles. These efforts have resulted in greater public awareness and appreciation for this public clam resource and in partial recovery of that resource through proper management.

# # #

Gathering and cataloging environmental data are merely the first steps in the wise management of marine resources. Beyond these steps, resource managers need efficient methods for analyzing and interpreting data and weighing them against other factors which have a bearing on a regional environment.

To this end, investigators on project NORFISH, directed by Lewis Bledsoe and Stephen Mathews, are working to increase the efficiency of those who monitor and manage Northeast Pacific fisheries and other coastal zone resources by using computers. Their goal is to provide managing biologists not only greater access to environmental data and methodology for interpreting these data, but also more time and money for biology.

Last year, project investigators provided Washington trawl fishery managers with the means to reduce the cost of data retievals that they need to do every day. As an example, they reduced the time for a typical retrieval from five man-hours to one man-hour and the cost from $20 to $1.

This year, investigators are concentrating upon standardization of groundfish data collection and storage procedures in all the Pacific Coast states, thereby making it easier for the states to meet future federal and international data requirements. In future years, NORFISH efforts will focus on greater efficiency in data reporting for a variety of Pacific Coast fish species.

A further example of NORFISH's computer-use project is in the area of fishery data-display. Last year, several atlases of Bering Sea catches were put out in cooperation with the National Marine Fisheries Service, and these atlases have attracted requests for consultation from fisheries scientists all over North America.

Another major thrust of NORFISH activity has been the implementation of a broad ecological systems approach to fishery questions. For instance, a major Washington salmon model was tuned in 1974. The model enables a fishery manager to estimate the short- and long-term effects of complex regulations. For instance, it can answer questions like, "What are the best estimates of the five-year impact on salmon gillnetters if the size limits and season lengths of the troll fishery on the same species are varied?" Such questions are complicated by factors like a low survival rate of fish that are caught and then thrown back because they are too small.

Because of the model's ability to sort through and assess a combination of factors relevant to such complex problems, modelling is a promising scientific tool. Modelling techniques are new, however, and many people do not yet fully understand their utility. Hence, investigators must try different modelling techniques in the attempt to make them more usable in the fisheries context.

Therefore, in 1975 and 1976, investigators will be applying some newer techniques to a major study of the complex dynamics of Northeast Pacific fisheries and the relationships among concerned nations; among species; among gears; between areas and ports; and among biology, economics, and regulations.

One of Congress's mandates to Sea Grant is that this university-based program devote a part of its effort to helping develop the nation's marine resources. Within the Washington Sea Grant program, there are several projects fulfilling that mandate. Through one of these, a professor is working with the commercial fishing and seafood processing industries to develop new methods for using waste fish. In another, scientists are examining a variety of marine sources for industrially valuable polymers, and in a third effort, these polymers have been made available to researchers worldwide for testing a wide range of potential applications. Finally, researchers are studying the properties of two common marine creatures--the jellyfish and the sea mussel--for their use in clinical research and in everyday medicine and dentistry.

Developing Commercial And Clinical Uses For Marine Resources

George Pigott despises waste, so his efforts as a professor in the Institute for Food Science and Technology have been directed for a number of years toward a Sea Grant project he describes as a total utilization concept (TUC). Through the TUC program, Pigott and student researchers working with him are developing processes which can utilize the tons of incidental fish catches dumped overboard annually by commercial fishing fleets.

Pigott's ultimate goals are twofold: (1) to provide the fishing industry with an efficient, economical (and possibly shipboard) process for extracting usable protein from "trash" fish and (2) to develop salable products which utilize that protein.

Last year, TUC scientists completed research on the interaction of lipids (fats) and protein during the extraction process. They found that during the aqueous extraction phase, many of the previous techniques used in processing fish and fish waste for fish protein concentrate (FPC) actually increased the ability of protein to

interact with and tie up lipids. This lipid-protein interaction work has been reported in three technical papers and a Ph.D. thesis and has had considerable impact upon groups studying this interaction. The process is expected to be in pilot plant operation in 1975.

Another major accomplishment of this program during 1974 was the implementation of studies to formulate fish protein products, to determine the shelf life of those products, and to develop economical commercial processing procedures. As evidence of success in this area, one local food company (not currently in the seafood business) was so impressed with a project-formulated smoked fish additive that company managers are negotiating a contract with the Institute to develop this product for large-scale commercial sales.

A third phase of the 1974 TUC program centered around research on an enzyme hydrolysis extraction process for the production of high-quality FPC. Here, the TUC program has resulted in a number of valuable spin-offs. Not the least of these is the training of students for jobs in industry. Last year, two students who worked as research associates on the TUC program completed their graduate studies and both found jobs in related fields. One went to work as process engineer for Land O' Lakes, Inc., Minneapolis, and the other joined the faculty of the University of Rhode Island, where he is continuing to work on total utilization of underutilized species of fish.

# # #

- *additive for improving wet and dry strength in paper*
- *coagulant for treating sewage and industral wastewater*
- *binder for nonwoven fabrics*
- *additive for improving printability of paper*

These are but a few of the large-scale commercial uses for polymers, and to help meet the market demand for this valuable material, Sea Grant researchers are studying the potential of various marine sources. The work is being conducted by Dr. Graham Allan and Dr. Kyosti Sarkanen of the University's College of Forest Resources and by Dr. Darrell Medcalf from the Chemistry Department at the University of Puget Sound.

The three, along with student research associates, are attempting to help develop a marine counterpart to the forest-based industry of the Northwest in such a way that this infant enterprise provides unique materials useful to the mature pulp and paper companies.

Thus far, their efforts have played a significant role in the identification of chitosan--a derivative of crab and shrimp shell wastes--as one source of polymers. Not only have their efforts provided the paper industry with an economically and readily available source, but they have also provided means for transforming a former waste into a commercial asset.

As a result, a small-scale chitosan production plant has been constructed in Seattle. Plans for larger facilities in both the Northwest and in Texas are already well advanced, and the latter may be onstream in 1975.

Although initial needs for polymers can be met by available crab and shrimp wastes, which now pose a severe pollution problem around seafood processing plants, ultimately a totally new source will be required. In a recently completed search, the investigators found tiny, culturable marine organisms (diatoms) which grow easily and from which a very pure form of the desired substance can be isolated.

Other types of diatoms have also been cultivated in tanks, and these have been found to contain substances which, in preliminary tests, show promise as thickeners for dressings, jellies, and similar products.

Future efforts of these investigators will emphasize resolution of the practical engineering problems associated with the cultivation of diatoms, so as to make the derived materials available in large amounts.

# # #

Because the potential for industrial use of chitosan appeared so great, the Washington Sea Grant program initiated a unique project in 1972 to make this material available to qualified researchers throughout the world at no cost other than for shipping and packaging. Under the able direction of the Oceanographic Institute of Washington (OIW), this project reached a successful conclusion and was terminated in June, 1974.

During the 30-month program, Sea Grant purchased quantities of chitosan from the Seattle firm of Food and Chemical Research Laboratories, Inc. OIW then provided the financial and employment safeguards normally required in the administration of federal contracts, processed request for samples, and published and distributed literature on the products.

Some 70 orders from university and government researchers and more than 40 orders from commercial laboratories were filled. Requests came from all over the United States and from as far away as Sweden, the Netherlands, Italy, Germany, Chile, and Japan.

The orders indicated the material would be used in experiments for a variety of applications: developing complexes of dyes; coating and encapsulating particles; and acting as a clarifier by removing materials suspended in liquids.

Undoubtedly this Sea Grant effort has stimulated the interest of a variety of industries worldwide in the utilization of chitosan and has afforded the opportunity for developing an economically viable marketplace for a unique product.

# # #

The jellyfish *Aequorea aequorea*, an abundant inhabitant of Puget Sound waters, is the source of a light-producing protein whose unique properties make it an invaluable research tool for detecting free calcium in blood. In the presence of calcium, aequorin emits proportional amounts of measurable light.

Because of this bioluminescing property, aequorin is sought after for medical research and may eventually prove useful in testing for fish freshness. Under the direction of Samuel Felton, researchers in the Fisheries Research Institute are developing this protein both as a detection tool and as a research product for market testing via a commercial chemical company.

Last year, the researchers delivered 100 preps (one prep will contain about 200-400 calcium determinations) at the ammonium sulfate stage to the Sigma Chemical Company. They anticipate that the aequorin will go on the market by mid-1975, along with considerable advertisement by Sigma, and that additional preps will be desired in 1975. During the year, they also reduced by at least an hour the time necessary to extract the protein from the jellyfish and produce the end product.

Ultimately, Felton's aim is to perfect a simple and rapid blood calcium assay test, and he has established ties with researchers in clinical medicine, pathology, and oral biology for budget-limited work in this area. Despite last year's budget constraints, a number of parameters were explored in order to determine whether aequorin's calcium figure in blood approaches that which is found in scientific literature. Felton is currently measuring 1.25 - 1.4 mM of calcium, while the theoretical level is estimated at 1 mM.

Beyond these studies, 1974 marked the production of an ion-free serum which is devoid of calcium. This serum was needed to study intra ion effect on the calcium assay. Felton hopes that as ions are returned to the serum, he will be able to arrive at a real ionized calcium figure for serum.

If this method is successful, the bright glow of aequorin will be seen in clinical laboratories across the country.

# # #

Although buffeted by waves and exposed alternately to salt water, air and sunlight, the common sea mussel (*Mytilus californianus*), found abundantly on the Pacific Coast, remains attached to wet, slippery surfaces. Scientists have long searched for the secret of

the mussel's powerful cementing capacity, for if the components of this biological glue could be isolated, analyzed, and reproduced synthetically, then dentists and physicians would have an adhesive material of great value.

The mussel's foot secretes tough, viscous thread of collagen-like protein. At the end of the threads are discs that attach the threads to rocks or other substrata. By learning the chemical nature of the adhesive disc and how the substances are synthesized and secreted, Dr. Patricia Keller, a professor of oral biology, hopes to learn something about its innate bonding power.

Earlier, Dr. Keller and her associates showed that the glandular tissue of the mussel foot contains three main elements: collagen, phenols, and enzymes. These are believed to be the precursors to the byssal threads and to be stored intracellularly in the mussel foot in membrane-bound granules.

During 1974, attempts were made to isolate these granules by centrifuging, a method of separating the respective secretory granules and sub-cellular structures by density. Preliminary experiments have resulted in a preparation that consists mainly of the so-called "collagen granules" and a few "enzyme granules." High-power electron micrographes show that the preparation is still contaminated with other sub-cellular fragments, so attempts will be made to further purify the granular fraction. After this procedure, it should be possible to determine the chemical nature of the precursor material.

On the basis of histo-chemical evidence, it has been suggested by several investigators that the "enzyme granules" contain polyphenoloxidase which forms quinones, which in turn cross-link collagen molecules to form the insoluble byssal threads. Accordingly, polyphenoloxidase was assayed in homogenates of the byssus-forming glands. A significant level of activity could be demonstrated only after the homogenate had been fractionated by gel-filtration. Therefore, investigators are examining the possibility that the activity is partially masked or inhibited in the tissue homogenate.

In a few short years, man's dream of farming the seas has moved from concept to reality. In Washington, experimental salmon farms are virtually commonplace. And pilot operations have been undertaken by such commercial enterprises as Union Carbide and Weyerhaeuser. Through these and other aquaculture efforts, growers and scientists are hoping to provide commercial quantities of high-quality fish for the American consumer. This chapter outlines Washington Sea Grant research aimed at supporting this effort.

Farming The Seas

Salmonid Aquaculture

In the College of Fisheries, Sea Grant supports aquaculture studies directed at improving regional sport and commercial salmonid fisheries. The program includes cooperative studies with state and federal agencies, native tribes, and private industry. It emphasizes fisheries management, genetics, nutrition, pathology, and behavior.

# # #

Stock development and selective breeding research begun more than 40 years ago by Dr. Lauren Donaldson continue to be integral parts of this program. In 1974, results of the selective salmon breeding program continued to show stock improvement evidenced by increased survival to maturity, larger size, and increased egg production.

# # #

Studies on selective breeding of chinook salmon emphasize size and rapid growth. In 1974, a series of crosses using mature adults of different ages demonstrated a strong effect on survival, size, and time of return in resulting generations. Although ocean environment could have an appreciable effect on these data, strong genetic influences were implied.

Last year, further crosses were made to define the importance of genetic components as opposed to environmental effects. These crosses were also analyzed for possible differences in early life-history characteristics. Because mortality is the most costly aspect of salmon rearing, any gain in growth efficiency or survival characteristics through breeding would be of immediate benefit to salmon growers. Factors analyzed included growth mortality, food conversion, and condition. Preliminary analysis of the results demonstrates some egg mortality and growth differences which can be correlated with parent stock age.

A suitable brood stock that will yield rapid-growing, high-quality offspring is a very important aspect of commerical pen-rearing of salmon. So a cooperative program between Dr. William Hershberger of the College of Fisheries and Conrad Mahnken of the National Marine Fisheries Service was initiated in which 1974 chinook salmon crosses were used to begin development of a brood stock for salt-water pen-rearing. Initial results demonstrated individual differences in early growth rates in salt water and, possibly, increased disease resistance--traits which are extremely important for pen-reared fish stocks.

# # #

Selective breeding for coho salmon has emphasized the further development of a stock adapted to accelerated rearing and early release. The number of adult fish returning in 1974 demonstrated a 2.6X increase in survival since the initiation of the program in 1967. Furthermore, the data indicate that this success is due not only to development of the cultural techniques which allow rapid rearing of these fish but also to the continuity of a selective breeding program of coho salmon which will respond to hatchery rearing.

# # #

Stock resulting from a rainbow trout breeding program continues to show increased growth rate, greater disease resistance, and high reproduction capacity. In 1974, programs were initiated to test the performance of this strain in lakes with sport fishing pressure and in commercial salt-water production facilities. Crosses with other rainbow strains are being examined for possible effects of "hybrid vigor." This testing is crucial because the Donaldson strain contains some unique genetic differences not yet found in other rainbow strains.

# # #

Nutrition research in 1974 was directed at three different areas, all of which provided some insight into increasing efficiency of food utilization, thus decreasing the cost of food to raise quality fish; in a feeding study of salmon alevins (before yolk absorption) it was found with chinook salmon fry that feeding immediately after removal from the incubator and before complete yolk absorption

resulted in fish that were 34% larger and 238% heavier than those that were fed later. On the other hand, coho salmon alevins did not feed or utilize offered food until after yolk absorption. Thus with chinook salmon, very definite gains can be made by feeding before yolk absorption is complete, yielding larger and more-easily-reared fish.

# # #

Another series of nutrition experiments, directed by Dr. Ernest Brannon, tested the effects of different protein sources on the growth and performance of chinook salmon alevins. Non-marine protein sources such as feather meal and single-cell protein were substituted in the diet. The results generally indicated a decreased food conversion to body tissue with an accompanying lack of the proper array of amino acids in the non-fish protein sources.

Since protein is a costly item in the diet of fish, an investigation was initiated to study the protein requirements for brood fish. Work completed in 1973 demonstrated a very definite influence of diet composition on the quality of sex products from brood stocks, and thus young fish. Diets differing only in protein content were fed to the College's rainbow trout brood stock during a time period when sex products were being formed and were maturing. The results are preliminary, but a definite effect was noted on adult fish growth and some differences are indicated on the quality of sex products formed.

# # #

Studies directed by Dr. Ernest Salo of the Fisheries Research Institute to assess the feasibility of pen-rearing salmon at different locations in southern Puget Sound, Willapa Bay, and Grays Harbor were completed in 1974. The results demonstrated that of the three sites tested, the best environmental conditions for growth and survival were present in Henderson Inlet in southern Puget Sound. Food conversion rates for chinook salmon averaged 2.0 using Oregon Moist Pellets. Maximum pen densities of 1.6 lb./ft.^{3} were achieved without density-related mortalities. Survival was 70% for the chinook salmon at market size and 78% for coho salmon with nine months of rearing.

As a result of the success of the pilot pen-rearing studies, the Weyerhaeuser Company decided to initiate a commercial salmonid pen-rearing project at Henderson Inlet. A cooperative agreement was established for 1974-75 between the State of Washington Department of Fisheries, the Weyerhaeuser Company, and the Fisheries Research Institute to continue the feasibility study in anticipation of developing a commercial production facility.

A limiting factor to rearing salmon in salt-water pens is mortality caused by *Vibrio anguillarum*. In 1974 investigations were completed on the incidence of this disease-causing bacteria and factors responsible for outbreaks in the marine environment and in pen-cultured salmon. No relationships were found between bacterial frequencies in the water, plankton, or fouling material from nets and the incidence of disease in the fish. Elevated water temperature, probably acting as a source of environmental stress, was found to be influential in initiating disease outbreaks. An attempt was made to distinguish between *V. anguillarum*-like bacteria and virulent and avirulent *V. anguillarum*, on the basis of different growth characteristics using different culture media. Using this procedure, separation of related *Vibrio* species was attained, but no growth pattern was consistently found which would identify all virulent *Vibrio* isolates.

# # #

Another method for increasing fish production is by managing the natural and semi-natural conditions under which the fish spawn. Using the controlled-flow spawning channel at the College of Fisheries Big Beef Creek Research Station, three conditions were studied as a part of the continuing program to increase chum salmon production. Groups of spawning salmon were temporally isolated and allowed to utilize a common spawning bed. The combined production of fry from the two groups was higher than that expected from one group of a density similar to that achieved by the temporal isolation. Thus, by allowing two groups of chum salmon to spawn in a given spawning area at two different times, an increased production could be achieved per given area of spawning beds.

Studies were initiated to test the feasibility of increasing chum salmon fry production from impoverished spawning areas by the addition of various depths of gravel. Preliminary results indicate a high egg-to-fry survival with at least 20 cm of gravel placed over a sand substrate. Less than this amount of gravel results in earlier emergence and less well developed fry.

Observation of chum salmon in the spawning channel has indicated a definite pattern of mate selection. Chum salmon of various sizes appear to show positive assortative mating behavior. To provide information necessary for stock development, experiments have been initiated to determine the influence of size of male and female parents on fry quality and growth.

Shellfish aquaculture

During 1974, shellfish research, directed by Dr. Kenneth Chew of the College of Fisheries, centered around two principal studies: one on molluscan culture, the other on oyster disease and genetics.

The former emphasized techniques for culturing the Pacific oyster *(Crassostrea gigas)*, the Manila clam (*Venerupis japonica)*, and the bay mussel (*Mytilus edulis*). The latter study dealt primarily with the summer mortalities which afflict Pacific oysters and the development of genetic strains of oysters more resistant to conditions that cause these mortalities.

In the first of three molluscan culture studies, a technique for growing oysters on trays was examined. Similar trays of Pacific oysters were placed in areas where they were submerged continually and on the intertidal zone to determine growth, survival rates, and fouling problems. Information from these studies will be used to help oyster growers assess best sites for rearing tray-cultured oysters.

In a second effort, undertaken in cooperation with the State of Washington Department of Fisheries, Manila clams of various sizes were planted in varying densities in select intertidal areas. This was done to determine if clam reseeding might be an effective means of rehabilitating commercial clam-producing beaches or of repopulating heavily dug public beaches. So far results are promising; however, further testing is scheduled for 1975.

The third investigation consisted of a study on raft-cultured mussels. Each month since early 1974, three types of substrate material have been hung from floating rafts at Seabeck Bay and Clam Bay to determine when seed mussels will set and to what substrate. The cultch materials tested were oyster shell strings, Manila rope, and a synthetic rope called Synclove. It was found that commercial sets of mussels can be obtained--particulary on the Synclove type rope.

Fouling was the key problem noted in 1974. Rope placed out too early became completely fouled within two weeks and thereby inhibited mussel seed set. Thus, it was determined that the time for placing the rope cultch material is critical. It should not be placed out too long before the availability of mussel larvae.

# # #

Because oyster disease can cause significant losses for commercial growers, monthly bacterial counts were made last year on natural sea water media in which oysters are grown. Investigations found that with the onset of summer temperatures, the percent incidence of *Vibrio anguillarum*, a bacterium implicated in oyster disease and death, increased and remained high during summer months.

Investigators also found that moribund oysters show increasing amounts of ammonia in the heart blood. Bacteria recovered from cultures of pericardial fluid from diseased oysters were injected into healthy oysters. A bacterium from moribund oysters from an

area of high estimated mortality, later identified as *Vibrio anguillarum*, and a positive control bacterium caused morbidity or death after 24 hours when other bacteria injected caused little or no morbidity or death. These preliminary results need to be substantiated in further laboratory investigation but seem to support a bacterial infection theory and concept of virulent strains.

As an initial step in genetic work to increase Pacific oyster resistance to mortality associated with *Vibrio* species, an investigation was begun to determine the amount of genetic variability available for breeding purposes. Further, a selective breeding program was initiated in an attempt to increase the disease resistance of the Pacific oyster. Groups of oysters have been challenged with a mortality-inducing laboratory situation similar to conditions which prevail in summer in the natural environment. A number of the more susceptible individuals were killed (up to 90%), but the survivors were spawned together to produce progeny for further testing in hopes of producing disease-resistant strains.

. . . sea farms . . . floating cities . . . safe harbors for sailboats and supertankers.

These are the aspirations of a modern, industrially based society to meet the food, space, recreation, transportation and energy needs of its citizens. If mankind is to successfully build such facilities, structures capable of withstanding the physical forces of the marine environment must be designed and tested. Such is the work of ocean engineers.

Engineering In The Ocean Environment

Floating breakwaters have several advantages over fixed breakwaters. First, the floating breakwater can be installed in waters too deep for a standard, rubble-mound breakwater to be economically feasible. Second, the floating breakwater permits circulation underneath; therefore, water behind it is self-flushing and less likely to become polluted.

Developing techniques and criteria for site selection, cost evaluation, and structural design of floating breakwaters is the goal of a Sea Grant engineering effort undertaken by Professors Bruce Adee and Eugene Richey and several graduate students.

The immediate focus of their work has been on floating breakwaters for small-boat harbors, but the models developed and field data collected may be applied to floating aquaculture pens, or to larger multipurpose floating facilities such as oil off-loading stations, and structures for preventing beach erosion.

Over the past year, the investigators measured the efficiency and dynamic characteristics of three breakwaters of different design

and subjected to different wave conditions. The data collected are being used to correlate the predictions of mathematical models and build an engineering design manual for future floating breakwaters of any shape or size.

Along with ocean engineering faculty at the University of Rhode Island, this group sponsored conferences on floating breakwaters held in Newport Beach, R.I., and in Seattle. These conferences attracted representatives from port authorities, the Corps of Engineers, private marinas, and civil engineering firms.

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While considerable effort has been directed toward the biological problems associated with pen-rearing of salmon, there has been a lag in the application of systems engineering principles which are essential for efficient salmon aquaculture operations. Last year in a feasibility study supported by Sea Grant and carried out in the College of Engineering, John Danielsen, a graduate student, undertook a survey and engineering assessment of floating pens presently used by Washington's salmon-growing enterprises.

A report prepared by Danielsen describes in detail and illustrates the basic design of salmon-rearing pens used by Weyerhaeuer, the National Marine Fisheries Service, Squaxin Sea Farm, DOMSEA Farms, Inc., Pacific Ocean Farms, Inc. Fort Ward Salmon Farm, and the Quinault Tribal Fisheries Development Project.

As a result of this work and with joint sponsorship from the State Department of Natural Resources, Danielsen designed, built and tested a full scale model of an optimized salmon aquaculture system. He then prepared a M.S. thesis describing this efficient, secure, low-maintenance pen design which incorporates the best features of existing designs but is specifically designed to function as an element in a systematic process for pen rearing operations.

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EXPENDITURES BY CATEGORY OF EFFORT

ACTIVITY SHEET*

Washington Sea Grant Program - 1974

	Sea Grant Funds	University Matching Funds
PROGRAM MANAGEMENT	$ 86,535	$ 88,053
ADVISORY SERVICES	267,030	125,951
EDUCATION & TRAINING		
New University Courses	115,377	20,347
Technician Training	74,663	162,929
RESEARCH & DEVELOPMENT		
NORFISH	133,832	36,015
Animal Aquaculture	203,542	51,720
Population Assessment	75,521	108,988
Applications of New Marine Materials	191,113	66,003
Managing the Nearshore Environment	42,440	48,049
Marine Acoustics and Ocean Engineering	82,036	41,788
TOTALS	$1,272,089	$749,843

*This summary is only approximate and represents expenditures for the second year of a two-year grant. The official financial report will be submitted to NOAA's Office of Sea Grant Programs in accordance with the federal grant requirements.