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WASHINGTON SEA GRANT PROGRAM

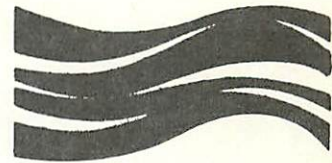
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A REPORT ON THE WASHINGTON SEA GRANT PROGRAM
FOR JANUARY 1, 1973 - DECEMBER 31, 1973

DIVISION OF MARINE RESOURCES
UNIVERSITY OF WASHINGTON 98195

Prepared under the
National Sea Grant Program

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Division of Marine Resources
UNIVERSITY OF WASHINGTON • Seattle 98195

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P R E F A C E

In 1966, Congress passed the National Sea Grant College and Program Act authorizing establishment of a program devoted to developing and conserving this Nation's marine resources. The program was intended to parallel the century-old land grant program created by the Morrill Act, which was aimed at developing the Nation's agricultural resources.

Under provisions of the Sea Grant act, grants were first made in 1968 to the University of Washington, University of Rhode Island, and Oregon State University to initiate programs in marine resource research, education, and advisory services. During the years between 1968 and 1973, the national program expanded to include similar programs at 15 universities and colleges in the Gulf of Mexico and the Great Lakes regions, as well as on the Atlantic and Pacific coasts, and each of these programs has, in turn, expanded and matured.

This report summarizes activities of one of these sea grant programs--that of the University of Washington--from January 1, 1973, through December 31, 1973, under grant number 04-3-158-42 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. Sea Grant requires a one-third non-federal matching fund. During 1973 matching funds were provided to Washington Sea Grant by the University of Washington, six other institutions of higher education in Washington, two state resource agencies, and numerous regional marine businesses, industries, and agencies.

In this report, highlights of the 1973 program are summarized and published by the University of Washington's Division of Marine Resources, administrative unit for Washington Sea Grant, not only in fulfillment of contract requirements but also in furtherance of its goal to provide useful information to the marine community. Further details about the program are available from the Division which is located at 3716 Brooklyn Avenue N.E., Seattle, Washington, 98195.

PROGRAM MANAGEMENT

The Washington Sea Grant program is administered by the University of Washington's Division of Marine Resources under the direction of Dr. Stanley R. Murphy. The program strives for balance but does emphasize marine fisheries because of the importance of this industry locally. Access to other fields of expertise has been broadened both within the University as well as elsewhere under Sea Grant sponsorship. From its very beginning, Washington Sea Grant has participated in marine resource planning at the state and federal level and has emphasized continuous communication with federal, state, and local agencies on a broad basis. Some programs, important to the development of the state's marine resources, are of such scope that Sea Grant alone cannot bring them to fruition; however, Sea Grant remains sufficiently flexible to assist other agencies in developing those programs.

Through such cooperative efforts, Washington Sea Grant projects have served and are serving as the stimulus for further work by state agencies. One indication of the cooperation with state agency programs is the substantial amount of additional matching money, not anticipated in 1972, which came into the program during 1973. This unexpected revenue totaled \$115,000, and similar unplanned matching funds are expected to materialize in 1974.

Within the University, the creation of the Institute for Marine Studies has prompted a developing relationship between the Washington Sea Grant's research project orientation and the academic focus of the Institute for Marine Studies. The Institute was created by the Board of Regents in September, 1972, and plans to conduct its first formal graduate level courses in the fall of 1974. It is anticipated that the Washington Sea Grant program will increase its interaction with the Institute in providing graduate assistance in research projects, cooperative publication efforts, and provide for potential expansion in advisory service capability. Although the exact details of the Washington Sea Grant-Institute for Marine Studies formal relationship are still in the formative stages, the arrangement cannot help but benefit both organizations. The Institute has identified six major areas of emphasis, which are for the most part in common with the Washington Sea Grant Program. These six areas are

Coastal Zone Planning and Administration; International Marine Policy and Management; Marine Resource Development and Management; Marine Transportation and Commerce; Naval Power, National Security and Foreign Policy; and Offshore Technology Systems.

SIX-YEAR PLAN

Late in 1973, the University of Washington established a long-range program in objective planning for the entire University. This exercise presented an excellent opportunity for the Division to assess its various activities and point out areas that needed sharper focus or more emphasis. With respect to the Washington Sea Grant program, the planning document clearly defined the areas needful of increased emphasis and effort and also showed the need for minor internal reorganization to permit a more effective management of the Sea Grant program. The University planning document specifies needs and priority definition for a 6-year period and will be updated annually to reflect changes in priority or program emphasis. Additionally, the Division of Marine Resources will use this planning document as a working tool to identify and focus priorities, goals, and objectives that reflect both the needs of the University of Washington and the goals of the Sea Grant program.

COST EFFECTIVENESS

In November 1973, Dr. James Bray was retained as a full-time staff economist to continue the benefit-cost evaluations of the Sea Grant program started by Mr. Robert Goodwin in 1972. One of his initial efforts was to review and edit the earlier papers of Mr. Goodwin in preparation for their publication as a single work. Dr. Bray has also been active in the evaluation of proposals from commercial interests giving guidance on the feasibility of investing significant sums of money in marine resource development. Some proposals have been encouraged while others have proven to be uneconomical and subsequently have been dropped. This analytic capability within the Division of Marine Resources is an extremely valuable asset in the evaluation of proposals as well as documenting the value of ongoing projects.

PROGRAM HIGHLIGHTS

Although all projects and programs are summarized elsewhere in this report, significant highlights of the Washington Sea Grant program are noted here. Under NORFISH project, two significant milestones were achieved during the year. The first was the development of the Salmon Management Model which is available to the Washington State Department of Fisheries to use in their negotiations with Canada for a revised salmon treaty to provide for a more equitable division of harvestable salmon runs. The second milestone is the development of the Computerized Graphic Information Retrieval System Model. This mathematical model utilizing reported halibut catches provided an estimate of the unreported halibut catch by Japanese fisheries and was used in international negotiations with the International North Pacific Fisheries Commission

in the fall of 1973. The model also assisted the National Marine Fisheries Service in formulating fisheries policy at the Law of the Sea conference held in the summer of 1974.

The Washington Sea Grant program provided modest support from rapid response funds to refine an innovative technique for underwater cleaning of ship hulls. Developed by Controlled Dynamics Corporation, the technique is based upon a net of primer cord suspended about the hull's exterior surface. A series of carefully calibrated explosions of this netting--or Sea Mesh as it is called--literally blasts barnacles and other growth from the surface and leaves paint intact. Because this entire process requires less than a half day, firms can now afford to clean their vessel hulls more frequently and are realizing appreciable fuel savings as a result. Formerly, vessels had to go into dry-dock for several days where workers laboriously scraped hulls clean by hand.

The sea mesh project has received worldwide attention through the efforts of the Program's communications services. By the end of 1973, more than 80 requests for further information had been received from shipping firms in 24 nations requesting the address and phone number of Controlled Dynamics Corporation. The success of this project is based on two contributing factors: namely, the economy of the explosive process and the ability of the Washington Sea Grant communications program to bring the process to the attention of the world's shippers through news coverage on a national wire service and in international newspapers and magazines.

A project described in detail on page 23 and aimed toward total utilization of shellfish wastes, will have reached its planned goals by mid 1974. Through this project, production of chitin/chitosan has now reached a commercially competitive status, and Sea Grant support will be terminated. The initial agreement was entered into on 1 January 1972 with initial funding and pilot plant operation started on 1 July 1972. The program reached maturity more quickly than anticipated and with less Sea Grant support than originally requested.

The Washington Sea Grant program also provided guidance and background information, primarily in the field of economic losses from fires, to the State of Washington and the Seattle Fire Department in the preparation of a proposal for grant support. The proposal outlined a concept to develop better fire-fighting techniques for shipboard fires, a program for providing vital information on shipboard fire suppression systems to fire departments, and a proposal for providing underway assistance to vessels who cannot contain onboard fires. The proposal was accepted by the U.S. Maritime Administration and will be funded in two phases totaling almost \$300,000 over a two-year period.

ADVISORY SERVICES

Bringing the results of University research to marine industries and identifying the needs for further research are two major thrusts of Washington Sea Grant's marine advisory program headed by Robert E. Harris. To help achieve these objectives, a team of specialists and field personnel devoted their efforts last year to the following projects.

SEA GRANT INFORMATION SERVICE

"I own a small boat and I am thinking about harvesting octopus for a living. What can you tell me about the octopus population in Puget Sound?"

"Do you have a recipe for kelp pickles?"

"Is it safe to eat fish containing worms?"

Those are but three of the many questions posed in 1973 to Mildred Palmer who operates the Washington Sea Grant Information Service. Begun in 1970, the service, now listed in the yellow pages of the Seattle directory, continued to help callers find answers for marine related questions.

SEAFOOD PROCESSING

In recent years, increasing regulatory controls and an expanding market for smoked fish products have provided this segment of the food-processing industry with problems as well as profits. Helping solve those problems related to seafood plant design and quality control was the main thrust of 1973 efforts by Robert Palmateer, Washington Sea Grant's specialist in seafood processing.

Through personal visits to plants and advisory workshops, this program has had a significant and beneficial impact upon Washington's processing industry. By year's end, 14 plants had undergone product quality analysis and production

system evaluation. This effort led to changes in methods of handling seafood products to increase plant efficiency and product quality and to assure processing met federal regulations. Sanitation equipment had been installed in, and was being used by, five seafood plants, and four processors who had no previous technological background had installed product analysis equipment for process control.

A plant design project begun in 1972 continued with a University architecture class in industrial design working with Palmateer to survey five plants and to recommend improvements. This effort led to extensive remodeling in three plants and the rebuilding of one to alter processing lines, thus permitting better care of products during processing. Results? More efficient plant operations, lower processing costs per product unit, better compliance with regulations, and a spreading reputation about this project that netted inquiries and calls for help from processors across Washington State and from as far away as Japan, Canada, Alaska, and Arkansas.

AQUACULTURE

Farming the sea is no longer a Jules Verne fantasy. Last year, three Washington salmon-farming operations alone projected a total production of approximately 1,050,000 pounds for the 1974 market, and there are indications that these producers will soon be competing with newer operations. Besides increasing numbers of salmon farms, Washington State also boasts an actively expanding shellfish industry.

Although these fish-farming operations differ with respect to factors such as hydrography, species reared, size, help and management techniques, there are common problems faced by all. To help identify and find solutions for these, Terry Nosho, aquaculture field agent, within the Washington Sea Grant Advisory Service program, worked with the industry with the following results.

A summer workshop organized by Nosho attracted both public and private oyster hatchery operators and identified four areas of common interest: water quality, feeds and nutrition, predators, and larval diseases. Subsequently, a workshop on salmonid aquaculture, sponsored jointly with the College of Fisheries, provided a forum for the exchange of thoughts and experiences by more than 50 registrants from industry and government and university research programs. Proceedings of the workshop (published in 1974 and available from Washington Sea Grant) summarize state-of-the-art reports on rearing methods, feeds, fish disease, and production and marketing relationships.

Besides his workshop activities, Nosho also helped local groups conduct field studies necessary to determine the cause of periodic oyster mortalities in Willapa Harbor and to assess the feasibility of commercial clam production around Lopez Island and in Grays Harbor. In the former study, final outcome awaits further analyses of water quality, live-box, and bacteriological data. In the latter tests, it was found that clam farming may not be biologically feasible in Grays Harbor. However, a planting and sampling strategy developed to assess survival of one million clam seed planted on Lopez Island indicated that commercial operations may be feasible in that area.

COMMERCIAL FISHING

How can a program serve the needs of a fisheries complex that ranges from a skipper with an 86-foot vessel who roams the whole West Coast in a constant search for seafood, to a fisherman with a 16-foot skiff who gillnets part time, to an Indian tribe that is actively increasing the fish and shellfish production on its lands, to an oyster company who would like to diversify, to a shoreland owner who thinks he'd like to grow a few oysters for the family dinner table? Sea Grant's answer was to station marine advisory agents at Grays Harbor College in Aberdeen to serve Washington's coastal area and at Clover Park Education Center at Lakewood Center near Tacoma to serve Puget Sound.

Working out of Grays Harbor's Marine Information Center, another Sea Grant operation, Eugene Johnson offered this coastal fishing community classes, which covered industrial first aid slanted to meet the needs of fishermen, and seminars on marine electronics and marine refrigeration systems. In cooperation with PASCAP, Johnson traveled to Alaska to conduct halibut longline workshops in five ports. A total of 568 persons attended these various group educational efforts held during 1973.

Additionally, Johnson counseled students in the Fisheries-Game Management Technician program at Grays Harbor College. And besides responding to those who came to the Marine Information Center seeking help, he visited marine users where they work, trying to learn their problems and seeking solutions for them. As a result of these contacts, Johnson and Dr. John Smith, Grays Harbor Sea Grant director, formed a Coastal Advisory Service committee composed of active members of the marine industry to steer the coastal program toward projects useful to the local marine community and to help evaluate the local Sea Grant effort.

Publications are an important part of the Grays Harbor effort, and Johnson produced several aimed at the general public, "Beach Logs Kill", "How to Buy Fish, Freeze It and Cut Down on that Meat Bill", and oyster recipe cards. Through *Harbor Tides*, a newsletter written monthly by information specialist Pansy Bray, Sea Grant communicates information of local interest to some 500 persons involved in the coastal marine fisheries. Publications dealing with many aspects of the marine field are being gathered in the Marine Information Center for the benefit of local schools, the marine industry, and interested citizens.

Sea Grant's advisory program at Clover Park is also designed to provide useful and timely assistance to commercial fishermen and other marine user groups through individual contacts and through workshops and short courses. In 1973, Scott Harrington, advisory agent, organized seventeen short courses and workshops in a total of eight fishing ports in the state, thus providing service to 378 fishermen and others interested in this facet of marine industries.

Moreover, a booklet outlining guidelines for refrigeration systems on smaller fishing vessels was compiled by John Ronning, commercial fishing instructor at Clover Park, and published by the Center's reprographics students under the direction of Lamar Hughes.

PUGET SOUND MODEL

At the Pacific Science Center in Seattle, a 200-square foot hydraulic model of Puget Sound, built with Sea Grant support, permits visitors to investigate tidal currents and see effects of major river discharge into the Sound. Moreover, the model provides information on the topography of Puget Sound, its water volumes, rates and direction of tidal flow, tidal patterns, and even some excellent fishing ports.

Designed by John Lincoln, a University of Washington oceanographer, the computer-controlled model is capable of simulating past, present, and future tidal conditions. One hour in nature is represented by three seconds on the model's clock, and high and low tides occur every eighteen seconds. By watching the time clock, visitors can see how long pollutants remain in the Sound.

The model, cast and installed in 1972, was first filled and operated in March, 1973. Since then more than 500,000 visitors to the Center have had the opportunity to learn from this model more about the dynamics of the Sound. Moreover, special demonstrations were arranged for various groups ranging from a sailboat club interested in improving competition records to a civil engineering team conducting a research project in North Sound.

EDUCATION AND TRAINING

Continuing progress in the wise use and conservation of the marine environment depends, in large measure, on an informed public. Such a public evolves, in part, through the education and training of students capable of pursuing useful careers in marine research and the maritime industries and capable also of understanding how use practices affect the marine environment. Cognizant of this fact, Washington Sea Grant in 1973 continued to support educational and training projects at the University of Washington and at several other institutions throughout the state.

COURSES AT THE UNIVERSITY OF WASHINGTON

Ocean Engineering

An Interdisciplinary Ocean Engineering Systems Design Course, implemented in 1970, continues to provide a mechanism for encouraging interdisciplinary marine studies among students and faculty. Through personal involvement in real-life systems and design efforts, students acquire an overall perspective on marine technology and find that they become motivated to explore new research directions--either in application of existing skills to new fields or in development of new techniques peculiar to problems connected with the marine environment.

The 1973 class, under the direction of Karl Vesper, of the Departments Mechanical Engineering and Management and Organization, concentrated on a study of new concepts for Bellingham Bay in northern Washington. These concepts included ideas for improved shoreline utilization in this bay; design of a barge port aimed at preserving shoreline by use of an offshore unloading facility coupled to an inland staging area via underground tunnels; and an "oceanarium" or underwater viewing facility consisting of an underwater transparent room joined to a shore-based aquarium/theater/museum to serve as an educational area for schools and the general public. All of these projects are intended to benefit directly the people of Bellingham and the Lummi Indian tribe. The Lummi have expressed an interest in carrying forward the oceanarium plan.

Fisheries

A series of courses in fisheries resource management were restructured and taught during 1973. These have students from several areas of the University in addition to fisheries enrolled and are of particular interest to those concerned with applying quantitative methods to the study and management of living marine resources. As an aid to updating the midcareer biologist, two short courses were offered: "Evaluation of Hatchery Techniques," which drew 20 participants; and "Acoustical Stock Estimation" (two sections), attended by 10 and 20 persons, respectively. The latter course is preliminary to formal university courses on this topic.

The Special Lecture Series initiated in the fall of 1971, with the appearance of John Gulland of the Food and Agriculture Organization, continued with Mr. David Cushing of the Lowestoft Laboratory delivering ten lectures in 1972. These lectures of Mr. Cushing were published in July 1973 under the title *Recruitment and Parent Stock in Fishes* and have been widely distributed by the University of Washington Press. Both Mr. Gulland's and Mr. Cushing's books are serving as class texts both here and elsewhere. The Special Lecture Series will continue in 1974 with the visit of Dr. William E. Ricker of the Fisheries Research Board of Canada.

Ocean Law

Recognizing that rational development and management of resources of the ocean depend, in part, on the creation of a sound legal framework at state, federal, and international levels, Washington Sea Grant in 1973 continued its support for the Law and Marine Affairs program of education and research in the University's School of Law. The program is under the general direction of Professor William T. Burke, who states categorically, "Without Sea Grant support, we simply wouldn't have a viable educational program at the graduate level."

Since existing teaching materials for international law of the sea require updating to pace the progress in international negotiations and national developments, Dr. Burke has further revised his teaching materials, entitled *International Law of the Sea: Cases and Materials* (796pp.). This activity was facilitated by Dr. Burke's participation as an expert on the U.S. delegation to the U.N. Seabed Committee and by other advisory work and research. A new law school course on coastal zone management is being developed, since the absence of such an offering is considered a critical gap; the course will be offered in the 1974-75 academic year.

The new Institute for Marine Studies is expected to strengthen the curriculum available for, and strongly recommended to, LL.M. students. Professor Burke served as chairman of the IMS faculty prior to recruitment of a director; and he and Professor Ralph Johnson are now members of the adjunct faculty of the Institute and active in its affairs.

Autumn Quarter 1973 enrollment in the International Law of the Sea course was 30 students. Three students receiving Sea Grant support graduated with an LL.M. degree in June. One is now Technical Associate on the Ocean Affairs Board of the National Academy of Sciences; another is in private law practice on Guam and Palau; and the third is a judge in the District Court in Seoul, Korea.

Marine Affairs

As further evidence of its interest in helping to provide solutions to ocean-oriented problems, Sea Grant has continued to assist the development of the University's marine technology affairs program. Graduate seminars under Professor Edward Wenk, Jr. have provided unique educational opportunities for graduate students from diversified fields including the natural sciences, engineering, law, public affairs and business, as well as midcareer students from government and industry. Enrollment increased to twenty students in 1973, and the seminar was expanded to three quarters.

Reports from the seminar dealt with the policy implications of such topics as international management of ocean space; guidelines for coastal zone management; oil spill hazards in Puget Sound; territorial implications of sea mounts; application of technological delivery systems to marine activities such as the Fish-from-the-Sea (FPC) Program. In 1973 an inventory of contemporary issues in marine technology policy of national significance was updated.

With aid of documentation procured through the grant, two papers were prepared and presented by Professor Wenk before national meetings concerned with marine affairs: "Regional Structures for Ocean Management--The Role of Political Will" before the Colloquium on the Oceans and National Economic Development sponsored by the National Oceanic and Atmospheric Administration in Seattle in July, 1973; and "National Policies for Marine Technology" before the IEEE International Conference on Engineering in the Ocean Environment in Seattle in September 1973.

A major class project of the 1973 seminar devoted to the problem of deep-water port issues for the state, entitled *Washington Harbors and Regional Facilities* (WHARF), received recognition from the Washington State Legislature and from the Office of the Governor as a very useful analysis of the port problems facing the state. A summary of this study was presented at the National Meeting on Water Resources Engineering of the American Society of Civil Engineers at Los Angeles in January 1974 and will be distributed to appropriate outlets by Washington Sea Grant. Two monographs prepared for the seminar on the Intergovernmental Oceanographic Commission and the United Nations and Marine Affairs are also being considered for publication.

Comprehensive evaluations of shoreline regulations for future development in Washington State undertaken by student researchers will be of significant value to the Department of Ecology. Another valuable service to the state was the coordination of free technical advice for shoreline management services through the Department of Ecology Interdisciplinary Advisory Committee, including publication of a bimonthly newsletter. This service to city, county and state agencies involves many of those presently within the Sea Grant program.

TECHNICIAN TRAINING

In addition to contributing to marine industry needs through education and research at the University, Washington Sea Grant is helping to meet the personnel requirements of this complex industry, both afloat and ashore, through various technician training programs at community colleges and vocational-technical schools.

Seattle Central Community College, with Sea Grant assistance, has shown steady growth in its marine program in the four years of its operation. Its primary objective has been the training of personnel for vessel operation, with the major emphasis over these first four years placed on diesel engine maintenance, hydraulic systems and shipboard refrigeration. Growth and refinement of the industry has required more specialization and indepth training in the curriculum. In addition to the 189-foot *Trident* and a 130-foot machine shop barge, the College now utilizes an 89-foot seagoing diesel-propelled tug, thereby permitting the school to offer underway instruction not only for engine room trainees, but for deck personnel as well.

A significant accomplishment in 1973 was Coast Guard recognition of the program so that graduation may now substitute for two years of sea service as applied to engineering licenses aboard motor vessels. There is no other two-year associate degree program with the mechanical aspects of vessel operation as its primary vocational training goal presently in operation in the Northwest, and it is significant that all students seriously interested in seagoing careers have been able to find either full- or part-time employment afloat or ashore in marine-oriented industries.

In addition to its regularly scheduled courses, the program in 1973 offered six specially designed two-week workshops to update the professional skills of those already employed by various Puget Sound tow boat companies.

In commenting on Sea Grant's contribution to the program, Donald Smith of *Seattle Central* remarked: "The only equipment we have had has been from Sea Grant. We would have had none otherwise, and it would have been a sterile program."

Grays Harbor College, Aberdeen, with Sea Grant help, expanded its activities in the Willapa Bay - Grays Harbor area. Weekly baseline data surveys by student technicians continued through the year at one estuary and three ocean stations, under the guidance of Dr. John M. Smith and Louis Messmer. Data, which are being sent to NOAA's National Oceanographic Data Center, are of particular value to local users, which include the Washington State Department of Fisheries, the U.S. Army Corps of Engineers, and the Port of Grays Harbor.

Student technicians from this program are being utilized in an oyster mortality study being conducted in Willapa Bay. Oyster growers in the area felt it was critical to have the environmental parameters measured over a several-year period and contributed money to help fund the survey, along with the Willapa Harbor Public Works Department.

The increasing local interest in aquaculture led to yet another study involving student technicians--the feasibility of raising Manila clams in Grays Harbor. Hatchery-reared Manila seed, some 100,000 of them, were planted in both the north and the south bay in donated beds. Growth and survival rates are being monitored on a regular basis to determine the feasibility of commercial rearing.

These three projects employed nine student technicians, while other students participated for credit in Sea Grant projects under special problems courses. During 1973, 45 students were enrolled in the College's two-year fishery technology program and in June 17 students graduated from the course. Nine of these entered full-time employment in the field, one is in full-time employment out of the field, and three transferred to four-year programs.

Shoreline Community College, Seattle, offers an oceanographic program and a marine biology technology training program that have gained considerable stature with the assistance of Sea Grant funding. On-the-job training is emphasized in these programs, which not only offer a unique training opportunity for the students but expose the program to prospective employers with excellent results. During the 1973-74 school year, 76 students were placed in jobs where their oceanographic or biological technical background was directly related. Since 1972, 110 students have entered the programs; 23 have graduated so far and 19 have found employment.

A permanent on-the-job training arrangement has been made with NOAA in Seattle. A special class in environmental biology was organized and taught at Shoreline to METRO (the municipality of metropolitan Seattle) personnel in the water quality laboratories to upgrade their levels of expertise in this area.

1973 saw the furthering of Volumes I and II of the Marine Technician Manuals, which are slated for completion during 1974. They are expected to find wide use throughout the United States, in other marine technology programs. In addition, 1973 marked the initiation of a Central Puget Sound benthic and water quality study. A paper describing this study was presented at the Northwest Estuarine Conference held at Oregon State University. Further progress was also made on development of a regional marine laboratory facility for the colleges of Puget Sound at a Richmond Beach Park site.

Phasing out Sea Grant funding of ongoing projects at the end of 1974 is anticipated, but new Sea Grant activities might appropriately center around baseline data studies and on-the-job training in the Puget Sound area.

Highline Community College, located at Midway, south of Seattle, serves as a regional diving service center for other educational institutions, government agencies, and private businesses. During 1973, the name of the program was changed from Underseas Technician Program to Diving Technician Program and the program structure was altered. The freshman now takes a full year of academic courses and engineering subjects; in the sophomore year, thirty out of the fifty students are selected to go on into the diving year. The graduate receives an Associate of Applied Science Degree and is trained specifically for employment by commercial diving companies which concentrate in underwater construction and salvage. During 1973, fifteen students completed the program and all but one are now actively employed in diving or similar fields.

In the fall of 1973 the college dedicated its new 5,500-square-foot pier, which further expanded its capabilities for training highly efficient underseas technicians. The facilities, including a decompression chamber and diving bell have seen use not only for college purposes but for a number of outside groups as well.

Shoreline Community College and Bellevue Community College have agreed to share the diving facility and equipment, thus giving the three colleges access to this unique Sea Grant supported facility with the added advantage of combining funds and equipment to enhance cost effectiveness.

Program Director Peter Williams stresses that significant public and industrial contacts with industries employing commercial divers were made during the year, resulting in broadened relations and job offers for students. Plans are now under way to offer two special courses during breaks between quarters: Introduction to Commercial Diving Equipment and Bell and Chamber Diving for Commercial Divers. It is also possible that a diving class will participate in a salvage attempt under consideration by the state of Alabama.

Clover Park Education Center, in Lakewood Center near Tacoma, serves the commercial fishing industry of Washington, with Sea Grant support, by providing two distinct programs. The first--Commercial Fishermen's Crew-member Training Program--is designed to train those interested in the fishing and shipboard skills needed to become effective crew members aboard any one of the nearly 10,000 licensed fishing vessels in the state. Students receive instruction in fishing methods, gear construction and repair navigation, vessel operation, maintenance, net mending, splicing, equipment operation, and cooking. The course is 1,320 hours in length, with the student's time divided so that he spends two-thirds in class lab and one-third in actual fishing activities aboard a school-operated vessel. In 1973, 37 people were trained and entered the fishing industry from the Center. The second program is discussed under advisory services.

RESEARCH AND DEVELOPMENT

NORFISH

NORFISH, the acronym for a major Washington Sea Grant research program, is oriented toward developing a quantitative management system for the oceanic and coastal zone resources in the North Pacific--with a primary emphasis upon fishery resources. During 1973, NORFISH moved toward application of computer and quantitative methods developed earlier in the program. Under the direction of Dr. Lewis J. Bledsoe, a three-pronged program of information system development, resource system models and external agency liaison resulted in the following progress by the end of 1973.

The NORFISH graphic computer information system now has the capability of displaying statistical information distributed over a region as a three-dimensional perspective projection superimposed on a map of the area (see Fig. 1). The system was implemented using the NORFISH graphic remote display console, a Tektronix model 4010. The software was developed at Los Alamos Scientific Laboratory.

The system has been applied to the Japanese Bering Sea trawl data base by a graduate research assistant to yield an atlas of harvest levels by species and location. This project demonstrated potentially dangerous unreported harvest levels of halibut in the Bering Sea. Wide interest in the graphics system has been generated as a result of the Bering Sea Atlas. The International Pacific Halibut Commission has expressed an interest in using the system to depict halibut catch and effort levels along the Pacific coast. The Food and Agriculture Organization of the United Nations is interested in utilizing the system to display world fisheries data. The project to automate the reporting of Pacific coast trawl fishery data in cooperation with the Pacific Marine Fisheries Commission (PMFC) was completed by James Buss. Future work with the groundfish committee of PMFC may involve use of the graphics system with coastal trawl data. PMFC has responsibility for assembly of the coastal data for transmission, via the National Marine Fisheries Service, to the International North Pacific Fisheries Commission in fulfillment of the United States treaty obligations.

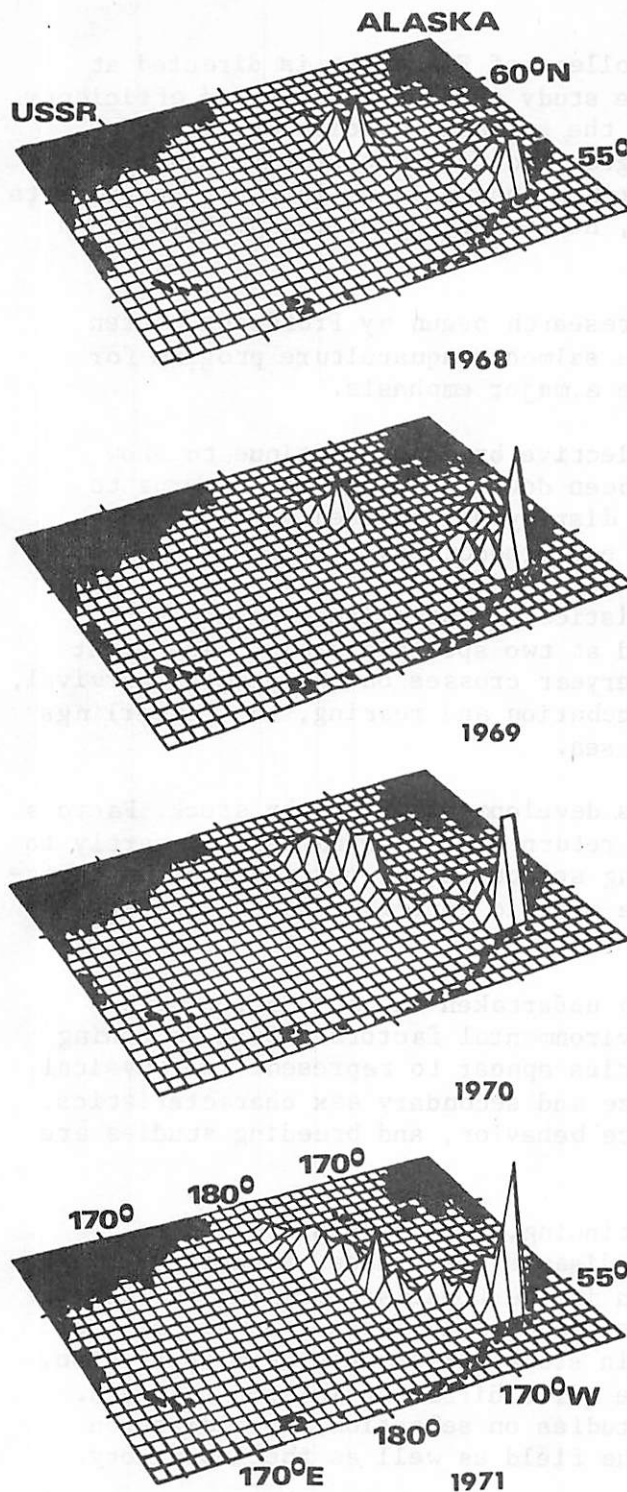


Fig. 1

not chronicled elsewhere. Sections on underutilized fish species, foreign fisheries in the Pacific including the spectacular Japanese fishery for Alaska pollock in the Bering Sea, and an analysis of U.S. and Canadian based fishing equipment and its capability for moving among fisheries are included.

In the area of fishery system models, the economic and biological multi-species trawl fishery model was completed this past year. Documentation of the validation and economic analysis of the model will soon be completed for the Washington trawl fleet. Additional work on fishery economics was also completed. This research effort on the crew share system of profit distribution in fishing vessels has shed light on the relative benefits of crew share versus a wage system of profit distribution.

This is a subject long debated by fishermen and fishing boat skippers. Research on models capable of predicting optimum management regulations, such as size limits, season lengths and area closures, for the sport and commercial salmon fisheries of Washington has been concentrated on various configurations of the GAMES multi-sector fisheries simulator. Although complete simulation of the Washington salmon fishery pushes currently available computer capacity, several smaller configurations are capable of providing answers for specific problems. For example, one configuration is aimed at the commercial coastal troll fishery and predicts catch in pounds and dollar value by that fishery as well as escapement to other inshore fisheries. The catch is expressed graphically as a function of management parameters. These results will be made available to negotiating teams currently working on a new salmon catch division treaty between the U.S. and Canada. This project is being developed in liaison with personnel of the Washington State Department of Fisheries.

A new project (NEPAC) of NORFISH was begun in 1973 to analyze possible configurations of U.S. fishing equipment to optimize harvests in the Northeastern Pacific. This project will require several years for completion. The first report, "Marine Fisheries of the Northeastern Pacific: A Synopsis," will be ready for publication in 1974. This volume details the recent history of many North Pacific fisheries

ANIMAL AQUACULTURE

Finfish Aquaculture

The salmonid aquaculture program at the College of Fisheries is directed at the improvement of culture technology, the study of diet sources and efficiency, and the development of brood stocks among the salmonid species utilized for sport and commercial production. The program includes cooperative studies with federal and state agencies, native tribes, and private industry on projects involving basic disciplines in management, nutrition, genetics, pathology and behavior.

Selective breeding and stock development research begun by Professor Lauren Donaldson has been an integral part of the salmonid aquaculture program for a number of years and continues to receive a major emphasis.

The results of the various programs in selective breeding continue to show improvement in the fish stocks that have been developed. Salmon returns to the University ponds in the fall of 1973 displayed increased survival to mature adults, larger size, and increased egg production.

In order to further enhance the characteristics of the chinook salmon run, the breeding program this year is directed at two specific areas. The first is an investigation of the effects of interyear crosses on the growth, survival, and population age composition. After incubation and rearing, the fingerlings will be marked and released to migrate to sea.

The second area of chinook salmon study is development of trophy stock. Factors responsible for large size at the time of return are believed related partly to the genetic constitution of the fish. Using selection and outcrossing, an investigation has been initiated to examine the genetic contribution to size at maturation.

Selective breeding of coho salmon has been undertaken in conjunction with studies on growth and the influence of environmental factors. Coho returning to the facilities at the College of Fisheries appear to represent two physical types, characterized by differences in size and secondary sex characteristics. The types are believed related to residence behavior, and breeding studies are exploring genetic differences.

The rainbow trout breeding program is continuing, with emphasis given to evaluation of family lines for mortality, disease resistance, fecundity, and growth. Even after years of selection in the Donaldson strain, variability in performance among family lines for these factors is large. Development of the brood stock also includes evaluation in stock performance as a sport fish. Criteria for commercial and sport fish are quite different in some respects. Meeting the requisites of both involves studies on selection, hybridization and outcrossing with evaluation made in the field as well as the laboratory.

In 1973 nutrition studies, researchers directed by Dr. Ernest Brannon compared the University's brood stock diet (principally salmon meal) with commercial feeds. Effects on growth and egg viability were the yardsticks by which diets were compared. Workers found that stock fed commercial diets showed viability levels as low as 40-45% while 80% egg viability occurred among stock fed the

University test diet. Although economics of the University's diet meal were not addressed in these studies, it should be noted that at least one commercial hatchery feeds the diet developed at the University.

Because feed sources are not always constant, scientists studied the growth and conversion rates of alternative protein sources on coho salmon. Using growth and survival as criteria, they found that of all sources studied--herring, codfish, flatfish, and dogfish--only dogfish meal proved inferior to the standard Oregon Moist Pellet diet, and that among the other protein sources, herring showed the best performance.

In 1973 the Fisheries Research Institute expanded its mariculture research, directed by Dr. Ernest Salo, by initiating pen rearing of coho and chinook salmon at the Naselle River estuary in Willapa Bay, the Elk River estuary at Bay City in Grays Harbor, and Henderson Inlet in southern Puget Sound. The objectives are to determine: (1) the environmental limitations of commercial mariculture, (2) the growth rates of each species on unlimited food rations, (3) the optimum pen densities for each species, and (4) the value of oral vaccines for control of *Vibrio* disease.

The Washington Department of Fisheries provided 18,000 of each species (chinook and coho salmon). Prior to transfer to the saltwater pens, 9,000 chinook salmon were given a 15-day oral vaccine immunization, and coho salmon a 7-day immunization. At the Bay City and Naselle River sites 1,500 fish were placed in each pen, with vaccinated and control fish in adjoining pens. At the Henderson Inlet site 1,000 and 2,000 each of the vaccinated and control fish were placed in the pens. Oregon Moist Pellet was the exclusive feed, and environmental data were recorded daily. Fish were sampled monthly for lengths and weights to ascertain the total effect of feed and environmental parameters.

Mortalities resulted from *Vibrio* disease, predators, and handling stress. The occurrence of *Vibrio anguillarum* may be a limiting factor in mariculture; therefore, the sources in the environment, the bacterial causative agent of the disease, and the effectiveness of available oral vaccines in disease prevention were considered as a part of the past year's work at Henderson Inlet. At this time, it appears from comparisons with control lots that no significant protection was obtained by the test groups since significant *Vibrio* outbreaks occurred at all sites during the summer. It is not known, however, whether the results are due to failure of the vaccine or to an inadequacy of present vaccination methods when applied on a large scale.

A research project to determine the effects of various incubation environments on the quality of chum salmon fry is underway at the Big Beef Creek Fish Research Station. Further experimentation is planned for the winter of 1973-74, with emphasis on standardization of flow rates in the various environments.

Under the cooperative sponsorship of the U.S. Environmental Protection Agency and the Washington Sea Grant Program, the Fisheries Research Institute is conducting an evaluation of the quality of receiving waters and affected biota associated with aquaculture facilities in the United States. This includes a critical review of the relevant literature, an inventory of anadromous fish

hatcheries and mariculture facilities and the status of their receiving waters and treatment methods, and sampling of water quality and benthic fauna influenced by operating salmonid mariculture facilities in Puget Sound.

The inventory indicated that pollutants produced during anadromous fish hatchery production--organic wastes, pathogens, and parasites, and medicinal chemicals and drugs--significantly increase BOD, ammonia, nitrite, nitrite phosphate, suspended solids and total solids in hatchery receiving waters.

The results of continuing sampling of benthos beneath salmonid culture pens in Puget Sound are indicating quantitative changes in the macrofauna and flora and organic nitrogen content of the affected sediments and associated benthic communities.

Shellfish Aquaculture

Research emphasis was placed on the Pacific oyster, Manila clam, and bay mussel during the past year.

The overall results of Pacific oyster raft culture suggest the importance of site selection and culture method to development of commercial growing in Puget Sound. The best approach may be to grow oysters on rafts for no more than one year to preclude severe fouling in the second year. Rearing to market size could be facilitated by placing oyster seed on rafts at a larger size or by raising the oysters for one year on rafts and for one year on ground.

At Seabeck Bay, studies of the growth rates of young Pacific oysters raised in stacked plastic trays and the effects of fouling have been carried on since July 1972. One third of the trays were placed on the beach at about the +2-foot tide level; one third were suspended 4 to 5 feet below the surface of the water by ropes attached to the dock; and the rest were initially put in a continuous-flow system in a laboratory, using bay water. Variations in waterflow required moving the laboratory cultures to the beach and dock sites.

Fouling is determined through monthly photographs and visual observation. The species composition of fouling organisms associated with the beach trays. On the former, most of the animals in the first 4 months of this study are sessile, or slow-moving, such as tunicates, anemones, sea urchins, sponges, and bryozoans, and only a few were small mobile amphipods. On the latter, the animals found were starfish, hermit crabs, littorine snails and blenny fishes.

An investigation of Manila clam seed planting was prompted by this clam's erratic and unreliable recruitment to some existing commercial potential beds. This study is concerned with the feasibility of using hatchery-propagated seed to replenish clam populations in marginal clam-producing areas in Puget Sound. In previous studies the reproductive cycle, setting, and growth of naturally occurring clams have been examined in select locations. In current studies the survival and growth of seeded clams under different environmental conditions, seeding methods, and bed types are being determined.

A small preliminary planting in November 1972 resulted in 100 percent mortality because of a bad freeze in early December. Success has been comparatively good with a planting in May 1973. Initial sampling showed losses ranging from 0 to 84 percent from handling and other stresses and migration to adjacent areas. Sampling in September 1973 revealed additional, differential disappearance among the experimental groups. Growth has been quite good over the summer in most of the areas, and the clams may be harvested as early as midsummer of 1974. Thus, a 2-year cycle in seeded clam beds may be obtained as opposed to the 3- to 4-year cycle in naturally seeded beds.

Although losses were higher in the more densely planted plots, it is not known whether the cause is a greater death rate in these plots or a greater emigration rate. Much needs to be learned about mobility of seeded clams and the optimum size of clam seed for planting to avoid predation, as well as other environmental causes of mortality. Further experimental plantings of seed clams in October 1974 and April 1975 should help better understand the situation.

An upswing in interest in mussel cultivation is occurring in the United States, especially in the New England states. Mussel culture was initiated at Seabeck Bay and Clam Bay on rafts used in previously completed oyster raft culture studies. In the spring and summer, several potential mussel seed-capturing devices were hung vertically at both sites, but few mussel seeds were obtained. Histological studies are presently being conducted on various size groups of mussels for determination of the reproductive cycle.

Temperature and nutrient enrichment of the sea water were found in the laboratory to be critical in abating or initiating a die-off of adult Pacific oysters. Artificial enrichment of the sea water with varying quantities of organic nutrient medium accelerated bacterial production and subsequently increased the rate of death at temperatures above 18°C. By manipulation of these two environmental factors, we have been able to control the mortalities in the laboratory.

Detailed studies as to the various types of bacteria that may be related to this mortality were conducted. There was a consistently high number of bacteria in the heart blood and pericardial fluid of moribund oysters and an absence of such a condition in healthy oysters. Histological sections through a special staining technique showed the appearance of concentrations of bacteria first in the stomach, next in the gills, mantle, digestive gland, pericardial fluid, and gonad.

Breeding the Pacific oyster for resistance to mortality apparently associated with *Vibrio* species was begun just this year. As an initial part of the program, populations of oysters are being sampled for characterization of possible genetic differences in commercial beds at several locations, some of which historically have shown high mortality and some low mortality.

Through this analysis, nine different genes have been found to vary within and among the populations. Calculations of the frequencies of the various types of genes within the populations have revealed that the groups sampled to date are not significantly different. This finding is not unexpected since most of the beds are "seeded" from a common source. Additionally, there have been no widespread mortalities on commercial beds recently to provide data on selective kill of susceptible oysters.

In laboratory experiments in which a large portion of test oysters were killed, it appeared that survival was better among individuals of a particular genotype. Although these results are preliminary, there is an indication that at least one gene can be used to "mark" oysters having slightly more resistance than others. Thus, these individuals could be chosen from a population for breeding stock.

Four shellfish hatcheries are now in operation or under construction in the State of Washington. The present high cost of hatchery operation is due partly to the cost of algal feed production which may approach 40 percent of the hatchery costs. Costs could be substantially reduced by either an extender of the algal food supply, or a replacement of the algae by a processed food. Unfortunately, there is little specific information on the nutritional requirements of oysters on which to design such modifications.

Brewer's yeast and red blood cells do not appear to be good foods for oyster juveniles, although providing a vitamin supplement may improve oyster larvae growth significantly.

At the relatively low levels fed, the starch replacement of an algal diet indicates that up to one half of the caloric content of an algal diet of juvenile oysters may be substituted by rice starch. Should this hold for higher feeding levels and for oyster larvae, the total operating cost of the hatchery could be lowered by as much as 20 percent.

Batch cultures are used to grow algae in most hatcheries, but the continuous culture system is better suited to hatchery production because it produces large amounts of algae per unit of floor space and provides better control of algal quality.

POPULATION ASSESSMENT

Although estimates vary, it is generally agreed that the impact of both commercial and sports fisheries on the Pacific Northwest economy is substantial. By assessing the abundance of these stocks at various depths and locations over time, Washington Sea Grant scientists are providing management agencies with data on which harvesting rationales for this regional resource can be based.

Acoustic techniques are the primary means by which fish stocks are assessed, and in 1973, research teams in the University's Fisheries Research Institute assessed stocks of hake and herring in Puget Sound, herring in southeastern Alaska, and sockeye salmon in several Washington lakes. Results of their surveys, which were made available to both federal and state fishery management and research programs, are described in the following paragraphs.

Hake in Port Susan and vicinity were surveyed acoustically during March and April. About 20 million pounds of hake were found in the survey area, which included Port Gardner, Possession Sound, and parts of Saratoga Passage. Only about one third of the hake was located in Port Susan; the amount was the smallest that had been found there since the surveys began in 1969. The results of midwater trawling in Port Susan also indicated a decreased population size.

Acoustic surveys of *herring in Puget Sound* were greatly expanded after preliminary studies in 1972. Herring were found during the day in narrow, high-density layers, rather than being uniformly distributed.

Surveys of *herring throughout southeastern Alaska* continued; the largest population encountered was in Bocas de Finis. Population estimates from four surveys ranged from 15.6 to 36.4 million pounds.

As in previous years, the abundance of *juvenile sockeye salmon* was assessed in *Iliamna Lake, Alaska* as part of a continuing monitoring of the utilization of the nursery grounds. A principal use of these estimates is to predict the magnitude of returns 3 to 5 years hence. Second, a mapping of the distribution of the juveniles in the lake gives a clue as to the degree of utilization of the nursery areas. In 1973, the abundance of sockeye salmon in Iliamna Lake was about half that observed in 1972 and about a tenth of that seen in 1971. The current period of low abundance is of special interest, since it provides an opportunity to evaluate the population of other pelagic resident fish. Small fish of other species cannot be distinguished acoustically from juvenile sockeye salmon, thus the determination of resident fish abundance can be used to estimate the proportions of sockeye salmon and other fish in the lake during periods of higher abundance of sockeye salmon.

A survey was also made in *Lake Nunavaugaluk, Alaska*. This lake is the site of a large program of enhancement of the *sockeye salmon* run in the Nushagak District that is being initiated by the Alaska Department of Fish and Game. In order to establish a baseline prior to the release of large numbers of artificially produced salmon fry, the distribution and abundance of limnetic, resident fish were assessed acoustically in 1973.

The *sockeye salmon run in Quinault Lake* is one of the more southerly runs of this species and is an important resource to the Quinault tribe. Acoustic techniques provide almost the only feasible means of assessing

the escapement and the resulting progeny of fry, which are needed for a scheme of rational management. At the request of the tribe, monthly acoustic surveys were conducted from October, 1972 through December, 1973.

In cooperation with the Washington State Department of Fisheries, biologists from the Fisheries Research Institute attempted to determine the size of the 1972 year class of *sockeye salmon* in *Lake Wenatchee* and *Lake Osboyoos*, the two remaining sockeye salmon-producing lakes in the Columbia River system. Acoustical surveys in the lakes conducted just prior to and immediately after out-migration of the sockeye salmon smolts.

Periodic monitoring of the size of the *adult sockeye salmon* population in *Lake Washington* by acoustical methods was continued in 1973. A series of eleven surveys over an identical transect pattern was completed during the months of June through November for estimation of the time and rate of movement into the lake, the total adult sockeye salmon escapement, and the rate of migration up the Cedar River. The estimate of escapement was similar to the estimate based on counts at the Chittenden Locks by the Washington State Department of Fisheries.

Estimates of the abundance of presmolt sockeye salmon in the lake were used in conjunction with estimates of adult escapement for further definition of the spawner-recruit relationship for the Lake Washington sockeye salmon run. A major goal is the development of a capability to predict escapement accurately from acoustic estimates of smolts.

Weekly surveys were conducted at dawn over the south end of Lake Washington in cooperation with personnel from the National Marine Fisheries Service. Maps reflecting the relative fish densities were constructed from these surveys and made available to recreational fishermen. After publication of the weekly map, distribution of boats fishing for adult salmon frequently appeared to be similar to the map's distribution of fish; however, a study of the change in the catch per unit effort of the recreational fishermen due to the maps was not conducted.

An economic- and management-oriented study of the recreational fishery was undertaken in conjunction with Dr. Stephen B. Mathews' Fisheries 367 class. Total catch, variation in catch per unit effort with date and time of day, and economic value of the fishery were estimated from data from angler interviews and boat counts. The estimated catch by recreational fishermen was 21,000, or less than 10 percent of the estimated adult escapement. The estimated expenditure by anglers per fish was \$20, or about \$4 per pound.

A supplement to the publication *Checklist of Puget Sound Fishes* (Washington Sea Grant Publication 72-3, July 1972) is being prepared. This supplement contains a listing of every available record for each fish species found in Puget Sound. Included for each species is a map of Puget Sound showing the location of each record.

Monthly otter trawl sampling was carried out at four locations. Two sampling locations were associated with studies for the Municipality of Metropolitan Seattle (METRO) to determine if Seattle's domestic sewage outfalls had any effect on fish populations, particularly with respect to incidence of diseased fish. The other two were associated with Washington State Department of Ecology studies to determine the preferred location of proposed sewage treatment plant outfalls. These studies are being conducted to minimize impact of future sewage discharge on the environment and on finfish and economically valuable shrimp and crab populations.

Assistance is also being given the Washington State Department of Fisheries and the Environmental Protection Agency in a study of the levels of potential pollutants in two common fish species at four areas in Puget Sound (Bellingham Bay, Duwamish estuary, Nisqually delta, and Big Beef Harbor in Hood Canal). Work is commencing on a habitat classification system for the Puget Sound nearshore environment, and a study of the fish populations inhabiting near-shore rocky areas and kelp beds.

NEW MARINE MATERIALS

Both economic and environmental concerns are behind several Washington Sea Grant projects involving the utilization of seafood processing wastes as well as the development of uses for other marine materials. Because of these studies, new industries have resulted and economical alternatives for pollution abatement around seafood processing plants have been found.

Protein Extraction

Working toward a total utilization concept, Professors John Liston and George Pigott in the Institute for Food Science and Technology have developed methods by which protein can be extracted from finfish or shellfish processing wastes or from whole scrap fish. So successful is this effort, that the researchers, using a brine-acid process, can now turn out a very low lipid fish meal from fish waste high in lipid content. This meal is in demand as stock feed.

A second extraction process, centered around enzyme hydrolysis, produces a high quality fish protein concentrate (FPC) that could meet requirements for human consumption. The researchers have concluded that the enzyme hydrolysis treatment must be a continuous production process before it can be economically feasible and thus are concentrating on this aspect of a pilot plant. By 1974, it is hoped that a portable pilot plant can be set up and moved to various sites in Alaska for field demonstrations.

Chitin/Chitosan

Once shellfish waste has been de-proteinized, the exoskeletons, which are composed primarily of chitin, can be ground to a uniform particle size and utilized. Chitin performs well as a substrate for long-term timed release of chemicals such as herbicides and pesticides. Converted to chitosan by a pilot plant process developed by Food Chemical and Research Laboratories, Inc., of Seattle, the product is in demand in nonwoven fabric manufacturing, and especially in pulp and paper production.

To assist in the further development of new uses for chitin and chitosan Sea Grant cooperated with the Oceanographic Commission of Washington to make these products available to researchers throughout the world at no cost other than shipping and handling. During 1973, 428 pounds of chitin and 533 pounds of chitosan were distributed in hopes of expanding the market and uses of this material.

Even though this is not strictly a Sea Grant sponsored research project (rather, it is a market development project), it is interesting that significant breakthroughs have been achieved in the technology of de-mineralization by substituting sulfuric acid (H_2SO_4) for hydrochloric acid (HCl). H_2SO_4 is a much milder product and safer to transport, store, and use than HCl. This is significant when one considers that recovery plants often will be in remote areas. H_2SO_4 can easily be made at the plant from sulfur, a commodity which is becoming less expensive all the time since large quantities of sulfur are being extracted from coal and oil to make more environmentally acceptable fuels. Production techniques have been developed to steam strip the residues, thereby recovering approximately one half of the acid for recycling. A significant amount has been learned at the pilot plant about handling the raw materials, increasing efficiency in the processing. Optimum particle size has been determined and the filter screens adjusted accordingly. This knowledge will influence future commercial plant design.

Two noteworthy changes in project scope occurred during the year. Besides processing shellfish wastes from Puget Sound plant sources, experimental batches of blue crab waste from Chesapeake Bay, Atlantic red crab waste from New England, lobster waste from Nova Scotia, and crayfish waste from Louisiana were processed into chitosan at the plant. These experiments were conducted because adaptability of the process to a variety of raw materials is necessary to its success in other regions.

The second project development holds promise for salmon farmers whose pen-reared products frequently lack the pink flesh preferred by consumers. To help solve this problem, project investigators looked at ways of recovering pigment from the bright pink and red shells of several species of crustaceans and of adding the pigment to salmon feeds.

Marine Polymers

In the College of Forest Resources, Dr. Graham Allan directed further research on utilization of chitosan in paper and nonwoven fabrics. Pilot-scale paper machine trials have shown that laboratory results are translatable to

industrial-sized uses. At the 1% addition level of chitosan, the dry strength of paper was increased by 33% and the wet strength was 44% of the dry strength of the untreated sheet. Surprisingly, printability was simultaneously markedly improved. With this encouragement, a company, the Keypro Corporation, has been formed to produce chitosan in large quantities (400,000 pounds per year, reputedly).

In other areas, water soluble polymers which appear to be novel have been isolated from uni-cellular red algae. Plant antiviral activity of polysaccharides derived from seaweed have been demonstrated and shown to be associated with the branched, highly charged nature of these polymers. A new procedure for the determination of the molecular structure of polysaccharides has been developed using nuclear magnetic resonance.

Aquaculture of Marine Algae

A relatively untapped marine resource of the Pacific Northwest is its commercially valuable marine algae, so Washington Sea Grant scientists like Robert Waaland are experimenting with various cultural techniques to learn which methods are best for economically growing this resource at a maximum sustained yield. Present emphasis is on the carrageen-producing red algae, *Iridaea* and *Gigartina*.

Whereas previous emphasis had been on obtaining successful colonization of seaweeds on artificial substrates in the natural environment, it now seems that greater emphasis should be placed upon development of cultures in large tanks supplied with running sea water and compressed air agitation, in which free-floating plants are cultivated. Accordingly, construction of large tanks for such culture experiments was begun at the National Marine Fisheries Service Aquaculture Research Station at Manchester, Washington. The commercial firm, Marine Colloids, Inc., is collaborating very closely in this part of the research. It is currently believed that tank culture systems offer the best prospects for an economically successful large scale aquaculture production.

Concurrently, experiments to correlate the type of carrageen with the life history phase of the plant have been conducted. This has important economic significance for aquaculture, besides being of intrinsic biological interest.

Work is continuing on determining optimum growth rates and optimum depths for populations of plants grown on artificial substrates suspended from rafts.

All of this information on basic biology and ecology of *Iridaea* and *Gigartina* populations and the marine communities of which they are a significant component has been gathered for interpretation as a guide for rational management policies for this marine resource.

Aequorin

During 1973, project investigator Samuel Felton concentrated his efforts on developing assay procedures for the protein aequorin that is obtained from the jellyfish *Aequorea aequorea* found in substantial numbers in the waters of

Puget Sound. Aequorin is the substance that causes these jellyfish to bioluminesce, and, when extracted, has the unique property of bioluminescence in the presence of the calcium ion, the amount of luminescence being proportional to the amount of calcium present. Content of body fluids is an important index of general health, and since medical researchers are investigating the role of the calcium ion in the regulation of cell function, it is important that a suitable intracellular ionized calcium indicator be available. Aequorin is the only known chemical that is suitable for the task.

The importance of the study is reflected in the fact that two commercial companies are making contributions to the effort. One, Quinton Laboratories of Los Angeles is supplying the quantities of valuable ion-free serum being used in the study. The other, the American Instrument Company, a division of Travenol, has offered the use of a new instrument for evaluation of the study.

Research objectives for 1973 were achieved when investigators established a purification procedure suitable for a large-scale economic production of aequorin. Subsequently, contacts were established with the Sigma Chemical Company to perform market tests on aequorin during 1974. Clinical evaluation of aequorin is well under way with collaborative efforts-involving the chief chemist from the University of Washington Hospital and a physician at the Veterans Administration Hospital, Seattle.

MANAGING THE NEARSHORE ENVIRONMENT

In recent years competition for the water-related resources of Puget Sound has greatly intensified, but unfortunately approaches to decision-making have been highly fragmented and hence inadequate to cope with this growing competition. To ensure best use of the nearshore environment, wise planning, an assessment of alternatives, and development of appropriate regional institutions are thus essential.

During 1973, Sea Grant efforts continued with the aim of integrating some of these fragmented approaches toward a solution of problems, particularly a resolution of nearshore use conflicts and a definition of changes necessary or desirable in the resolution of these conflicts.

Socio-economic, Institutional, and Legal Considerations In the Management of Puget Sound

This study, under the direction of Professor Crutchfield and Professor Robert Bish, is expected to provide the major source of information on management of water and land resources in the Puget Sound area, on the basis of case studies surrounding public controversies over potential uses of Puget Sound shorelines. The culmination of five years' work on the project will be a substantial book entitled, Coastal Zone Resource Use: Decision-Making in the Puget Sound Region. Even though the book deals with the Puget Sound area, it is obvious already from the number of prepublication inquiries that the book will be of interest and application nationwide. It should provide

public officials, academicians, and concerned citizens with a thorough understanding of demands placed on shoreline resources, processes by which uses are determined, and consequences of alternative legal structures for future management. Joint publication by Sea Grant and the University of Washington Press is planned for late 1974 and will be supported by a grant from the Washington State Department of Ecology.

Biological Production Model for Puget Sound

Since 1966, METRO (the municipality of metropolitan Seattle) has daily been discharging about 45 metric tons of treated sewage-sludge from its West Point plant into Puget Sound. This activity, which was terminated January 1, 1973, inevitably raised questions about its effects upon the biological production of the Sound.

Accordingly, an investigation was initiated to identify the environmental and physiological factors that govern the biological production of this environment. Taking historic hydrographic and biological data supplied by the University's oceanographers, Sea Grant scientists have constructed a mathematical model describing the effects of environmental factors upon phytoplankton growth in Puget Sound.

One of the major objectives of 1973 was to document the results of the past years' efforts. A number of papers dealing with various aspects of biological modeling have now been written and submitted for publication in scientific journals and delivered at symposia. A monograph has also been drafted describing hydrography and circulation in the central basin of the Sound and its relation to phytoplankton production. The knowledge and insight gained in modeling hydrographic and biological processes have made it possible to identify those environmental factors of greatest importance in determining primary production levels in Puget Sound.

During 1973, Professors Donald Winter and Karl Banse of the Department of Oceanography expanded contacts with agencies at the federal and local level to inform them of findings for the purpose of formulating policy and making decisions regarding the management of water resources.

Marine Environment of Puget Sound

Puget Sound is a complex estuary with many branches. As yet it is relatively unspoiled by the influence of man, but to keep it unspoiled it is essential to make intelligent decisions regarding its use--decisions determined, to some extent, by the data available to those concerned. For some 40 years, oceanographers at the University of Washington have been collecting data on the marine environment of Puget Sound. Realizing the importance of these data, Sea Grant is supporting their organization, computer storage, and subsequent publication in readily accessible and usable formats. Two major works have already been published jointly by Washington Sea Grant and the Department of Natural Resources: Index to Physical and Chemical Oceanographic Data of Puget Sound and Its Approaches, 1932-1966 and Bibliography of Literature: Puget Sound Marine Environment. The wide demand for these publications attests to their importance and usefulness.

Work on a third publication in this series was carried forward in 1973. Authors Eugene Collias, Noel McGary, and Clifford Barnes submitted all drawings and text for An Atlas of Physical and Chemical Properties of Puget Sound and Its Approaches for publication in June 1974. This atlas presents vertical profiles of temperature, salinity, density as sigma-t, dissolved oxygen, oxygen saturation, and inorganic phosphate and is based on observations made from 1952 through 1966. The atlas is planned to provide graphical data on Puget Sound for anyone making decisions based upon the physical and chemical characteristics of these waters. Ocean engineers, commercial fishermen, fish farmers, regulatory agency personnel, and legislators are among those who will be interested in the data portrayed. The book is being published by Washington Sea Grant with support from the State of Washington Department of Ecology and is being distributed by the University of Washington Press.

At the request of the Washington State Department of Ecology, a study of two potential locations for sewer outfalls was started: one at the north end of Pickering Passage and the other off Union in southern Hood Canal. Three field trips were made to the study areas to determine the chemical and physical properties of the waters. These data, in combination with other data already collected, will be used in the preparation of a technical report discussing the potential effects of these proposed outfalls on local areas.

SUPPORTING SCIENCE AND ENGINEERING

With the growing recognition of the marine environment as a valuable national resource, it is important to develop more efficient means for exploiting the ocean's potential for public and commercial use. Two Washington Sea Grant projects were directed toward these objectives in 1973. The first was an engineering effort aimed at testing floating structures; the second project involved development of hardware and techniques that would provide more accurate acoustic assessments of aquatic populations.

Testing Floating Structures

Floating breakwaters may provide an economical alternative to permanent installations, so Washington Sea Grant engineers like Dr. Gordon Gray of the Applied Physics Laboratory are developing techniques for testing the strength and efficiency of these and other floating structures. Their work is facilitated by two instruments developed in earlier Sea Grant engineering projects.

The first of these instrument packages can sense the six different modes of motion (roll, pitch, heave, yaw, surge, and sway) experienced by an object floating in a sea state, and it can produce a tape record for subsequent computer analysis. A second package automatically records data from wave fields in remote locations.

Several of these are being used to monitor breakwaters installed at Friday Harbor, Washington and at Tenakee Springs, Alaska. Collection of the first field data on full-scale sea state and breakwater interaction began in 1973, and analyses are in progress.

Besides testing hardware, the engineers also developed a two-dimensional theoretical model to describe breakwater dynamics and efficiency as a function of wave characteristics, breakwater geometry, and anchor forces.

Although the primary goal of this project is providing structurally sound yet cost effective designs for floating breakwaters, the impact of this effort has not been limited to breakwater design. For example, the Washington State Highway Department is utilizing this engineering technology in design studies for modifications of floating bridges, and the city of Kirkland has found data from this study useful in compiling an environmental impact statement on waterfront installations.

Marine Acoustics

Studies of aquatic populations described earlier have been accelerated by the theoretical work and hardware developed by scientists and engineers in Washington Sea Grant's marine acoustic program. Much of this acoustic research has been based upon earlier work, conducted by the University's Applied Physics Laboratory under auspices of the U.S. Navy, to produce devices capable of filtering biological noises from underwater sound sources.

Ironically, it is the filtered biological noises which constitute the primary data needed for fish stock assessment and subsequent management. Early project developments involved cooperative field work with the State of Washington Department of Fisheries, the Alaska Department of Fish and Game, and the National Marine Fisheries Service. The major breakthrough was the transfer from an analog echo integrator to an echo integrator that produced its output in digital form.

These developments led to further refinements for the National Science Foundation's coastal upwelling experiment in which sensors mounted on a controllable towed body were coupled with the digital output of the echo integrator.

In 1973, investigations were made into the problem of assessing high-density fish populations by acoustic means. The original impetus for this work came from salmon farmers who need to monitor fish densely packed in rearing pens. But results of this effort should also prove useful for assessing stocks of densely schooled fish, such as anchovies, in their ocean environment.

EXPENDITURES BY CATEGORY OF EFFORT

ACTIVITY SHEET*

Washington Sea Grant Program - 1973

	<u>Sea Grant Funds</u>	<u>University Matching Funds</u>
PROGRAM MANAGEMENT	\$ 80,777	\$ 65,195
ADVISORY SERVICES	247,466	96,815
EDUCATION & TRAINING		
New University Courses	113,772	120,700
Technician Training	70,693	103,445
RESEARCH & DEVELOPMENT		
NORFISH	145,078	44,880
Animal Aquaculture	234,584	59,245
Population Assessment	71,945	36,890
Applications of New Marine Materials	207,467	90,015
Managing the Nearshore Environment	57,038	16,065
Marine Acoustics and Ocean Engineering	87,291	32,045
	<hr/>	<hr/>
TOTALS	\$1,316,111	\$665,295

*This summary is only approximate and represents expenditures for the first 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.

1973 PUBLICATIONS

Key to sources from which publications can be obtained is at end of this publications listing.

ADVISORY SERVICES

Norris, Louisa, Kenneth K. Chew, and Alyn C. Duxbury. June 1973. Shellfish and the red tide. Reprinted from June 1973 issue of Pacific Search. 2 p. WSG-AS 73-2. Available from DMR or NTIS No. COM-73-V1899/4AS.

Ronning, John P. March 1973. Refrigeration systems on smaller fishing vessels. 17 p. WSG-AS 73-3. Available from CPEC.

Johnson, Eugene. July 1973. Oyster delights. (recipe cards) WSG-AS 73-5. Available from GHC. Bulk sales only.

Johnson, Eugene A. July 1973. Beach logs kill. (poster) WSG-AS 73-7. Available from DMR or GHC.

Local impacts of the law of the sea. July 1973. Proceedings of a conference sponsored by the Council of Organization for International Affairs, the Battelle Memorial Institute, and the Washington Sea Grant Program, held in Seattle, October 10-11, 1972. 150 p. WSG-AS 73-8. Available from UWP. \$5.00.

AQUACULTURE

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Moring, John Richard. 1973. Aspects of growth, and the effects of some environmental factors on pen-reared chinook salmon, Onchrhynchus tshawytscha (Walbaum) in Puget Sound, Washington. Ph.D. Dissertation, Univ. Wash. 225 p. WSG-TH 73-3. Available through UWL.

Allendorf, Frederick W., and Fred M. Utter. August 1973. Gene duplication within the family salmonidae: disomic inheritance of two loci reported to be tetrasomic in rainbow trout. 3 p. WSG-TA 73-21. Available from NMFS, NTIS COM-74-10494.

Traynor, Jimmie John. 1973. Seasonal changes in the abundance, size, biomass, production and distribution of the pelagic fish species in Lake Washington. M.S. Thesis. 91 p. Univ. Wash. WSG-TH 73-8. Available through UWL.

Lie, U., and R.A. Evans. 1973. Long-term variability in the structure of subtidal benthic communities in Puget Sound, Washington, U.S.A. 10 p. WSG-TA 73-8. Available from DMR.

COASTAL ZONE MANAGEMENT

Harrison, Peter. June 1973. The land water interface in an urban region: a spatial and temporal analysis of the nature and significances of conflicts between coastal uses. Ph.D. Dissertation, Univ. Wash. 182 p.
WSG-TH 73-1. Available through UWL, NTIS No. COM-73-11257.

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WSG-AS 73-4. Available from UWP. \$5.00.

MARINE ACOUSTICS - POPULATION ASSESSMENT

Ehrenberg, John E. January 1973. Estimation of the intensity of a filtered Poisson process and its application to acoustic assessment of marine organisms. 135 p.
WSG- 73-2. Available from DMR or NTIS No. COM-73-11912/5AS.

Ehrenberg, J.E., and D.W. Lytle. 1973. Some signal processing techniques for reducing the variance in acoustic stock abundance estimates. Paper presented at Symposium on Acoustic Methods in Fisheries Research, Bergen, Norway, June 19-22, 1973. 17 p.
WSG-TA 73-5. Proceedings.

Thorne, Richard E. 1973. Digital hydroacoustic data-processing system and its application to Pacific hake stock assessment in Port Susan, Washington. Fishery Bulletin 71(3):837-843.
WSG-TA 73-9. Available from DMR or NTIS No. COM-74-10893/AS.

Ehrenberg, John E., and Dean W. Lytle. September 1973. A bound on the variance of fish abundance estimates obtained from acoustic echoes. Paper presented at IEEE Conference on Engineering in the Ocean Environment, Seattle, Washington, September 25-28, 1973. 4 p.
WSG-TA 73-13. Available from DMR or NTIS COM-74-10573.

Nunnallee, Edmund Pierce, Jr. 1973. A hydroacoustic data acquisition and digital analysis system for the assessment of fish stock abundance. M.S. Thesis. 70 p.
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Thorne, Richard E. 1973. Application of acoustics to the assessment of the Pacific hake population in Port Susan, Washington, 1969-1973. Proceedings OCEAN 73 International Conference on Engineering in the Ocean Environment: 249-252.
WSG-TA 73-23. Available from DMR.

Sprigarelli, S.A., G.P. Romberg, and R.E. Thorne. 1973. A technique for simultaneous echo location of fish and thermal plume mapping. Trans. Amer. Fish. Soc. No. 2:462-466.
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Thorne, Richard E. 1973. Acoustic assessment of Pacific hake and herring stocks in Puget Sound, Washington, and Southeastern Alaska. Paper presented to the ICES/FAO/ICNAF Symposium on Acoustic Methods in Fisheries Research held in Bergen, June 19-22, 1973. 30 p.
WSG-TA 73-25. Available from DMR.

Mathisen, O.A., T.R. Croker, and E.P. Nunnallee. 1973. Acoustic estimation of juvenile Sockeye salmon. Paper presented at the ICES/FAO/ICNAF Symp. on Acoustic Methods in Fisheries Research held in Bergen, June 19-22, 1973. 22 p.
WSG-TA 73-26. Available from DMR.

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WSG-TA 73-27. Available from DMR.

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Dawson, James Joseph. 1972. Determination of seasonal distribution of juvenile sockeye salmon in Lake Washington by means of acoustics. M.S. Thesis, Univ. Wash. 112 p.
WSG-TH 73-7. Available through UWL.

OCEAN LAW

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Cannon, Glenn A. 1973. Observations of currents in Puget Sound, 1970. 77 p.
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Liston, J., and J. Baross. 1973. Distribution of Vibrio parahaemolyticus in the natural environment. J. Milk and Food Technology 36(2):133-117.
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Allan, G.G., G.K. Crosby, J.H. Lee, M.L. Miller, and W.M. Keif. 1973. New bonding systems for paper. Paper presented at symposium of man-made polymers in papermaking, Helsinki, Finland, June 1972. 12 p.
WSG-TA 73-15. Available from DMR, NTIS No. COM-73-11905/9AS.

Young, R.A. September 1973. Kinetics and structural aspects of alkaline degradation of polysaccharides. Ph.D. Dissertation, Univ. Wash. 55 p.
WSG-TH 73-9. Available through UWL.

Crosby, G.D. September 1973. The utilization of chitosan as a papermaking additive. Ph.D. Dissertation, Univ. Wash. 97 p.
WSG-TH 73-10. Available through UWL.

Onoue, Y., and V.M. Riddle. 1973. Use of plastein reaction in recovering protein from fish waste. J. Fisheries Board of Canada 30:1745-1747.
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Low, L.L. 1973. Chlorophyll "a" pigment analysis. Computer Program FRL 323 B. Fish net engineer, Seattle, Marine Fishing Supply.
WSG-TH 73-11. Available through UWL.

Waaland, J.R. 1973. Experimental studies on propagation of Iridaea and Gigartina. Journal of Phycology 9:12.
WSG-TA 73-14. Available from DMR.

KEY TO SOURCES FOR OBTAINING 1973 WASHINGTON SEA GRANT PUBLICATIONS

CPEC	Clover Park Education Center 4500 Steilacoom Blvd. S.W. Lakewood Center, Washington 98499
DMR	Division of Marine Resources University of Washington 3716 Brooklyn Avenue N.E. Seattle, Washington 98195
GHC	Grays Harbor College Aberdeen, Washington 98520
NTIS	U.S. Department of Commerce National Technical Information Service Springfield, Virginia 22151 (please include NTIS number with your request)
UWL	Suzzallo Library Interlibrary Loan Office University of Washington Seattle, Washington 98195
UWP	University of Washington Press 1416 N.E. 41st Seattle, Washington 98195
Proceedings	Proceedings published by society listed, but reprints were not made available.