·ACCOMPLISHMENTS·

BIENNIAL REPORT · 1981 & 1982

Washington State. The 20th largest state in the Union, both in terms of area (66,511 square miles) and population (4,132,156 in 1980). But this "middle-size" state occupying the Northwest corner of the continental United States is bounded by one of the nation's longest seawater coastlines—extending some 2,656 miles.

On the south, Washington shares with Oregon the nation's second largest river system, the Columbia, and its estuary. On the west, the seacoast has two distinct regions—the rocky, mountainous, relatively inaccessible northern half, and the sandy, low terrain, and readily accessible southern half. The low-lying coast of the southern half is interrupted by two large estuaries—Willapa Bay and Grays Harbor—which provide homeports for fishing fleets, important wetlands for marine life, and cargo ports. The northwest corner of the state is bounded by the greater Puget Sound system, a large island-studded, inland sea with 1,411 miles of shoreline.

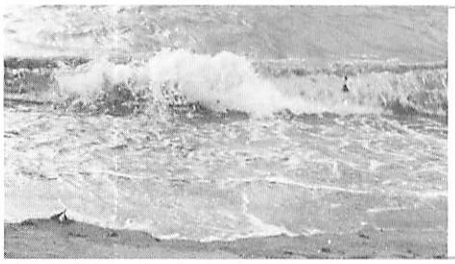
The activities that result from this geography are as varied and abundant as the terrain itself. For instance:

- There are 73 public port districts—more than 50 are active—in Washington. Eleven provide deep-water ocean terminal facilities, seven accommodate slackwater barge traffic, and 38 engage in industrial development activities.
- Washington State supports one of the largest salmon production programs in the world. In 1982, 319 million of these fish were released by public and private hatcheries into Washington waters. That is 53 percent of the 600 million fish released by all hatcheries in Alaska, Washington, Oregon, Idaho, and California combined.
- The State of Washington annually issues 8,000 to 9,000 commercial fishing licenses. However, this statistic reflects only a portion of Washington's commercial fishing fleet which operates not only in local waters, but also off the U.S. Pacific Coast from California to the Bering Sea.
- In 1982, U.S. fish landings exceeded 6.3 billion pounds for a value of more than $2.3 billion. Traditional reporting systems attribute a tenth of this volume and an eighth of the value to Washington fishermen. However, a recent study commissioned by the National Marine Fisheries Service suggests that if U.S. fish landings were examined by the catchers' state of residence, Washington's national ranking probably would be elevated to fourth by volume and second by value.
- The same study estimates that the total 1981 catch by Washington based fishing vessels from the fisheries conservation zone and in Washington and Alaska waters was 655 million pounds valued at $307 million.
- Washington oyster production is about five times that of the other Pacific coast states combined and annually ranks third or fourth in the nation.
- Approximately 350 seafood processing companies are headquartered in Washington State. The majority of these firms have at least one plant located in Washington and most of those plants are in the greater Puget Sound area. The remaining plants are scattered along the coast and the Strait of Juan de Fuca.
- More than 200,000 motorized pleasure craft are owned and operated in western Washington waters. An unknown number of kayaks, rowboats, day sailers, and other non-motorized craft swell this fleet considerably.
- In western Washington marine waters well over 200 private marinas and boat and yacht clubs provide two-thirds of all wet moorage facilities for these small craft.
- Citizen concern for the state's marine and coastal resources is deep. It is evidenced by the fact that in 1971, voters approved one of the earliest state shoreline management acts in the country. In 1976, Washington became the first state to receive federal approval for its coastal management program.

It is clear from these examples that Washington State is a place where the marine "action" is. It is to the needs and opportunities of these sectors that the Washington Sea Grant program, administered by the University of Washington, addresses itself through research, educational programs, and advisory services. This report describes some of these efforts and describes why and how this university-based program is working in partnership with industry, government, and citizens and providing innovative leadership for addressing problems and opportunities of marine resource conservation, development, and management.

This report covers the calendar years 1981-1982, the most tumultuous period in the history of the National Sea Grant College Program and a time of transition for our own Washington program.

For a time early in 1981, it appeared that the national program would disappear, a victim of massive federal budget cuts. Then, as the year progressed it became apparent to the Congress that Sea Grant, in the words of a congressional committee, is one of the most efficient, cost-effective programs in which the federal government is involved. It became abundantly clear that Sea Grant is an investment in the future of the nation's marine resources, and that we are part of the solution to the nation's problems.



Washington Sea Grant—a university-based partnership with industry, government, and citizens that is providing innovative leadership for addressing problems and opportunities of marine resource conservation, development, and management—

By just one measure of productivity alone—economic benefits—it was shown that annual economic benefits of Sea Grant equalled more than six times the current annual federal expenditure on the national program. The present annual economic yield—as measured by sales and by increased fishing revenues—of just one area of Washington Sea Grant endeavor, marine acoustics, closely approximates the annual federal investment in *all* of the Pacific area Sea Grant programs. This is no mean achievement for a small, young activity.

It is too soon to declare that Sea Grant has weathered the crisis of the early 1980s. However, over the past two and a half years the program has received a number of clean bills of health, and it is now widely acknowledged that in any decision based on the merits, this program will be sustained. This report shows why and demonstrates how the Washington Sea Grant Program is serving the needs of the state, region, and nation. The items covered in the report also underscore a number of themes that are essential to a successful program. As we complete our fifteenth year and strive to continue and increase our record of achievement, these themes need to be emphasized, not only as guides to the future but as an affirmation that Sea Grant has long been pursuing a program of scientific achievement and social benefits that should be a model for current state and national scientific and development policy across the board. As you read this report, many of these themes will be evident.

- Sea Grant is a *university-based partnership* involving industry, government and citizens in a unified approach of education, research and advisory services designed to promote wise use of our marine resources.
- A Sea Grant College has a primary responsibility for *strategic research* that provides a fundamental underpinning for marine resource use. Activity runs across a continuum from basic work in the laboratory to applications in the field—or classroom—and back again. For Sea Grant the test for supporting an activity is whether it contributes to our understanding of a marine resource problem or to the education of the manpower needed to address future problems.
- Sea Grant is a *long-term investment* involving many people over time. While there may be many short-term benefits along the way, real progress in science and in resource policy requires sustained effort and a steady program of development.
- Sea Grant's most notable achievements involve *high risk* research, work in areas that industry and mission-oriented agencies must eschew. Sea Grant follows an investment model, supporting a range of well-articulated projects by the soundest investigators, and placing calculated bets that some of today's risks will be tomorrow's triumphs.
- Sea Grant is a *grassroots* program—first identifying problems and opportunities where they exist; then applying to them the resources of the universities, our nation's primary reservoir of scientific talent; and finally ensuring that the results are made available to the international scientific community and to those in society who can use the results.
- Sea Grant is a *network* of people operating across the country and indeed throughout the world. Besides being a partnership among universities, industry, government and citizens, Sea Grant is a partnership among sister-institutions in the Pacific region, in all coastal and Great Lake states, and among fellow professionals throughout the world.

There are many challenges ahead. Washington has a bountiful treasury of marine resources, but many of these resources are stressed, and all need careful husbandry. At the national level, events of recent years have led to the President's declaration of an exclusive 200-mile economic zone, amplifying the needs for trained personnel and for continued sound resource and scientific policy. Advances in such areas as biotechnology offer possibilities for quantum jumps both in scientific understanding and in the applications of science. The needs and the opportunities for a network of Sea Grant colleges are greater than ever.

In closing, I offer my thanks to the dedicated faculty, students, and staff who have served this program, university, and state so well, and who have given distinction to the Washington Sea Grant Program. I would particularly like to pay tribute to my predecessor, William R. Davis, who guided this program over the past three tumultuous years. This report is a record of his stewardship of the program and a testimonial to a career of distinguished service.

Louie S. Echols
September 1983

RESEARCH

During 1980-81, Washington Sea Grant supported 38 major research projects and in the following pages accomplishments of selected projects are featured. Most projects were carried out at the University of Washington and involved more than 40 faculty members and almost 90 students. The remaining projects—such as the seaweed demonstration farm described in the story here—were conducted by institutions and research organizations across the state and, occasionally, in neighboring states.

A Seaweed Farming Industry for Washington State

The use of Puget Sound waters for aquaculture took a step forward this year with the first harvest of *Porphyra*, an edible red seaweed, from demonstration culture facilities in the lower Sound. Washington Sea Grant's long-term commitment to the development of a seaweed aquaculture industry in the Sound, recently assisted by the Washington Department of Natural Resources and the Pacific Northwest Regional Commission, began to pay off as marine biologist Thomas F. Mumford demonstrated that techniques used for nori culture in Japan will work in Washington waters as well. Mumford's success has stimulated the establishment of several private nori farms in the state.

Nori, produced from the seaweed *Porphyra* or other flat seaweeds, is a product of an old and well-established industry in Japan. Once harvested, the seaweed is processed into dried thin sheets for sale. Consumers use the product as a wrapper for rice and fish or crumble it as a topping for rice and soups.

Mumford's winter 1982 harvest, totalling 2,000 sheets, was judged by Japanese nori officials and Washington importers and restaurant owners to be of moderate to excellent quality. Mumford took advantange of the availability of nori processing facilities in Japan and arranged for his crop to be processed there.

The 1982 nori crop was sown with certified pathogen-free cultures of *Porphyra* plants from Japan. A microscopic phase of the seaweed's life cycle, called the conchocelis phase, was grown in shells during the summer. This phase releases "seed" or conchospores which will attach to nets, allowing growth of the edible blade on the nets suspended in seawater during the fall.

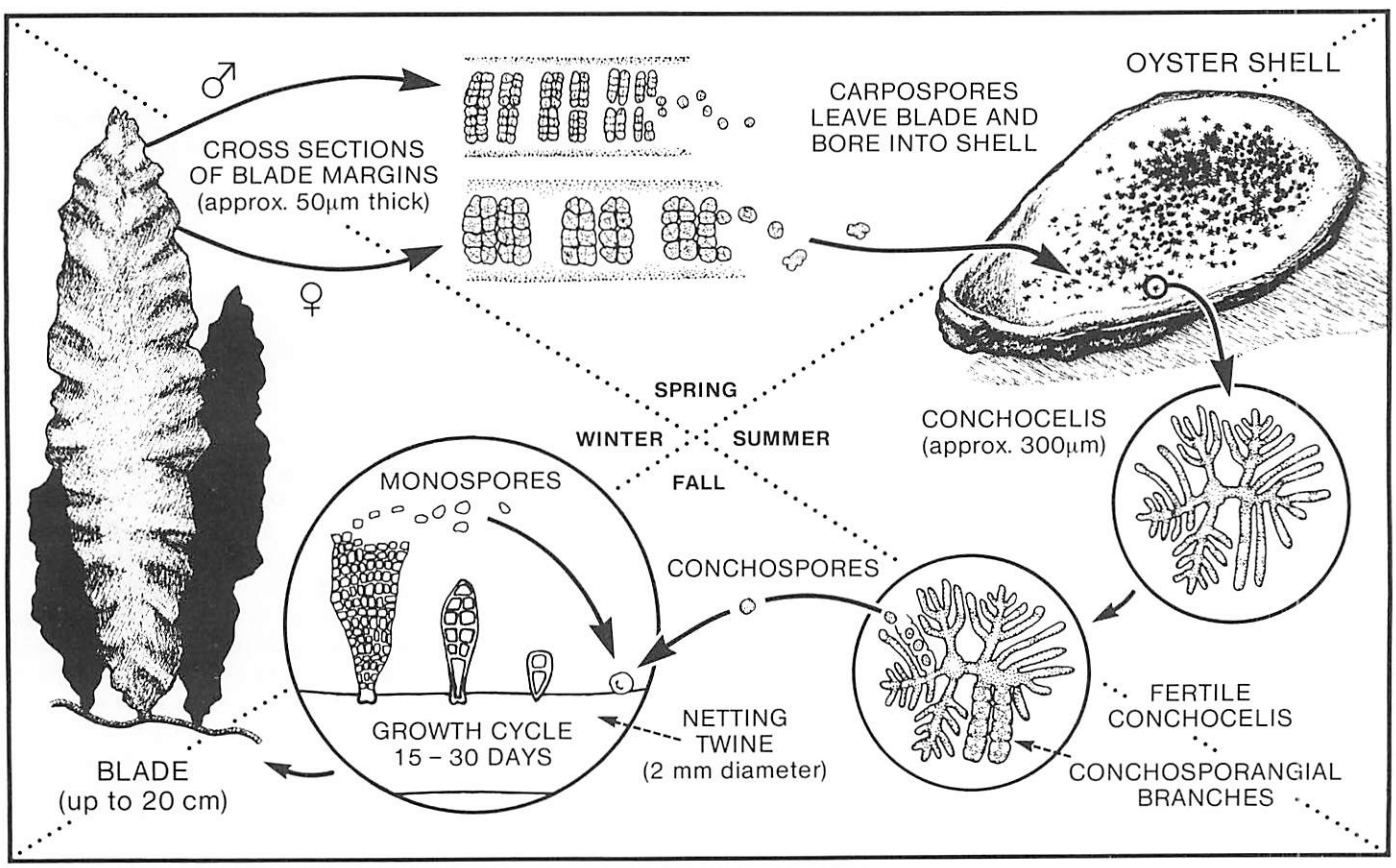


Illustration by Radek Tune

Though Japan's nori production is a centuries-old tradition and is still largely cultivated on family "farms," science and technology have made significant contributions to the industry. No one knew the complete life cycle of the seaweed until 1949, when the British phycologist Kathleen Drew Baker discovered the conchocelis phase of the plant's two-phase life cycle. She determined that cells sloughed off the blade of the plant are carpospores (seeds) which settle onto shells, growing and burrowing into the shell and forming a mass of filaments barely visible to the eye. This conchocelis phase in turn releases conchospores into the water which float to beaches and attach to rocks or nets, anchoring the blade phase of the seaweed's life.

Until Baker's discovery, Japan's nori farmers knew only to put their nets out into the water at certain times of year. If lucky, they would be rewarded with the growth of seaweed blades from the microscopic conchospores which settled on the nets. But they couldn't control the process.

Because of Baker's contribution, cultures of the conchocelis phase can be maintained by the farmers themselves. And because the farmers and nori growers' associations can keep track of the parentage of the seaweed blades, the Japanese have made great strides in stock selection, developing faster-growing, larger and better-tasting blades. In addition, by observing growth in different locations and controlling their stocks, the Japanese have come to use different species of *Porphyra* in different areas, optimizing growth under local conditions.

As a graduate student of phycologist Richard Norris at the University of Washington, Mumford had completed basic biological studies of *Porphyra*. During those years another University of Washington phycologist, J. Robert Waaland, worked on a Washington Sea Grant-supported project to develop methods for culturing the carrageenan-rich species *Iridaea* and *Gigartina*. The attempts to cultivate *Iridaea*, though successful, proved uneconomical; however, the culture methods appeared to hold promise for the more valuable *Porphyra*.

After starting work with the Washington Department of Natural Resources, which because of its jurisdiction over state marine bottom lands has an interest in aquaculture development, Mumford expanded a small DNR *Porphyra* project, already underway, to include development of a pilot nori farm. He and his coworkers built a greenhouse on the dock at the Department's Marine Research Center, near Olympia, for culture of the conchocelis phase. They also built net frames for the blade phase of the growth. During the first season they were assisted by a Japanese nori consultant, Makota Inayoshi.

The winter 1982 harvest, totalling 2,000 sheets, was judged by Japanese nori officials and Washington importers and restaurant owners to be of moderate to excellent quality.

Nets were seeded with conchospores on September 1, 1982. These were placed on nursery frames (ikada) for growth in the waters near Squaxin Island. After one month of excellent growth, overcrowding of the blades made division of the nets desirable. Some nets stayed at the Squaxin Island site while others were transferred to growing frames located at sites near Hartstene Island and Wycoff Shoal. The crop's appearance and growth at the three sites were monitored and compared. Site differences proved to have important effects on blade growth: waters near Squaxin Island and Hartstene Island were poor while the Wycoff Shoal site was satisfactory.

Besides underscoring the need for good site evaluation, the first crop's reduced growth rate in late fall indicated that this particular Japanese variety is perhaps not a good one for farming in Puget Sound and adjacent waters. The second demonstration year, now under way, will test four new Japanese varieties and some local *Porphyra* species (see accompanying story on farming native *Porphyra*) to be seeded in September, 1983.

Economics of Nori Farming

A person does not have to live in Asia to eat nori. In 1982, the U.S. imported an estimated $16.8 million-worth (retail) of nori, all of it from Japan and Korea. Although most U.S. consumers of nori are Asians, westerners are learning to appreciate it. It is estimated that U.S. sales increased 50 percent between 1980 and 1982.

As part of Mumford's evaluation of nori aquaculture in Washington, Kramer, Chin and Mayo, Inc., a consulting firm, studied the economic feasibility of nori farming. They estimate that 25 nori farms, each requiring a 20-acre site for 300 nets, could supply the entire 1982 U.S. demand for nori—about 40 million sheets.

There is considerable interest in this industry's potential for the Puget Sound area. A Pacific Northwest Nori Growers' Association has been formed to promote the concept and to exchange information through workshops and newsletters.

Since site selection is critical, potential nori farmers with a particular site in mind will work with DNR to make a preliminary site analysis. At present, two individuals, one in the San Juan Islands and one on Vashon Island, have obtained permits to set out a small number of nets and another person at Dungeness has permits for some test frames. Should nori farming become a reality, the public will benefit through income (either leases or royalties) from farming state-owned marine lands.

According to Mumford, the coming year will be a critical one for showing the feasibility of nori aquaculture in Washington. Interested investors and potential farmers can refer to the Kramer, Chin and Mayo study which assesses nori market potential in the United States. This information and the results of this year's demonstration farms in Puget Sound should help them evaluate their chances for success in nori farming.

Farming Potential of Native Seaweeds

The *Porphyra* species harvested last year at the Department of Natural Resources demonstration nori farm is a native of Japan. Is this or any other seaweed from Japan a good candidate for farming in Washington waters?

Some significant differences between the Western Washington environment and that of Japan suggest that local species of *Porphyra* may have better growth potential. The seasonal ranges in water temperature are quite different: Japan's annual range of 4 to 25° C is much broader than Puget Sound's range of 8 to 14° C. A second difference is sunlight, critical to plant growth. Japan's winter skies are much clearer and sunnier than are Washington's. Nori farmers in Japan expose plants on clear, dry winter days as a means of pest control. This tactic may not be possible in Puget Sound and adjacent waters.

University of Washington botanist J. Robert Waaland is evaluating the farming potential of four species of *Porphyra* native to Washington waters. He will determine what environmental factors regulate reproduction of the four, two of which have passed nori taste tests. Not only is information about reproduction needed to get reliable spore formation for seeding, but also it would be useful for developing blades with delayed sexual maturity. As this seaweed matures, the reproductive cells are sloughed off the edges of the blade, in effect breaking down blade tissue that could have been harvested earlier.

Other seaweed characteristics Waaland is looking for, both in the four local species and in hybrids with Japanese species, are fast growth and high production rates under typical culture conditions.

In addition, he is investigating novel methods of propagating *Porphyra*. If the blade phase could be propagated vegetatively, then the microscopic, time-consuming conchocelis growth phase could be avoided altogether. Second, it would give the researchers control of the offspring which would be genetic copies of the "parent" blade. In the natural life cycle, there is genetic variation in each new generation.

Photo: Washington Sea Grant

Breeding Coho Salmon for Pen Culture

Private companies growing salmon in marine net pens cite two major reasons for developing their own salmon stocks. First, the supply of eggs from public hatcheries is variable and may often be insufficient. Natural changes in the abundance of salmon or alterations in planning may result in insufficient eggs for public hatchery needs, much less for the needs of private enterprise. Second, eggs are generally obtained from widely different sources—from whichever hatcheries have an excess. This factor precludes the development, through selection and breeding, of a salmon stock with traits suited to pen culture.

The need to develop a strain of coho salmon for pen culture led Domsea Farms, Inc., to University of Washington fisheries geneticists William K. Hershberger and Robert N. Iwamoto. Through a cooperative effort using Domsea facilities, Sea Grant support, and the techniques of selective breeding, two stocks of coho salmon have been developed that exhibit faster growth rates and better survival than non-selected control stocks. In addition, losses of maturing adults have been reduced and gamete viability has been improved to yield a more reliable egg supply.

These improvements in the stocks have been obtained by use of several independent selection methods. After spawning, the researchers keep only the "families" of young fish from those females whose eggs have a high percentage of hatching. Next, an index based on growth rates of juveniles in freshwater and seawater and the success of parr-to-smolt transformation is used to select superior families. Third, the numbers of eggs produced and adult size are characteristics used to select adult spawners.

Since the coho salmon brood fish are grown under conditions that accelerate their growth, only two years are required for them to develop from egg to sexual maturity. Consequently, Hershberger and Iwamoto have established two selected lines, one maturing in odd-numbered years and the other in even-numbered years.

After one generation of selection, the odd- and even-year lines show growth rate increases in freshwater of 43 and 25 percent, respectively, over their parents. The lines show a smaller growth rate increase—12 percent—over the non-selected con-

Fisheries biologists William Hershberger and Robert Iwamoto check one of the University of Washington's specially-bred "Donaldson" rainbow trout for signs of sexual maturity.

trol group. The larger increase relative to parents combines both genetic changes and husbandry-related influences, such as nutrition and water quality. The smaller improvement relative to non-selected controls represents only genetic improvement, since both sets of fish experience the same environmental conditions and food. Both ways of looking at the data are important since both genetic and husbandry-related improvements are of interest to commercial growers.

Seawater growth rates were also increased (38 percent better than controls), as well as seawater survival (93 percent for the selected fish versus 51 percent for controls). Thus, use of these stocks can potentially yield a larger, more rapid production of the 350-400 gram salmon now marketed by commercial net pen operations.

In addition to the selection and breeding program, research was conducted to improve techniques for holding maturing fish in net pens to ensure greater survival to spawning. Initially pen-reared coho salmon were maintained in seawater until final maturation and spawning. However, this resulted in low survival of the adults and a high frequency of inviable eggs. Development of an antibiotic treatment protocol and transfer of the adults to freshwater for final maturation increased the number of adults surviving to spawning by 6.4 percent. In addition, survival of the eggs from freshwater-held adults increased to an average of 80 percent, compared to an average of 64 percent from seawater-held adults. Such improvements will soon allow a private pen culture company to become completely self-sufficient for its egg supply.

Both the selective breeding approach and the improved methods for handling maturing fish should help improve the commercial viability of net-pen culture of coho salmon.

Hormones—Critical Factors in Salmon Life Cycles

The transformation of Pacific salmon parr, the freshwater-tolerant stage, to smolt, the seawater-tolerant form, is a critical step in the fish's development. If salmon are placed in seawater before they have completed the parr-to-smolt transformation (smoltification), large numbers of the fish will not grow or will die. For public hatcheries in salmon enhancement programs and private salmon aquaculturists, there is a clear need to know when fish have completed smoltification in order to stock them at the appropriate time and avoid large losses of fish.

University of Washington zoologist Walton W. Dickhoff has studied the role of thyroid hormones in the parr-to-smolt transformation. By measuring thyroid hormone levels in the blood of smoltifying salmon, he can determine accurately a fish's readiness for release from public hatcheries or aquaculture facilities.

Since the thyroid gland plays a major role in preparing salmon for entry into seawater, it is possible to accelerate smoltification of fish by adding thyroid hormones to their food. Administered to salmon fry early in their development, the hormone accelerates growth and adaptability to seawater, and may reduce the time necessary to rear salmon in fresh water. Because small amounts of thyroid hormone incorporated into the food are cleared out of the fish rapidly, there is little chance that any hormone residue would remain in the fish when they enter the fishery a year later.

Dickhoff is also studying the feasibility of synchronizing spawning in adult salmon. Checking fish ripeness and collecting eggs from salmon spawning over a period of several months currently requires a large number of personnel. The administration of a gonadotropin-releasing hormone to adult fish stimulates spawning. A low dosage of the hormone is injected, and 10 days to two weeks later spawning occurs, thus providing a means of synchronizing spawning in a number of females injected at one time.

Besides allowing the collection of eggs over a shorter period of time, the method also permits the collection of a larger number of eggs because hormone injections cause spawning in fish that otherwise might die without spawning. This increased egg production could help reduce the number of eggs that private aquaculture companies now must purchase from other sources.

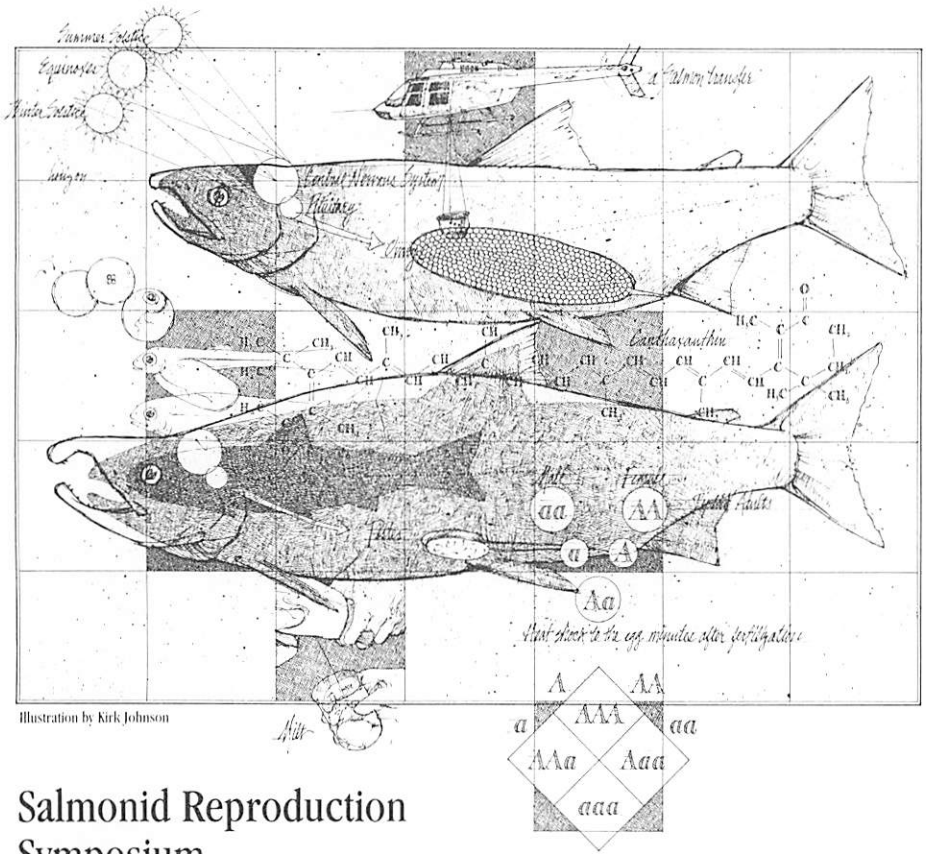


Illustration by Kirk Johnson

Salmonid Reproduction Symposium

The accomplishments in salmon aquaculture described on these pages were generated in a two-year period at one institution and, despite their significance, represent a small part of the several-decade research commitment in salmonid biology and husbandry at the University of Washington and at other institutions throughout the world. The long-term international investment in basic and applied salmonid research has led to an understanding of the animal that now permits unprecedented control over key aspects of these fishes' life cycles. With such control comes a critical need to evaluate the consequences of using the new capabilities in the field.

In keeping with Sea Grant's role as a link between university researchers and resource managers, Washington Sea Grant is sponsoring a symposium on salmonid reproduction in the Seattle area, October 31-November 2, 1983. The symposium addresses research on broodstock management and husbandry and on environmental factors affecting reproduction, as well as the three areas described in the accompanying reports—endocrinology, genetics, and nutrition. (At press time) this symposium has attracted the participation of more than 100 scientists from all over the world—from Canada, Japan, Australia, the U.S.S.R., the United Kingdom, France, Norway and Sweden. It is the first symposium to bring together researchers working on these usually separated aspects of salmonid reproduction, in addition to involving both researchers and managers from industry and from state and federal agencies. It is hoped that this wide representation will promote a valuable interchange of both basic information and policy-related concerns.

Additional sponsorship of the symposium comes from the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and other members of the Pacific Sea Grant College Program—the Universities of Alaska, California, and Hawaii and Oregon State University.

Developing a Salmon Broodstock Diet

The successful rearing of salmon from hatching to maturity in captivity is a relatively new development in marine aquaculture and a tremendous technical achievement. Both private industry, which grows salmon for market, and public agencies, which rear fish to rehabilitate depleted or threatened stocks of salmon, are benefitting from this new aspect of fish husbandry which allows development of select broodstock and insures a constant supply of eggs and fry.

Two problems, the prespawning mortality of adult brood fish and the variable quality of eggs obtained from captive broodfish, still plague the culture of broodstock salmon.

University of Washington fisheries biologist Ronald W. Hardy, suspecting that improper diet may underlie both problems, is investigating the nutritional requirements of maturing female salmon. According to Hardy, commercial salmon growers feed maturing females diets containing vitamin-and-mineral supplements developed for juvenile salmon, rather than adult females.

Working with salmon at a commercial growing facility, Hardy has completed a baseline study of the changes in the levels of particular vitamins and minerals, both in the female body and in the ovary during maturation. Unlike sexually mature males, whose tissue biochemistry is virtually identical to that of juvenile males of similar body size, females undergo drastic changes in tissue composition during maturation. Egg development, Hardy has found, is a continuous process that begins seven to nine months before spawning and is completed approximately four to six weeks before spawning. Some nutrients are deposited in the ovary at a constant rate while others are deposited in the ovary during the early stages of ovarian maturation. Increased ovary levels of some nutrients are associated with reduced levels of these nutrients in the body tissues of the female salmon.

After pinpointing particular nutrients that are reduced in the female's tissues, Hardy has formulated a dietary supplement with increased amounts of five vitamins—B_{12}, folic acid, vitamin C, pyridoxine and biotin—and higher amounts of the minerals zinc, manganese, copper, iron and cobalt.

The supplement was given with food to a group of females over the summer and fall of 1982. Spawning occurred in December, but difficulties resulting from the commercial growers' handling of female salmon and eggs prevented a valid assessment of the diet's effects. Hardy is repeating the experiment with modified procedures designed to give him more control.

Unlike sexually mature males, whose tissue biochemistry is virtually identical to that of juvenile males of similar body size, females undergo drastic changes in tissue composition during maturation.

This year's experimental work is heading "a step further into the animal," according to Hardy. Because the commercial grower with whom he is working cannot afford to lose many adult salmon to the researcher's knife, Hardy has developed microchemical methods for analyzing adult female salmon blood and tissue for the nutrients he is following. The idea is similar to human medical diagnosis, where one cannot sacrifice the patient in order to find out what is wrong. Hardy must use techniques which have minimal effect on the salmon but still yield the necessary information. The diet of the adult females is supplemented as it was a year ago, so that Hardy can determine whether the "improved" diet lowers prespawning mortality and improves egg quality. And because he is checking on the females' body nutrients as the salmon mature, Hardy is a little less dependent on the egg quality and survival results alone for evaluating his dietary supplement.

Vibriosis under Scrutiny

The pen rearing of Pacific salmon has become an economically important industry in recent years. Accompanying its rapid growth is an increased awareness of the need for more efficient methods for treating and or preventing communicable disease.

One devastating disease is vibriosis, caused by *Vibrio anguillarum*, which affects salmonids and many other species of fish throughout the world.

Microbiologist Jorge Crosa of the Oregon Health Sciences University is studying the molecular nature of the fish-bacteria interaction which results in vibriosis. Crosa's ultimate aim is to use knowledge of the mechanisms of pathogenesis (origins of disease) to develop measures for disease prevention.

In his study, Crosa has demonstrated a link between the disease-causing potency of a strain of *Vibrio anguillarum* and the presence of a particular type of plasmid in the bacterium. A plasmid is a DNA structure occurring separately from the bacterium's chromosome, and it can be replicated independently of the chromosome. Like chromosomal DNA, plasmids carry instructions for building particular proteins required by the bacterium. It has become apparent that an increasing variety of important properties of microorganisms are controlled by plasmids.

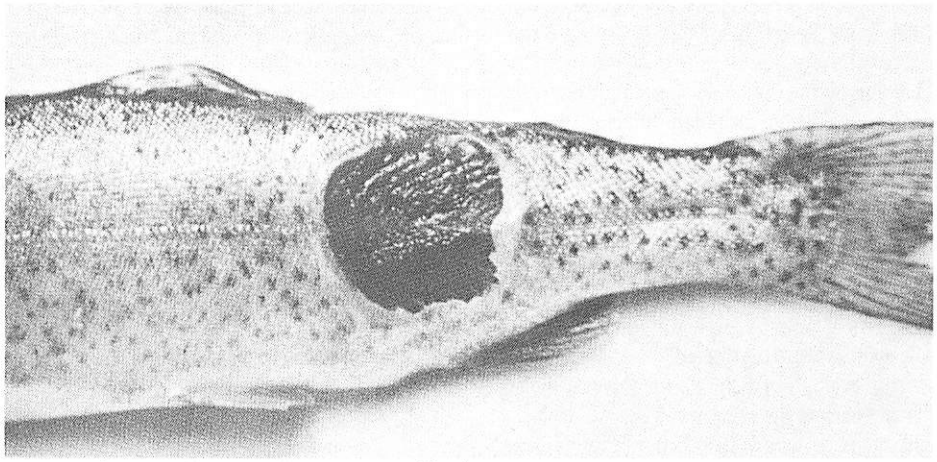
The virulence-causing plasmid identified by Crosa specifies a very efficient iron-sequestering system that enables the bacteria to survive and grow under conditions of limited iron availability. Iron is an essential element for bacterial growth, but in body fluids and secretions of vertebrate hosts it is bound to iron-building proteins such as transferrin or lactoferrin. Consequently, it is not readily available for pathogens attempting to establish an infection. Crosa suggests that the high virulence of particular strains of *V. anguillarum* is due to the presence of the plasmid-controlled iron-sequestering system which allows the invading bacteria to utilize iron bound to specific proteins.

By experimentally infecting fish with vibriosis, Crosa has demonstrated that the plasmid-controlled iron-sequestering system plays a vital role in both initial and continued bacterial invasion.

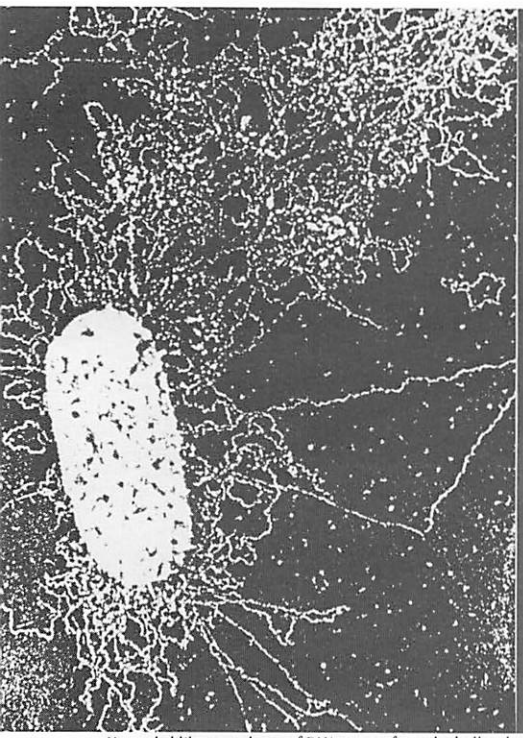
Crosa has also identified a protein on the outer surface of the bacterium which appears to play a role as a receptor for iron in the process of iron uptake in the host fish. Because this protein is on the surface, exposed to the fish immune system, Crosa thinks that it may prove useful in vaccine trials, and he has begun experiments to test this idea.

Working in collaboration with Michael H. Schiewe of the National Marine Fisheries Service in Seattle, Crosa has determined that another reason *V. anguillarum* is virulent is its ability to withstand the bacterial action of non-immune serum of the host fish.

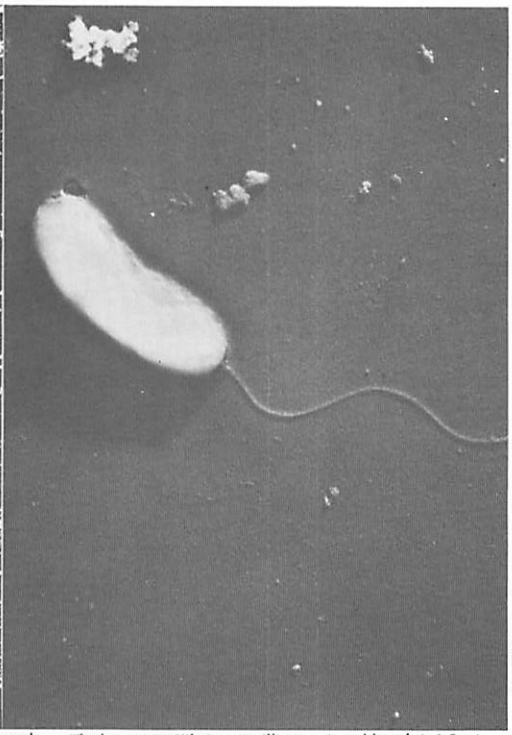
Another direction the vibriosis work has taken is a comparison of causes of virulence of strains of



Seawater rainbow trout with an external lesion accompanied by *Vibrio* sp.



Unraveled like yarn, loops of DNA stream from the bullet-shaped bacterium *Vibrio anguillarum* which causes disease in fish. The small "circle" of DNA, right center, is the virulence-causing plasmid identified by microbiologist Jorge Crosa.



Jorge Crosa

The bacterium *Vibrio anguillarum*. Actual length is 1.5 microns.

V. anguillarum isolated from different locations: Maine, New Hampshire and Japanese coastal waters. Crosa's results indicate that both iron uptake and serum resistance are important components of virulence in these strains, although in some strains the iron-uptake genes appear to be located on the chromosome. Several membrane proteins are also induced in the cell envelope of these strains under conditions of iron limitation. Crosa is investigating whether the different membrane proteins are related and are the product of variations in the state of a common gene or set of genes. He suggests that knowledge of the detailed molecular architecture of the *Vibrio anguillarum* surface would be an important tool in understanding the role of surface components in the host-parasite interaction, and would benefit both the diagnostic and the immunologic approaches to the disease.

An example of the impact of this new molecular approach to the study of fish diseases is the publication, in *Nature* (London), of Crosa's paper, "A Plasmid Associated with Virulence in the Marine Fish Pathogen *Vibrio anguillarum* Specifies an Iron-Sequestering System" (Vol. 284: 566) (1980). This paper will be included in the series, "Benchmark Papers on Microbiology," to be published sometime during 1983.

In his current Sea Grant-supported research, Crosa has now initiated studies on another fish pathogen, *Aeromonas salmonicida*, which causes the devastating disease furunculosis. Crosa expects to apply knowledge gained from his study of the *Vibrio* system to this pathogen and eventually, by utilizing techniques of recombinant DNA and genetic engineering, to develop vaccines to control this disease.

"Jogging" Salmon

Exercising hatchery fish to improve their fitness and vigor has much the same result in fish as jogging has for people. Since the activity level of salmonids in hatcheries is somewhat comparable to that of office workers, it is not surprising that fish, like people, can benefit from periods of increased activity.

In the spring of 1982, Lynwood S. Smith, University of Washington fisheries professor, worked with Anadromous, Inc., a commercial salmon "ranch" in Oregon, to exercise coho salmon smolts for about ten weeks before they were put in seawater and then for an additional three weeks before they were released into the estuary. Groups of fish were reared in circular plastic swimming pools about twenty feet in diameter. A recirculating pump sprayed water forcefully onto the surface of each pond, causing the water in the pond to rotate. By varying the water pressure, Smith and his assistants provided a different water velocity for each pond, except for the control group which had no added velocity.

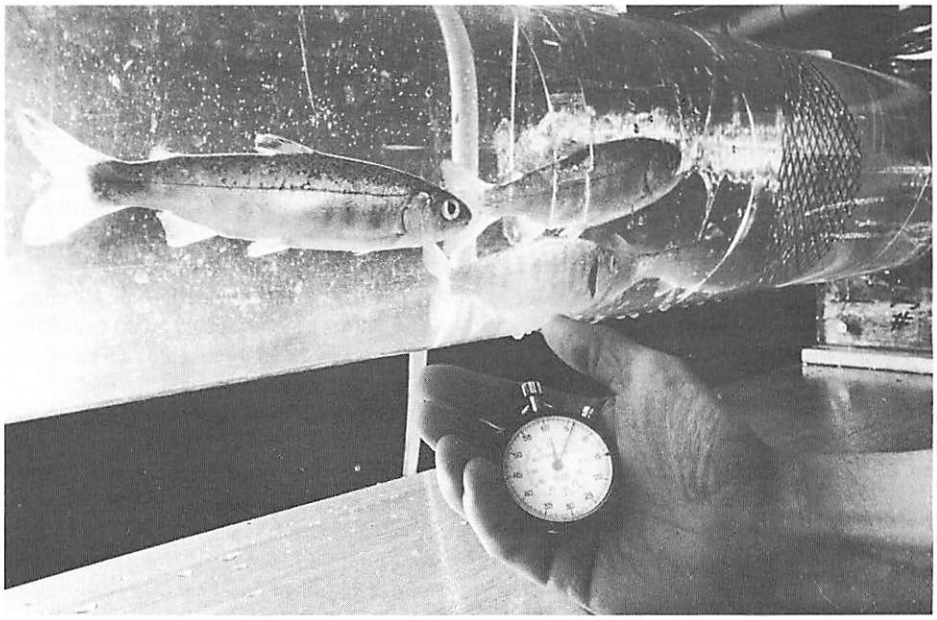
The fish tended to hold their position by swimming against the current and thus were exercised in proportion to the water velocity. All fish except the control group were exercised for two hours in the morning and two hours in the afternoon. During the thirteen weeks of training, samples of fish from each group were tested for swimming stamina (the maximum velocity of water against which they could swim for fifteen minutes) and for changes in several physical and biochemical functions.

The exercised fish remained in smolted condition in the hatchery ponds for four to six weeks, significantly longer than the two weeks typical of controls. This extra time should give hatchery managers more flexibility in scheduling transportation and estuarine acclimation of the fish.

The early results resembled those from Smith's previous small-scale studies. Exercised fish exhibited greater swimming stamina than non-exercised fish. This difference disappeared during the general decrease in swimming stamina which hatchery-reared salmon may experience during smolting (the process of preparing to go downstream into the sea). However, the exercise benefits showed very dramatically after the fish were trucked from their freshwater home in Corvallis to their estuarine acclimation site at Coos Bay. After being put into seawater, all fish were generally lethargic and exhibited a further decrease in swimming stamina. The control group recovered in about three days and were eating vigorously after about a week. In contrast, the fastest responding exercised fish recovered their swimming stamina in only a day and a half and were eating vigorously before the end of the first day.

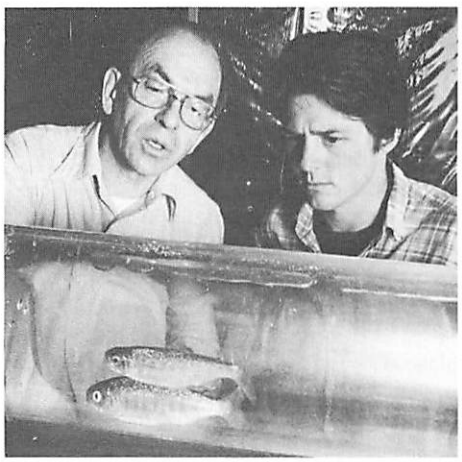
As soon as they regained their stamina, the fish received their morning and evening exercise regime again. In addition, the control fish were introduced to a pond with moving water. About half of the control fish swam upstream, half swam downstream, and they swam at all depths. In contrast, exercised fish all swam downstream and only in the bottom half of the pond. Presumably, if they had been released directly into the estuary, the exercised fish would have paused briefly, entered the seawater layer on the bottom of the estuary, and headed out to sea immediately. The control fish would have hung around for at least a week, half of them longer, before migrating, if they migrated at all. When fish stay longer in an estuary, they are more likely to be eaten by predators. Thus one can be optimistic about improved survival of the exercised fish, although nothing more can be determined until the tagged adults of all groups return.

All groups of fish suffered severe mortality during their first few days in seawater, an abnormal occurrence later confirmed to be the result of a widespread presence of a bacterial kidney disease. Even then, exercise provided some benefits. The control group (initially 15,000 fish) showed a total loss of 37 percent while one exercise group showed only an 11 percent loss and none of the other exercise groups lost as many fish as the control group. Thus, Smith unintentionally demonstrated that exercise may produce some degree of disease resistance.



James Larson, Oregon Sea Grant

In his study of the effect of exercise on smolting, fisheries professor Lynwood Smith, left, measures the swimming ability of coho salmon smolt in a laboratory stamina testing tube. Fisheries biologist John McClenahan looks on.



James Larson, Oregon Sea Grant

Biochemical tests revealed surprisingly few detectable differences between the exercised and the control fish. Smith and coworkers measured a gill enzyme, ATPase, and thyroid hormone levels, both usually reliable indicators of smoltification (see related story on salmon hormone research by Walton Dickhoff), and several other factors without detecting major differences among groups.

There are several possible reasons for the fishes' failure to show signs of smoltification, according to Smith. He didn't sample for thyroid hormone levels as frequently as Dickhoff does and may have missed the pulse. Then, too, these fish were reared at constant temperature in wellwater and some research indicates that the thyroid hormone pulse does not occur without the stimulus of incremental temperature change characteristic of stream life.

A further difference in the salmon stock raised by Anadromous is its mixed, virtually untraceable, origins in several Oregon rivers. Smith notes that certain Oregon river salmon strains characteristically show little change with smoltification, and the Anadromous stock may have some of this influence.

Whatever the reason, smoltification may be difficult to detect in some fish stocks. As one researcher has suggested, there may not be any key factor or best indicator of smolting, only the sum total of a great many small changes which characterize a smolt. And exercise may still be a good way to influence smolting.

Exercise produced an additional beneficial result. The exercised fish remained in smolted condition in the hatchery ponds for four to six weeks, significantly longer than the two weeks typical of controls. According to Smith, this extra time should give hatchery managers more flexibility in scheduling transportation and estuarine acclimation of the fish.

Breeding a Better Oyster

Pacific oysters (*Crassostrea gigas*) that are resistant to summer mortality are the goal—and now the product—of a selective breeding program at the University of Washington's School of Fisheries. The summer mortality phenomenon kills significant numbers of market-size oysters (3 or more years old) on commercial beds in south Puget Sound. In some years mortality can reach as high as 60 percent.

The research team consisting of fisheries professors Kenneth K. Chew and William K. Hershberger, hatchery manager J. Hal Beattie, and predoctoral research associate James A. Perdue has for two summers running had better survival in its selectively-bred strains of oyster than in controls. The approach of the breeding program is to take adults from the field that have survived a summer mortality and to mate these survivors in the laboratory to produce families of known parentage. Generally 25 to 30 of these families are produced annually in an experimental hatchery facility in Manchester, Washington, and are then placed on three commercial oyster beds in south Puget Sound to be monitored for survival.

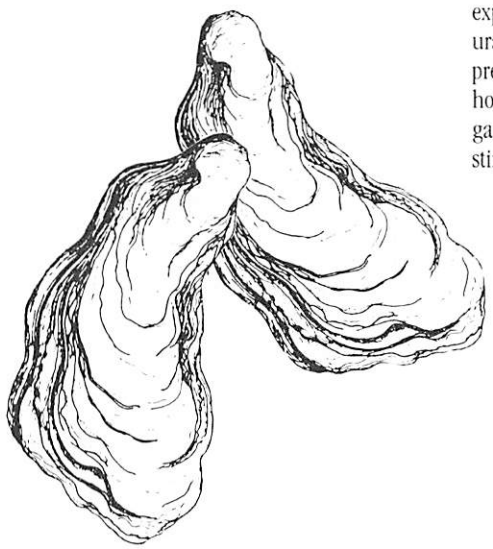
Results from the past two summers indicate that the breeding program has been successful. Significant summer mortalities (over 50 percent) occurred among commercial oysters in Mud Bay, Washington, in both 1981 and 1982. In 1981, 60 percent of Chew and associates' selected families exhibited better survival than the control group. Mortalities of the best five families ranged from 14 to 20 percent. In 1982 all 27 families monitored survived better than the control group. Mortalities of the best five families ranged from only 8.5 to 11.9 percent.

Besides survival, the researchers monitor growth rate and glycogen content. Growth rate is an important commercial trait that must be maintained in any stock. The growth data indicate that inbreeding depression and resulting stunted growth can occur in the second generation of oysters from common family lines. Information such as this is critical to commercial oyster hatcheries.

The second trait monitored, glycogen content, appears to bear directly on vulnerability to summer mortality. Chew and his coworkers have found that oysters with low glycogen reserves suffer high summer mortalities, while the experimental stocks that delay gonadal development and thus maintain higher glycogen reserves do not exhibit severe summer mortality. High glycogen content also means better meat quality. Oysters maintaining high glycogen levels would be more marketable than those with the low meat quality associated with spawning in the summer months.

A change in the procurement of seed by oyster growers has made the results of this study immediately useful to the industry which can now obtain seed from commercial hatcheries. Before 1981 virtually all of the oyster seed planted each year came from natural-catch sources. In 1981, however, 65 percent of the seed procured was hatchery-produced and in 1982 over 90 percent was hatchery-produced.

The result of this development is that stocks of oysters developed in this research program can be utilized immediately by the industry through commercial hatcheries. In fact, two major oyster growers utilized some of the mortality-resistant stocks of adult oysters to produce the new seed for planting on their oyster beds. In addition, one small grower of gourmet oysters for the half-shell restaurant market is currently raising some of the selected stocks which exhibit superior meat quality during summer months—a time when it is traditionally difficult to market oysters.



A Bacterial Link In Oyster Death

In 1980, University of Washington researchers seeking to demonstrate an alga's toxic effect on oyster larvae were stumped. In some of their experiments, the alga, *Olisthodiscus luteus*, had little effect on the microscopic larvae of *Crassostrea gigas*. In other experiments, usually ones using older larvae, the larvae were killed in high numbers when exposed to the alga or the water in which the alga had grown. It was apparent that some additional factor, not controlled in experiments, held the key to this alga's fickle virulence.

The toxicity of *O. luteus* in coastal seas is no more predictable. On several occasions in the 1970s, at locations off both Atlantic and Pacific coasts, blooms of *O. luteus* were associated with particular fish and shellfish kills. But the species is not always toxic. In fact, non-toxic blooms are much more common than toxic ones.

The U.W. researchers—botanist Rose Ann Cattolico, post-doctoral associate L.G. Williams, and graduate student Kathleen Welling—tried a new approach. At the suggestion of a colleague, Welling began pre-treating the oyster larvae with an antibiotic. This would help to control a possibly important variable, the health of the larvae which at times had a noticeable bacterial flora.

The antibiotic's effect was impressive. It reduced not only the bacteria on the larvae, but also the numbers of larvae dying in the presence of the alga. This result, combined with the results of other experiments, suggested that bacteria occurring naturally on the oyster larvae were proliferating in the presence of *O. luteus*, and eventually killing their hosts. *O. luteus*, for its part, was secreting an organic substance, as yet uncharacterized, which stimulated the high levels of bacterial growth but

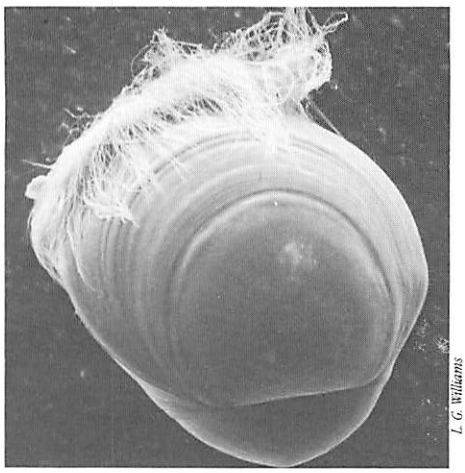
Vicki Mikes, Washington Sea Grant

was not directly toxic to the larvae. Thus, the alga's effect on the oyster larvae was an unexpectedly indirect one.

The researchers determined further that another planktonic alga, *Isochrysis galbana*, can similarly enhance bacterial growth on oyster larvae and similarly affect larval survival. Consequently, Cattolico wonders how general in nature such an interacting triad consisting of an algal species, a bacterium, and a fish or shellfish species may be. It is possible that other instances of toxicity fit this model.

Do bacteria act as intermediaries in *O. luteus'* occasional toxicity in coastal waters? The laboratory work of Cattolico and her coworkers does not answer this question, but it does lay important groundwork for the greater complexity of a field investigation.

In addition, the research effort underscores the importance of bacterial control in shellfish hatchery facilities. Further, it enhances our perception of the detailed fabric of biological interactions in the ocean.



L. G. Williams

Top: Leslie G. Williams and Rose Ann Cattolico hold culture flasks of the marine alga *Olisthodiscus luteus*, which their research has shown causes increased growth of pathogenic bacteria on oyster larvae.

Above: Larva of the Pacific oyster *Crassostrea gigas*. Actual size 123 microns.

Fertile Prospect For Marine Bioassays

Concern about pollution of marine waters has sparked a search for organisms suited to use in toxicity bioassays. Unlike medical research, marine environmental research has no laboratory white rat to subject to experiment. Several considerations affect the choice of test organism. On one hand, marine habitats differ too widely, potential pollutants are too varied in their effects, and too many organisms are important to marine food chains, for any one species to be the "right" one to study. On the other hand, practicality demands that a few, very versatile organisms be available for routine rapid-response screening of potential toxicants.

In the past, organisms chosen for marine bioassays were ones which already could be cultured in the laboratory. For example, oyster larvae were routinely used as test organisms in early studies of the toxicity of pulp mill effluent. In one respect, these larvae are good test subjects because both acute mortality and sublethal developmental effects can be measured. They are not ideal for rapid screening of many pollutants, however, because the assays are more expensive to run, require highly-trained personnel to interpret the results, and require a 48-hour exposure time.

Recognizing the need for bioassay subjects suited to tests of short duration, University of Washington fisheries biologist Quentin J. Stober looked for, and has found, a test subject eminently suited to this application.

In the "sea urchin sperm bioassay," the test criterion is the successful fertilization of sea urchin eggs by sperm. Seawater contaminated with any of several kinds of pollutants inhibits fertilization.

The dependence of fertilization success on clean seawater has been recognized for some time. Stober's contribution, made with the assistance of colleagues Paul Dinnel, Jeanne Link, Roy Nakatani, and Samuel Felton, has been to improve the methods, test a variety of pollutants, and construct a roster of test organisms whose eggs and sperm can be used in the assay. In addition, the researchers have determined the sensitivity of the sperm bioassay relative to bioassays using other life stages of marine organisms—embryos, larvae, juveniles and adults.

An advantage of the sperm bioassay is the short time—usually 60 minutes—required for ex-

posure of sperm to water whose quality is suspect. Bioassays with juvenile or adult organisms often require much longer exposures to detect toxicity.

The bioassay procedure begins with exposures of artificially-spawned sperm cells to test water samples for short periods of time. Eggs are subsequently added to the treated sperm, and fertilization is allowed to take place. The samples are then examined for percent fertilization success and the results compared to control fertilization success to determine the presence of toxicity in the test samples.

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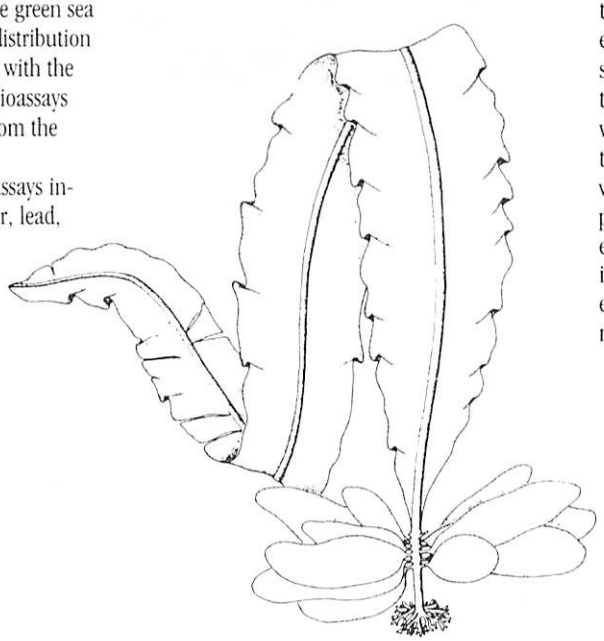
Stober and coworkers have extended the test to sperm from other organisms—sand dollars; green, red, and purple sea urchins; oysters; and salmon. Such versatility should make the bioassays useful to laboratories in many areas. The green sea urchin, for example, is circumpolar in distribution and so is widely available. Furthermore, with the availability of artificial seawater, these bioassays could even be run at locations distant from the ocean.

Toxicants tested in the sperm bioassays include the heavy metals cadmium, copper, lead, zinc, and silver as well as the pesticides endosulfan, DDT, dieldrin and endrin. The sperm test is sensitive to all of these chemicals but is less sensitive than other bioassay organisms to the pesticides.

The investigators report that the 60-minute sperm bioassays closely follow in sensitivity 48- and 96-hour bioassays using embryos and larvae of marine organisms. Juvenile and adult stages of marine fish and invertebrates are least sensitive to most metals but are quite sensitive to the pesticides and exhibited a greater sensitivity to cadmium than do sperm, embryos, or larvae. Once relative sensitivities are known, the sperm bioassay can be used as the method of choice for rapid screening of pollutants because of its short response time and low cost.

Stober and his colleagues have reported their initial results in *Aquatic Toxicology and Hazard Assessment*, Proceedings of the fifth annual symposium on aquatic toxicology, published in 1982 by the American Society for Testing and Materials. Through dissemination of this and subsequent reports on the project, the researchers expect to see widespread adoption of this versatile marine bioassay subject.



Untangling the Food Web Of Estuaries

Nearshore marine and estuarine seagrasses and macroalgae may constitute a major organic carbon source to the food web, supporting certain commercial fisheries. This result comes from research in Hood Canal (a fjord-like arm of Puget Sound) by research scientists at the University of Washington's Fisheries Research Institute. Their studies suggest that the natural estuarine habitats of the seagrasses and macroalgae play a vital role in production of the prey resources of commercially important species such as Pacific salmon.

The research also points out potentially significant differences between the estuarine food webs of the east and west coasts of the United States. On the East Coast salt marshes appear to play a significant role in carbon pathways, while seagrasses and macroalgae may have greater importance in West Coast estuarine food webs.

In order to determine carbon sources to detrital food webs supporting juvenile Pacific salmon, researchers Robert C. Wissmar and Charles A. Simenstad analyzed three possible sources. Using the ratio of two natural carbon isotopes ($^{13}C/^{12}C$) to fingerprint them, they analyzed three possible sources in Hood Canal:

(1) terrestrial and wetland plants,
(2) neritic (surface water) phytoplankton, and
(3) estuarine seagrasses and macroalgae.

They then compared these with the $^{13}C/^{12}C$ ratios of the estuarine consumers and their predators. Although all three sources are available in the estuarine environment of Hood Canal at different seasons, the researchers found the $^{13}C/^{12}C$ values of the seagrasses and macroalgae were closest in value, and thus the most important carbon source, to the epibenthic (bottom-dwelling) crustaceans on which juvenile salmon feed. Thus, these primary producers in the estuarine and nearshore marine environments should also be considered as economically important components of the Puget Sound ecosystem and their role recognized in estuarine management decisions.

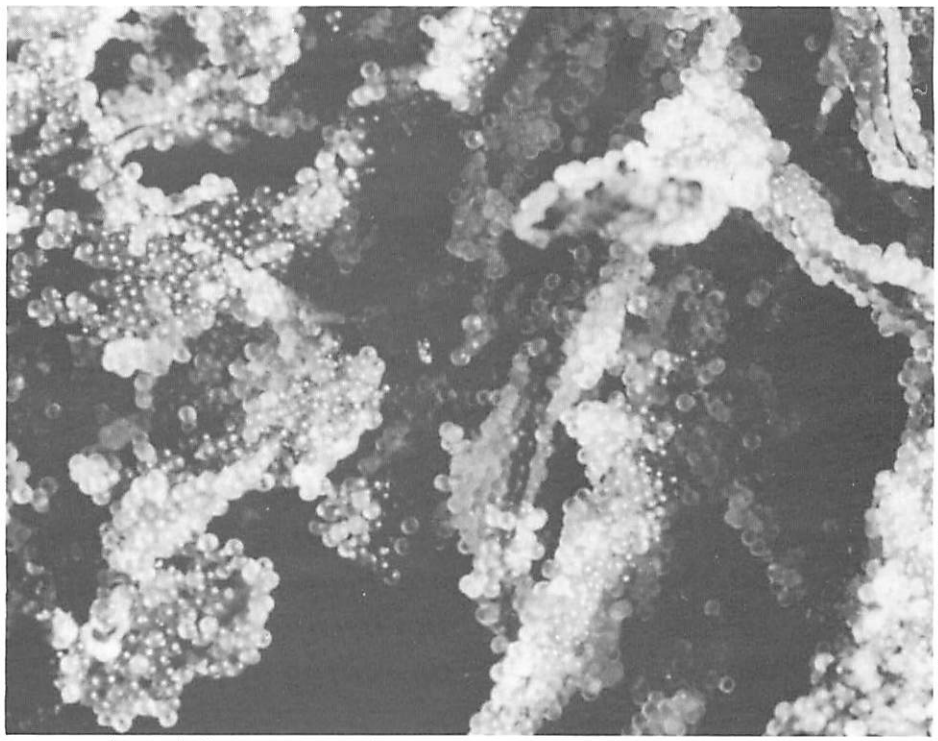
Herring Egg Mortality

Since 1973, the Pacific herring stocks in the east Strait of Georgia have declined to such low numbers that in 1980 the important Washington State roe fishery (valued at $3.7 million in 1979 alone) was suspended. A study of Pacific herring egg mortality by Professor Bruce S. Miller is directed toward understanding the factors which may be important not only in preserving the roe fishery but also in optimal management of the adult herring fishery.

Observations of herring spawning suggest that factors affecting egg mortality include the rate of predation on the eggs, the depth and type of substrate on which spawning occurs, and the number of eggs released together. In order to evaluate the importance of these factors, Miller, co-investigator Donald R. Gunderson, and graduate student Wayne Palsson, all of the University of Washington Fisheries Research Institute, investigated natural egg mortality in Quartermaster Harbor (Vashon Island) and in the east Strait of Georgia.

To assess impacts of predators on egg numbers the researchers set protective cages over some eggs immediately after the initial wave of spawning in early January. Eggs in cages and adjacent unprotected eggs were counted at several times after spawning so that effects of both predators and other mortality-causing factors could be measured over time. Although the cages did not exclude one predator, a marine snail, the study did show that predators destroyed up to 90 percent of the unprotected eggs. Comparing the Vashon Island and east Strait of Georgia sites, the researchers found that denser egg deposition in the latter area attracted greater numbers of bird predators which in turn caused higher rates of mortality.

The information being accumulated by the researchers will also help in assessing the impacts of proposed alterations of known spawning grounds by dredge or fill operations.



Don Howse, Alaska Dept. of Fish & Game

Herring spawn forms a jelly-like coating over seaweed.

Miller, Gunderson, and Palsson also evaluated the use of artificial substrates by herring. In cooperation with the Washington Department of Fisheries, the researchers placed different kinds of artificial substrates at three different bottom depths. Most eggs were found on substrates placed in eel grass at mid-depth. Herring did spawn on all of the artificial substrates; however, few late-stage eggs were detected, apparently because of the low rate of deposition and high predation rates.

In another phase of the project, SCUBA divers have taken samples that were then used to estimate egg abundance. Egg abundance is usually measured by towing a rake along the spawning ground and then observing the spawn. The accuracy of the two methods will be compared. "The purpose," says Miller, "is to improve herring population estimates for use in managing the fishery."

The information being accumulated by the researchers will also help in assessing the impacts of proposed alterations of known spawning grounds by dredge or fill operations. As one Department of Fisheries official points out, "We don't yet know why herring spawn in the places they do, nor do we know whether they can move to other grounds to spawn."

Concludes Miller, "It is becoming increasingly apparent that good scientific information on herring spawning is useful to people all the way from Alaska to California. Our data and results will help in the development of more precise methods of stock assessment and will provide a better information base for making decisions relating to proposed marina and industrial shoreline development."

Vessel Stability—a Safety-at-Sea Factor

The University of Washington's Fishing Vessel Safety Center has taken several approaches to developing an understanding of fishing boat safety. The need for a systematic collection of fishing vessel accident data led to establishment of the Center in 1978. Since then the Center has gone beyond this initial task, sponsoring seminars on different aspects of vessel safety, developing a vessel safety inspection checklist for marine surveyors, and conducting research on the factors contributing to instability in Alaska King crab boats.

Research on the King crab boats is proceeding under the direction of Center director Bruce Adee, associate professor of mechanical engineering. Using an 8-foot model of an Alaska King crab vessel made available by the U.S. Coast Guard, Adee is gathering data on the vessel's dynamic response characteristics in hopes of developing an understanding of this vessel class's particularly poor accident record.

Conducting experiments with a model in the natural environment is an important approach, Adee explains, because it can provide information on actual vessel performance under different conditions of wave height and direction, load size, vertical load position, boat speed, and boat heading. Vessel designers provide only "static stability calculations," which assume calm water with the boat at a standstill.

Adee's findings thus far indicate that a crab vessel's heading is particularly critical to stability. The worst thing the boat operator can do is head away from the waves, putting the boat in a "following sea." Unfortunately, this is usually the most comfortable heading because there is less pounding by the waves.

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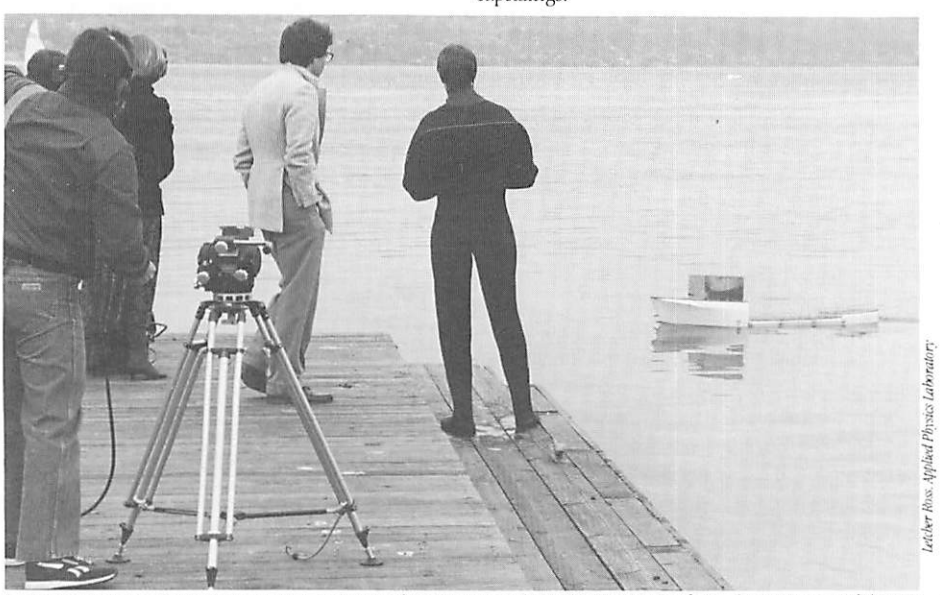
The importance of heading to boat stability, relative to other factors, was something of a surprise to Adee. Static stability calculations show the most important factor to be level of stability, or vertical position of the boat's center of gravity. Improper loading, leading to a higher center of gravity, has been a suspected factor in some of the crab boat capsizings.



Ledcher Ross, Applied Physics Laboratory

A television news crew observes as Bruce Adee, University of Washington mechanical engineering professor, demonstrates a stability test of the model King crab boat.

A second result not anticipated by Adee and his students was the King crab boat's stability in beam seas. During the model tests they have had difficulty in producing beam seas capsizes. This may be related to the fact that the model has no bulwarks and cannot trap water on the deck.

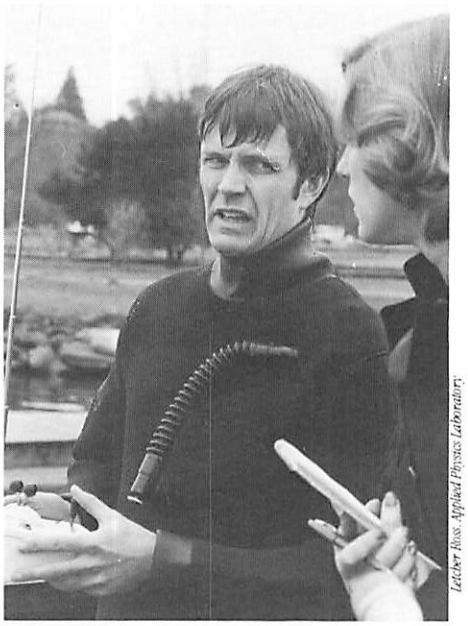
Getting a record of the remotely-controlled model's behavior in the natural environment requires electronic monitoring of both boat and waves. Adee and graduate students Feng-I Chen and Yutaka Nakamura have set up a semisubmersible automated wave measuring platform to record wave height and direction. On the boat itself are sensors for boat movements, accelerations, rudder angle, engine speed and heading. For each 3½ minute test of the model, new conditions of load size, load level and boat heading are set, and the vessel's motion reponse—the amount of roll, pitch, heave, yaw, surge and sway, plus its rudder angle, engine speed and heading—are recorded.

The data collected in these tests provide not only a way of assessing the factors critical to vessel stability, but also can point to the factors which should be monitored by a stability alarm system. Adee is currently testing two stability alarms, developed by commercial firms, which operate on different principles. He will determine the degree of correlation between a triggering of each alarm's signal and capsizing—this correlation must be virtually perfect to be useful. He also will observe when the alarms go off relative to the time of capsize. Two factors he believes such an alarm needs to monitor are the degree of heeling of the boat and the rate at which the roll is occurring.

Videotapes of the model's behavior, shown during Adee's seminars for the fishing community and other marine industry personnel, provide convincing supporting evidence for his conclusions. In addition, Adee has reported the project's results in *Alaska Sea and Coasts*, an Alaska Sea Grant publi-

cation. Technical information about performance of the model will be made available to naval architects.

In order to provide comparative data, Adee and Chen are now constructing a new model, using the design of a King crabber with a high accident record. He expects to be ready to test this model, in the same experiments as the first, in late 1983. Once a series of models has been tested, the Fishing Vessel Safety Center should have a valuable data base that will aid in understanding the factors, both operator-controlled and design-related, that are critical to stability of these vessels in a variety of sea conditions.



Letcher Ross, Applied Physics Laboratory

Vessel safety researcher Bruce Adee explains the workings of the remote-controlled crab boat model to a television newscaster.

Coastal Management Issues

The sequence of events is not uncommon. In the 1850s, an abundance of resources—finfish, shellfish, timber, a mild climate, and deep and protected waterways—attracted settlers to the Washington Territory. Within 130 years the trees that stood at water's edge were felled, the catches of fish diminished, the natural beds of clams and oysters virtually depleted.

Today, two-thirds of Washington State's population resides in the twelve counties bordering Puget Sound, and to meet the needs of the growing population, major developments are being undertaken continually. It is understandable that conflicts arise over uses of the state's abundant but finite coastal resources, and these issues are the subject of three Washington Sea Grant projects:

- Conflicts over the use of aquatic areas in Washington's coastal zone arise because of competing uses. The difficulties in resolving these conflicts result from overlapping federal, state and local jurisdictions and the differing management objectives of each. Aquaculture siting, dredged material disposal, location of municipal sewage outfalls, port facilities development and landfill siting are issues that generate conflict, often pitting local forces against each other and against municipal, state, and federal agencies. Lack of a statewide aquatic area management framework for solving such problems has meant that the problems that are resolved are worked out on a case-by-case basis and some are not resolved at all.

  Because there is a lack of information about possible alternatives and because shorelands management is a collection of localized plans at the city and county level, state agencies have been unable to devise a system for aquatic area management.

  Marc J. Hershman, professor at the U.W. Institute for Marine Studies, is completing a study of current aquatic use and management systems. To address the lack of comparative data, he and his students have studied management systems elsewhere along the West Coast of the United States. At the conclusion of the project Hershman will recommend reforms aimed at reducing aquatic area conflicts that arise from overlapping authorities and assess ways to implement such reforms.

- Washington State, with the largest number and longest history of public ports in the nation, offers valuable case study material for developing an understanding of the political powers, governance and financial structures of public ports. In research aimed at providing this understanding, University of Washington political scientist David J. Olson has studied 12 Western Washington ports serving ocean-going vessels. Using data for the years 1974-81, he has developed a method for analyzing the financial data to generate information about the performance, financing, organization and governing of the ports and findings have been presented at six professional meetings.

  Besides producing information essential to the continued development of ports and pertinent to a scholarly understanding of the role of public enterprise in American society, Olson has used the material to develop undergraduate- and graduate-level courses, titled "Ports as Public Enterprise." As a public service, Olson has advised civic organizations on port-related issues and has contributed to a study of New England ports. (See related story in advisory services section.)

- At University of Victoria, policy analysts Robert L. Bish and Mark H. Sproule-Jones are addressing the legal foundations and institutional arrangements for coastal resource decision-making in Washington State and British Columbia. The researchers compare the performances of the two political units' domestic structures and procedures governing such resource use as water transportation, fisheries, waste disposal and water quality, marine recreation and major facility siting on shorelines. In addition, they are investigating ways these internal institutional arrangements affect the resolution of problems which occur along their common international boundary.

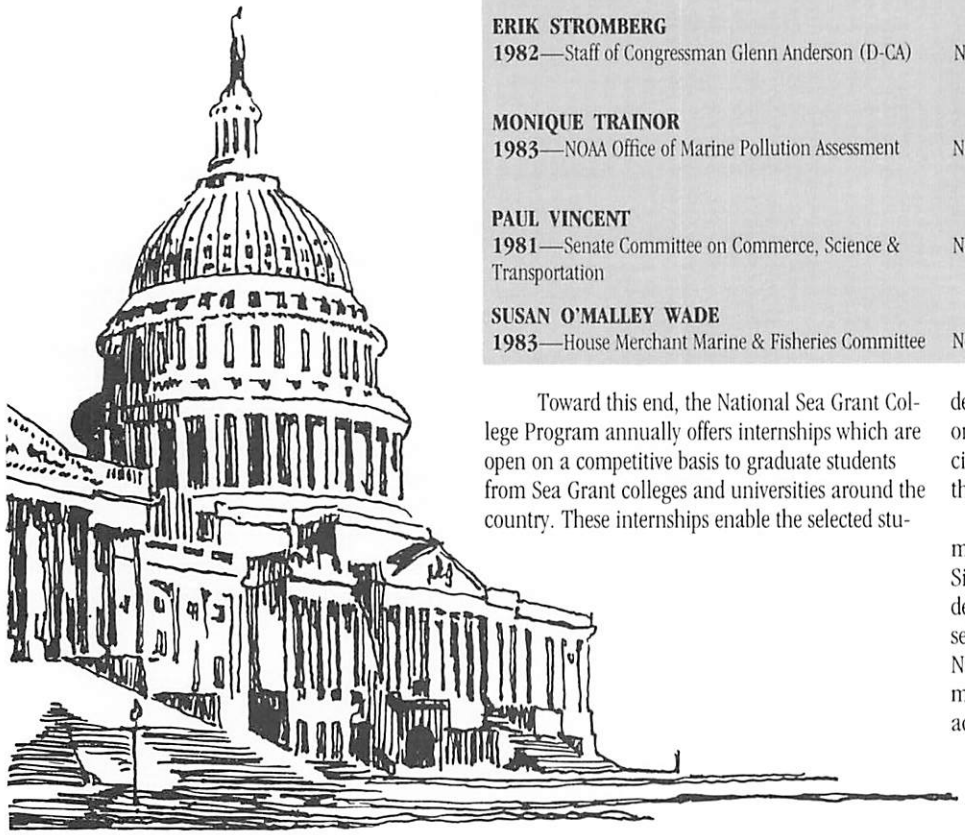
  Results of the study, which will be published as a book, will aid legislators, citizens, and agency officials in understanding how institutional arrangements affect both domestic policy and function as well as across-the-border decision-making, performance, and international relations.

. . . that it is in the national interest of the United States to develop the skilled manpower, including scientists, engineers, and technicians . . . necessary for the exploitation of these resources . . .

National Sea Grant College Program Act, 1966

Sea Grant Interns from University of Washington

Student/Internship	Status as of March 1983
DAN ASHE **1982**—House Merchant Marine & Fisheries Committee	Now a regular staff member House Merchant Marine & Fisheries Committee
DARRELL BROWN **1980**—Oceanography Subcommittee, House Committee on Merchant Marine & Fisheries	Now a regular staff member Oceanography Subcommittee, House Merchant Marine & Fisheries Committee
CHRISTINE L. DAWSON **1979**—National Ocean Policy Study, Senate Commerce Committee	Now working for State Department, OES/OSA
GINA DeFERRARI **1981**—Coast Guard Subcommittee, House Committee on Merchant Marine & Fisheries	Now a regular staff member Coast Guard Subcommittee, House Merchant Marine & Fisheries Committee
KEVIN McMANUS **1983**—National Marine Fisheries Service	Now serving internship
JAMES H. RENDALL **1979**—National Marine Fisheries Service	Deceased
ALLEN STAYMAN **1979**—Staff of Senator Lowell P. Weicker (R-CT)	Summer 1982 worked for NMFS High Seas Tagging Project—Now self-employed
ERIK STROMBERG **1982**—Staff of Congressman Glenn Anderson (D-CA)	Now on staff of Federal Maritime Commission
MONIQUE TRAINOR **1983**—NOAA Office of Marine Pollution Assessment	Now serving internship
PAUL VINCENT **1981**—Senate Committee on Commerce, Science & Transportation	Now on staff of Federal Maritime Commission
SUSAN O'MALLEY WADE **1983**—House Merchant Marine & Fisheries Committee	Now serving internship



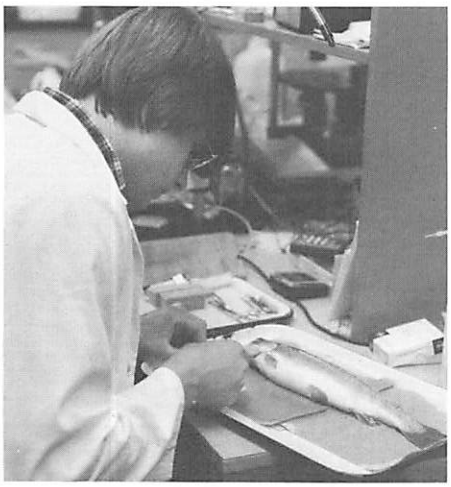
Toward this end, the National Sea Grant College Program annually offers internships which are open on a competitive basis to graduate students from Sea Grant colleges and universities around the country. These internships enable the selected students to spend a year in Washington, D.C., working on Congressional committees or for federal agencies. There they experience first-hand the impact of the federal government on marine affairs.

Competition for these posts is keen. Last year, more than 50 students applied for 15 internships. Since interns were first named in 1979, eleven students from the University of Washington have been selected–more than from any other university. Names of those students, their one-year assignments, and their present positions are listed in the accompanying table.

Diagnosing Fish Diseases

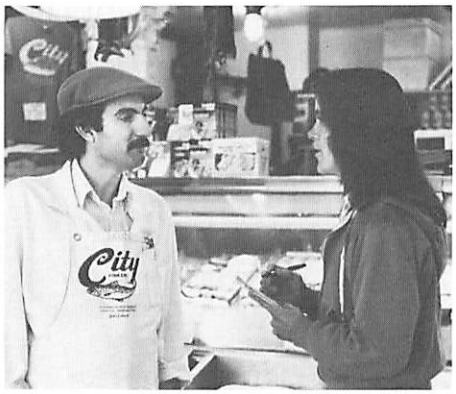
In 1981, a training program was begun in the School of Fisheries by Professor Marsha Landolt to provide graduate students with experience in the diagnosis of aquatic animal diseases. A by-product of the program is the provision of diagnostic services for the marine/aquatic community that are not readily available elsewhere.

During the year, forty cases were referred to the laboratory for processing by three graduate students who gained both experience and academic credit for their work. These cases came from a variety of sources, including university scientists, federal biologists, proprietors of private hatcheries, and pet fish owners. The specimens referred ranged from salmon to crayfish and their disorders from infections to tumors. In many instances, the student pathologists were able to recommend treatment or management strategies which cured or at least alleviated the problem. All data, photographs, and tissues collected in the diagnostic program are filed for future reference and classroom study.



Vicki Miles, Washington Sea Grant

Chris Rockwell, a graduate student in Marsha Landolt's diagnostic pathology training program, prepares to take tissue samples to aid in determining the cause of death of a fish.



Debbie Dwyer, fisheries biology graduate student, questions Bruce Levy of the City Fish Company, Pike Place Market, Seattle, as part of her study of marketing strategies of seafood vendors.

The Human Factor

The significance of local attitudes in the formulation and implementation of marine/coastal laws and policies cannot be underestimated. A community molded by geographic proximity or by a common occupation or social identity can mean the difference between success or failure in management policies devised for a public resource such as a fishery or a coastal recreation area. In turn the community may be initially affected by a policy change, and possible effects should be considered in the policy process.

Researchers have repeatedly documented failures of resource management policies that take into account biological (or other scientific) factors but ignore human factors. A few years ago, Marc L. Miller, an anthropologist in the Institute for Marine Studies, examined the customs of a traditional East Coast fishing community and described the subsequent impact of federal regulations on that community. He noted flagrant violations of the regulations by the community because the regulations failed to consider the cultural values of the fishermen in that community.

As a result of his research, Miller determined that an introductory course in anthropology was needed to introduce students pursuing careers in marine policy and resource management to the results of previous research on maritime communities and expose them to ethnographic research methods. The course was introduced in 1981 and has been offered each year since. Students have undertaken field studies of groups of people whose lifestyle, work, or play depends on the environment. These groups have included ferry boat workers, drawbridge operators, tugboat crews, houseboat dwellers, and female oceanographers. In the long term, Miller hopes that this maritime anthropology course will result in future policy makers and resource managers who not only appreciate cultural differences but who also achieve rapport and work effectively with diverse public groups.

Fisheries/Oceanography Seminar

Most students majoring in fisheries have limited knowledge of the physics of the surface layer of the ocean and of the interaction of the fishes at the layer. Because this environment dominates the life cycle of important stocks of fish, and because existing courses are not designed to provide this knowledge, faculty members from the Institute for Marine Studies, the School of Fisheries, and the School of Oceanography asked Sea Grant for funds to support development of a seminar in fisheries/oceanography. During Winter Quarter 1982, Professor Donald L. Gunderson, of the School of Fisheries, and Professor Warren Wooster, of the Institute for Marine Studies, joined forces to offer a series of graduate seminars on the topic. Seven students from Fisheries, six from Oceanography, and a number of employees of the Washington State Department of Fisheries and the National Marine Fisheries Service attended and participated in these sessions.

The course brought the graduate students up to date on the fisheries/oceanography literature and focused their attention on several important areas for future research. The course was so well received that it subsequently was offered in Winter Quarter 1983 and will be offered in future on an annual basis.

EDUCATION

In 1971, two professors of fisheries—Ole Mathisen and Douglas Chapman—launched an annual series of lectures on living marine resources. The initial purpose of this Sea Grant-supported effort was to enhance the standard curriculum of students of fisheries by bringing to the campus internationally known experts to lecture on important subjects related to the management of fisheries and other living marine resources. It was quickly recognized that the stature of the visiting lecturers and the significance of their topics were too important for their lectures to remain limited to the original local audience.

Therefore, the Sea Grant communications office undertook publication of the lectures either as books or technical reports for worldwide distribution. The demand for these publications has been gratifying. Several of the publications have been adopted as textbooks, one is being translated into Spanish, and European rights for a third were sold to a major British publishing house. The lecturers and their topics are summarized in the table. Several items, such as those by Regier and by Lasker, et al. have been highly influential in the field. All are in wise use.

A second series of lectures, which was also published, was initiated with Sea Grant support in 1980 by the faculty of the University's Institute for Marine Studies. These lectures in marine affairs were begun to commemorate the contributions of Donald L. McKernan, director of the Institute until his death in Beijing in May, 1979. Before coming to the Institute in 1974, McKernan's career had spanned that of fisheries scientist, federal administrator, diplomat, and chief spokesman for the United States on matters concerning fisheries, marine research, and preservation of the marine environment. The lectures summarized here seem a fitting tribute to McKernan's achievements. These lectures and the resulting publications are important contributions to rational understanding of marine policy issues and help to underscore the need for a Sea Grant role in enhancing national ocean policy.

Washington Sea Grant Lecture Series

Year/Topic	Lecturer/Affiliation
Lectures on Living Marine Resources, School of Fisheries	
1971—Population Dynamics of World Fisheries[1]	**John Gulland,** U.N. Food and Agriculture Organization, Rome
1972—Recruitment and Parent Stock in Fishes[2]	**David H. Cushing,** Ministry of Agriculture, Fisheries and Food Lowestoft, U.K.
1974—Footnotes on Population Dynamics[3]	**W. E. Ricker,** Pacific Biological Station, Nanaimo, B.C.
1975—Early Life History of Marine Fish: The Egg Stage[2]	**Gotthilf Hempel,** Institute of Marine Sciences, Kiel University, Kiel, Germany
1975—Aquaculture in Southeast Asia: A Historical Overview[2]	**Shao-Wen Ling,** School of Marine and Atmospheric Sciences, University of Miami
1976—A Balanced Science of Renewable Resources: With Particular Reference to Fisheries[1]	**Henry A. Regier,** Institute of Environmental Studies, University of Toronto, Canada
1978—Conservation and Management of Whales[2]	**K. Radway Allen,** Scientific Committee, International Whaling Commission, Cronulla, Australia
1979—Some Recent Advances in the Estimation of Animal Abundance[1]	**G. A. F. Seber,** Mathematics Dept., University of Auckland, New Zealand
1979—Marine Fish Larvae: Morphology, Ecology, and Relation to Fisheries[2]	**Reuben Lasker,** Paul E. Smith, H. Geoffrey Moser, John Hunter, Southwest Fisheries Center, NMFS, La Jolla, CA
1979—Early Life History of Eastern North Pacific Fishes in Relation to Fisheries Investigations[4]	**Arthur W. Kendall, Jr.,** Northwest & Alaska Fisheries Center, NMFS, Seattle, WA
1980—Seals and Man: A Study of Interactions[2]	**W. Nigel Bonner,** British Antarctic Survey, Cambridge, U.K.
1981—Physical Features of Coastal Upwelling Systems[4]	**Robert L. Smith,** Oregon State University, Corvallis, OR
1981—Nutrient Budget and Primary Production in Upwelling Systems[3]	**R. T. Barber,** Duke University Marine Lab, Beaufort, NC
1981—Modelling of Coastal Upwelling Systems[3]	**John J. Walsh,** Brookhaven National Lab, Long Island, NY
1982—Population Genetics and Its Application to Fisheries Management and Aquaculture[3]	**Nils Ryman,** Genetics Department Stockholm University, Sweden
McKernan Lectures in Marine Affairs, Institute for Marine Studies	
Apr. 15-17, 1980—Pacific Salmon: Scenarios for the Future[4]	**Peter Larkin,** Graduate School, University of British Columbia
Oct. 15-16, 1980—Should We Cut Our LOSes? U.S. Foreign Policy and International Regimes[4]	**Joseph S. Nye,** Kennedy School of Government, Harvard University
May 26-28, 1981—Extended National Fisheries Jurisdiction: Palliative or Panacea?[4]	**Roy Jackson,** Natural Resources Consultants, Seattle; Formerly, U.N. Food & Agriculture Organization
Oct. 27-29, 1981—Balancing Unknowns: A Decade of Controversy about Developing the Outer Continental Shelf[4]	**H. William Menard,** Scripps Inst. of Oceanography; Formerly Director, U.S.G.S.
May 3-4, 1982—Science and Politics: International Atmospheric and Oceanic Programs[4]	**Robert M. White,** University Corp. for Atmospheric Research; Formerly, Chairman, World Climate Conference, W.M.O.
Jan. 18, 1983—Neither Guns nor Butter: A Look at National Maritime Policies[3]	**Henry S. Marcus,** Dept. of Ocean Engineering, Massachusetts Inst. of Technology

[1] Out of print
[2] Available from University of Washington Press, Seattle 98195
[3] Unpublished
[4] Available from Washington Sea Grant Communications, Seattle 98195

Developing Classroom Materials with a Marine Flavor

On the one hand, most people would agree that appreciation for the value of the marine environment grows out of knowledge of that environment. Most would also agree that such knowledge is best fostered through public school education. On the other hand, recent studies of the nation's public school system point to the problems of turning out graduates skilled in basics of reading, writing, and arithmetic—much less in matters marine.

Thus given a mandate to develop marine education programs, Sea Grant faces a dilemma: How to expose students to marine subjects, yet not dilute existing efforts to teach basic subjects.

Andrea Marrett, manager of the Pacific Science Center's marine education project, has devised such a program. She and her colleagues have developed curriculum packets for grades K–12 that integrate marine examples into basic courses—language arts, history, and the sciences.

Sixteen packets (see table) have been developed, trial taught, and published. Last year, the packets, which have attracted the attention of marine educators nationwide, were disseminated to 2,800 teachers throughout Washington by the State Office of the Superintendent of Public Instruction. In addition, Pacific Science Center records indicate that more than 3,000 packets have been sold since they were first printed in 1980.

An average of 25 packets are sold each month to teachers, businesses, and public agencies. Included among the requests have been orders from the National Audubon Society and Sea World of San Diego. Income from sales goes toward reprinting and sustaining the supply of these packets.

Vicki Miles, Washington Sea Grant

The task of measuring water movement in the Pacific Science Center's 16-foot-long Puget Sound model challenges three students. Assisting them is marine education project manager Andrea Marrett.

The following marine activity packets were developed under a Sea Grant Project at the Pacific Science Center to supplement existing school courses. The packets were designed to involve students in hands-on participatory activities.

Packets may be ordered from the Arches Gift Shop, Pacific Science Center, 200 Second Avenue North, Seattle, WA 98109. Each activity packet is priced at $6.00, and a $.75 shipping and handling fee is charged for each activity packet or slide set sent.

Title of packet	Grades	Purpose
ELEMENTARY		
High Tide, Low Tide	3-4	Introduces students to twelve common rocky shore animals
Life Cycle of a Salmon	3-5	Presents life cycle of salmon in Northwest waters
Waterbirds	4-6	Emphasizes ecological factors which affect both birds and people
Whales	4-6	Consists of six activities related to ancient and modern whaling methods, whale biology, and population management
JUNIOR HIGH		
Beaches	7-9	Introduces the physical and biological processes of the beach zone
Beach Profiles and Transects	8-9	Gives directions for measuring and recording the profile of a slope and shows how to sample beach populations using a single line transect-quadrat method
Early Fishing Peoples of Puget Sound	7-9	Presents early Puget Sound Indian cultures and their independence on a water environment
Energy from the Sea	7-9	Explores the potential of offshore oil deposits and proposals for tapping the energy of tides, winds, currents, and ocean thermal differences
Literature of the Sea	7-9	Includes short stories, poems, and longer prose selections about the sea
Tides	7-9	Examines the relationship of tides and the position of sun, moon, and earth. Shows how tides are predicted and how to read tide charts
Tools of Oceanography	7-9	Familiarizes students with tools oceanographers use for navigation and scientific measurements
SENIOR HIGH		
American Poetry and the Sea	10-12	Presents poems about the sea written by American poets
Marine Biology Activities	7-Com. College	Develops understanding of structural and behavioral adaptation, zonation, and habitat through classroom, laboratory and field trip activities
Marine Biology Field Trip Sites	K-Com. College	Provides teachers with information necessary for selecting a beach field trip site in Puget Sound region: maps, inventories of facilities, checklists
Marshes, Estuaries and Wetlands	10-12	Introduces students to the watershed system and importance of salt and fresh water environments
Squalls on Nisqually A Simulation Game	10-12	Simulates land use decision making in a coastal zone environment

ADVISORY SERVICES

Washington Sea Grant's marine advisory services links marine resource users and managers with the information and research capability essential for making wise decisions—decisions that address local, regional, and national marine-related concerns and that bring economic and social benefits to the community.

In Washington, advisory services are directed toward identifying important marine resource problems and opportunities of seven constituent sectors:

- Aquaculture
- Commercial fishing
- Government agencies and other public institutions
- Marine manufacturing, trade and services
- Marine recreation
- Ports, harbors, and marinas
- Seafood processing and marketing

Once problems and opportunities are identified, marine advisory personnel help stimulate new research within the Sea Grant program or tap existing research efforts for solutions or help.

During the 1981-82 biennium, a wide range of technical assistance and information was provided to Sea Grant constituents by marine advisory personnel through workshops, courses, consultation and publications. The following articles describe some of these efforts.

Reducing the Economic Impact of Regulations

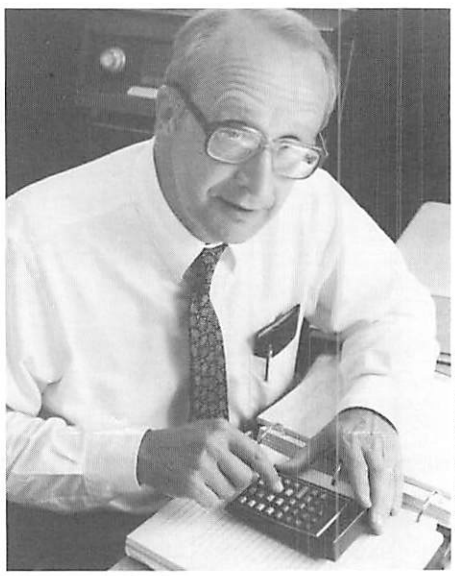
In the mid-1970s, Washington Sea Grant began a substantial commitment to the evaluation of the economic impact of environmental regulations. Initial involvement in this area came in reponse to a 1975 request from the Northwest seafood processing industry. The industry sought help in evaluating the Environmental Protection Agency's (EPA) analysis of the economic impact of the technology the agency had proposed for treating seafood processing wastewater. Sea Grant's review, completed by marine economist James Bray, demonstrated that EPA's assessment of the economic impact of the regulations was flawed and inaccurate. If the regulations were adopted, many seafood processors would be forced to shut down. EPA acknowledged these problems and withdrew the proposed regulations for the pertinent sectors of the processing industry.

Subsequently, Sea Grant's Office of Applied Marine Economics, under Bray's direction, has completed other reviews of proposed regulations. In some cases, the office has demonstrated that adoption of the regulations would require costly technology without providing offsetting environmental benefits.

Economic impact analyses are increasing in importance as the economic and social costs of overly strict regulation become apparent.

Such economic impact analyses are increasing in importance as the economic and social costs of overly strict regulation have become apparent. Where small businesses are affected, regulatory agencies are now required to evaluate the economic impact of proposed regulations. The intended result of the new requirement, stated in the Regulatory Flexibility Act (P.L. 96-354), which went into effect January 1, 1981, is to reduce unreasonably burdensome regulations on small businesses, such as seafood processors.

Bray has recently worked with Dr. Teh-Wei Hu of Pennsylvania State University's Department of Economics, the National Fisheries Institute and the Office of Regulations Coordinator of the National Marine Fisheries Service (NMFS), to develop economic profiles of several segments of the U.S. fishing industry. The several-volume Saltonstall-Kennedy study, published in 1983, includes analyses of the Maine sardine, New England bottomfish, menhaden, oyster, blue crab, headless and peeled shrimp, breaded shrimp, and canned shrimp industries. Bray contributed primarily to the design of sampling and interview procedures, to the review of data, and to drafts of the study. The study provides valuable summaries of economic data that will assist the NMFS Regulations Coordinator in monitoring and insuring government compliance with the Regulatory Flexibility Act, as well as providing valuable insight to others interested in the U.S. seafood industry.



Vicki Vules, Washington Sea Grant

Marine economist Jim Bray

Serving Ports And Marine Industries

Port industries specialist Tom Dowd's 1982-83 year of full time volunteer service with Washington Sea Grant Marine Advisory Service has provided new tools for port managers and developed a new constituency for Sea Grant.

The port and transportation sectors are constituencies that have in past years seldom looked to Sea Grant for services or expertise. But a year's effort has rewarded Dowd and Sea Grant with a working relationship with ports and port associations, and future efforts are expected to broaden this to include marine transportation and other port-related industries.

Using his extensive training in port management, business administration, and finance, Dowd has developed advisory services particularly valuable for small- and medium-size ports, which have fewer management resources than large ports.

An important factor in the growing need for port management strategies is the perception that ports have an economic impact on a whole area. They may be the key to success for a local or a regional economy.

"Our main function is to assist ports in making management and policy decisions and to help them explore the options that are available to them in their long term strategic planning," explains Dowd. "These organizations can use us as a sounding board for making financial and operational decisions. We can show them how to use data they already have to develop policies."

Vicki Uhler, Washington Sea Grant

Volunteer port specialist Tom Dowd

A variety of factors have led to an increased need for financial and management services for ports. First, planning at small- and medium-size ports has been, traditionally, an informal process. Records are kept but are not used as part of a strategic planning process. Second, as ports begin to grow, they find that capital improvements are increasingly expensive. Commitments to projects are longer term, requiring more financial planning. A parallel development has been the tightening of tax revenues and budgets. Most ports get some of their income from tax revenues and these have been reduced as a percentage of the total port revenues, thus forcing ports to rely more on operating income.

An important factor in the growing need for port management strategies is the perception that ports have an economic impact on a whole area. They may be the key to success for a local or a regional economy.

Besides working with individual ports in Washington and Oregon, Dowd has worked with the Oregon and Washington Public Ports Associations, has spoken at a Port Management Seminar sponsored by the State of Alaska, and has written a Marine Advisory Report, "Port Management Control System."

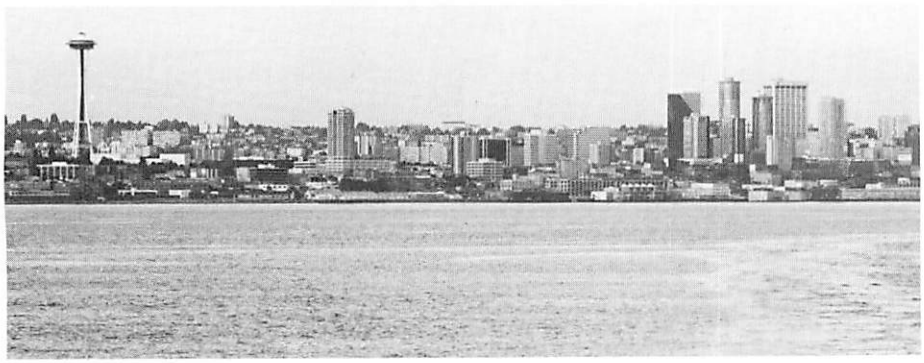
This report describes a monitoring system which enables port management to isolate significant data and use them alone or in concert with other data to formulate intelligent policies. The system measures simply and accurately:

- The efficiency with which a port uses its resources such as land, labor and capital
- The care with which a port controls its expenses
- The profitability of a port's investments

Presented by Dowd at the annual seminar of the Washington Public Ports Association Finance Committee in April, 1983, the Management Control System received much favorable comment and was accepted enthusiastically by the Committee. Subsequently, this Report was offered to ports through the American Association of Port Authorities. This Marine Advisory Report describing the system has been requested by more than 300 ports in the U.S., Canada, and abroad.

Shaping the Future of Seattle's Waterfront

The most important policies for future development of Seattle's central waterfront are maintaining and enhancing maritime use of the area and making it an attraction for people. This view of a panel of six professional planners was hammered out and broadly discussed over a three-day, intensive "Seattle Waterfront Symposium" in September, 1982. The symposium brought together diverse local groups and city and state agencies with special interest in the waterfront. The symposium, sponsored by Washington Sea Grant, the Institute for Marine Studies, and Waterfront Awareness, was coordinated by Robert Goodwin, Sea Grant Marine Advisory Service, and Greg Moore, graduate student in the Institute for Marine Studies.



The blue-ribbon panel included Ogden Beeman, Ogden Beeman and Associates, Portland, Oregon; David Bowden, Bowden Development Consultants, Ltd., Vancouver, B.C.; Dennis Derickson, Director, City of Everett Planning Department; David Kinsey, Director of the Planning Group for New Jersey's Department of Environmental Protection; Larry Reich, Director of the Department of City Planning for Baltimore, Maryland; and Myer R. Wolfe, Professor of Urban Planning at the College of Architecture and Urban Planning, University of Washington.

In addition to providing outside professional scrutiny of central waterfront use, the symposium accomplished these results:

- Provided city planners and citizens with a useful reference—the substantial amount of background information on the waterfront assembled in a notebook for the symposium.
- Provided an opportunity for public participation in the city's planning process.
- Influenced a privately-sponsored proposal for the Alaskan Way section of the waterfront to include consideration of water and pier use and to diversify the public uses and attractions along the Way.
- Through good press and TV coverage of the event and its conclusions, increased public awareness of current waterfront development and the need for a policy directing future development.

At present the waterfront area is the most underutilized section of the downtown area, with 24 percent vacant space or open water. According to a city planner who is studying alternative uses of the waterfront, the area has been zoned for manufacturing since the 1930s, putting it in a holding pattern. Current and future development of the central waterfront is subject not only to city zoning laws, but also must adhere to the state Department of Natural Resources regulations affecting harbor areas and the state-approved Shoreline Master Program for the city.

Seattle's Downtown Land Use and Transportation Project is in the process of developing an alternative policy for the waterfront area. Once completed, the plan will be subject to City Council approval.

The waterfront symposium was designed to focus the best of outside professional expertise on the central waterfront, given the constraints and possibilities of its present facilities and functions. On the first day, the invited panelists discussed their experiences with waterfront issues in other cities and gave their initial impressions of the Seattle waterfront. The current policies and laws governing the waterfront were then explained by local agency officials, followed by sessions in which projects currently under way and planned for the future were presented. Finally, major issues of the day were highlighted in a discussion session in which audience reaction and comment were encouraged.

At present the waterfront area is the most underutilized section of the downtown area, with 24 percent vacant space or open water.

The panel's recommendations for waterfront policy were presented in a Panel Interim Report to symposium participants on day three. Copies of the report were mailed to participants and interested persons after the symposium.

In May 1983, Sea Grant followed up the symposium during Seattle's Maritime Week. In conjunction with Waterfront Awareness, a citizen's group, the Institute for Marine Studies at the University of Washington, the Port of Seattle and the Propeller Club, three evening lecture/discussion programs were held to ascertain which of the panel's recommendations were areas of agreement and which were still unresolved issues. These were summarized and sent in report form to Seattle Mayor Royer, the City Council, and state agency officials for review, in hopes that this emerging consensus would be influential as the city develops its policies for the waterfront area.

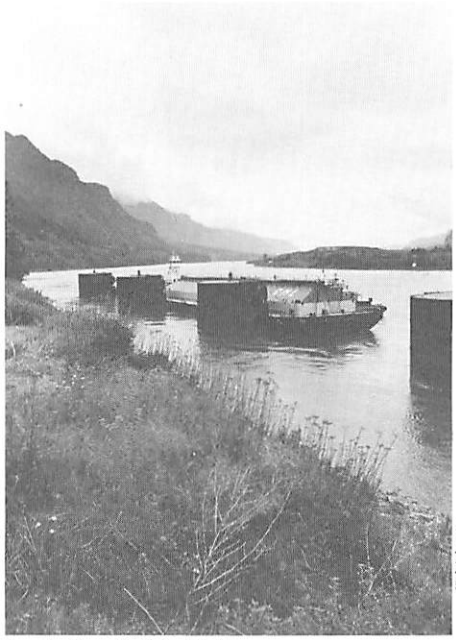
Evaluating a Whole River System

The Columbia River-Snake River system is the second largest river system in the United States. Along the 1,210 miles of the Columbia's main stem alone are found diverse uses: transportation, irrigation, pleasure boating, sportfishing, commercial fishing, hydroelectric power production, and other commercial uses. As some activities begin to crowd others, there arises a need to view the entire river system so that informed and fair decisions about its use can be made.

As Michael S. Spranger, Washington Sea Grant's extension marine specialist for the river area, explains, "Historically, people have viewed the river system either as a series of segments, such as the stretch between Portland and the ocean, or they've looked at it in terms of particular uses—commercial navigation, for instance, or recreation. What is needed is a way to look at the system as a whole."

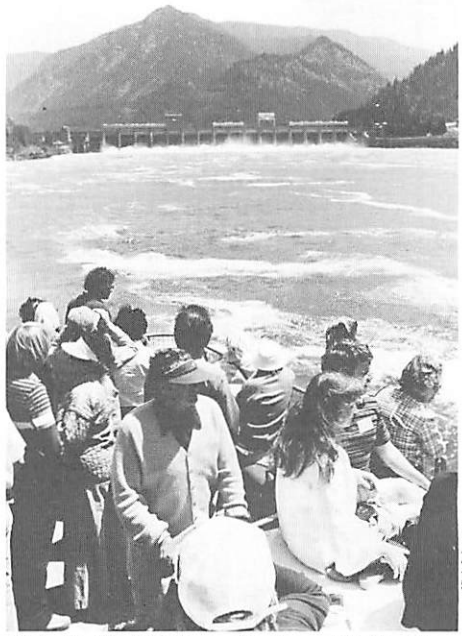
In cooperation with Steve Lindstrom, executive vice president of the Pacific Northwest Waterways Association (PNWA), Spranger organized a day-and-a-half forum of Northwest university researchers to focus on the problem of evaluating the river as a whole. Eight economists and a geographer came together on April 29–30, 1983, to share and exchange views and information. Sponsors for the forum were Sea Grant and PNWA, which is a private lobbying organization with 200 members, including commercial users of the river, irrigation interests, conservationists, hydroelectric power companies, and others.

The purpose of the forum, according to Lindstrom, was to consider whether the river system could be analyzed to determine the total public and private benefits and costs of the river to Pacific Northwest citizens. He asked the researchers to identify areas of research which might be undertaken by the academic community in the interest of furthering such analysis.



Kirk Johnson

Barge traffic on the Columbia River



Kirk Johnson

A Columbia River Short Course, offered annually to the public, acquaints people with the beauty and diverse recreational and commercial uses of the river.

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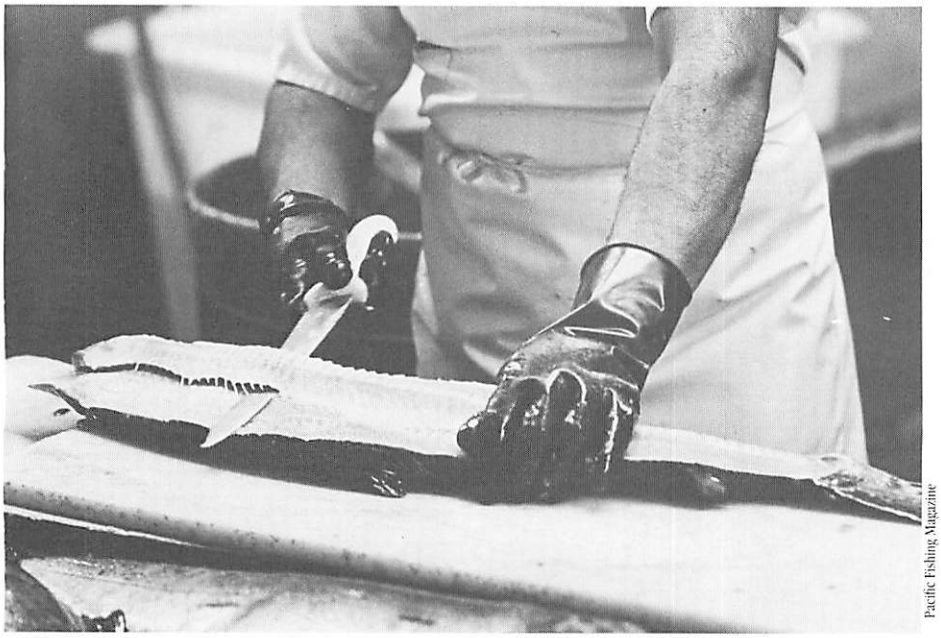
The complexity of the forum's task was evident. Among the issues brought up during the day's discussions were difficulties in quantifying public and private values; the limits of economic analysis in the public sector; and the problem of changing public values.

In light of these complexities, which would prevent a straightforward economic analysis, the participants recommended some initial steps toward developing a comprehensive evaluation of the river system. One suggestion, that an annotated bibliography of research done on water user fees be compiled, has been accepted by PNWA for a future effort, providing funds are available.

According to Lindstrom, PNWA hopes to develop bibliographies on three subjects:

- Information available on the Columbia-Snake river system
- Research on water user fees for other river systems
- "How-to" information: a collection of the methodologies for valuation used in economics, agriculture and other disciplines



Pacific Fishing Magazine

Seafood Processing Short Course

Class sizes reaching the 90s now characterize the annual short course in seafood processing coordinated by Washington Sea Grant seafood processing specialist John Peters. The 30-hour evening lecture series held on the University of Washington campus is taught largely by quality control supervisors from many of the seafood processing companies whose headquarters are in or near Seattle.

Aimed primarily at inexperienced persons, the course is also useful for people already working in the seafood processing industry, or in related occupations such as food retailing. It serves to bring together employers and potential employees.

One reason for interest in the course by seafood processors is this industry's constant need for trained personnel. The seasonality and remote location of much of the work in the Pacific Northwest seafood processing industry contribute to high employee turnover. And the continued striving to improve product quality adds to the need for training.

Topics covered in the lecture series include microbiology and sanitation; fish and seafood handling, both on the boat and at the plant; canning and can seam evaluation; marketing and health regulations. There is a session on seafood spoilage evaluation in which students learn to assess the quality of the product through smell and touch. And there are special sessions on particular segments of the industry, such as salmon, crab, shrimp and bottomfish. Federal regulations and inspections earn a separate lecture, taught by Food and Drug Administration representatives and representatives from the Alaska Department of Environmental Conservation.

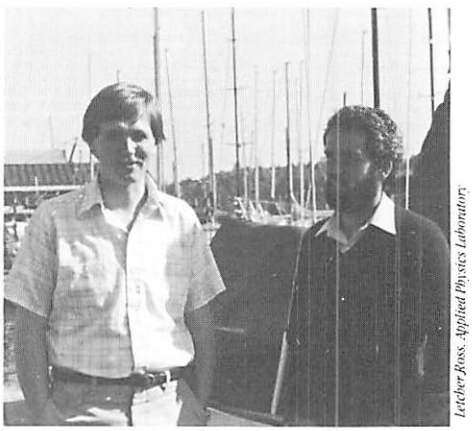
Passing students are awarded a certificate signifying satisfactory completion of the course. For those interested, however, the real reward will be a job in the industry.

Computer Use in Marine Businesses?

Some of the pros and cons of using microcomputers in marine businesses, commercial fishing, and seafood processing were explored in workshops held in the Aberdeen and Bellingham areas in 1983. Marine advisory service field agents Steve Harbell and Jim Humphreys arranged sessions in their respective regions of the state. Fred Smith, an Oregon State University Sea Grant economist, had developed the workshop concept for Oregon and assisted in the Washington sessions.

At the workshops, participants were able to evaluate both an assortment of microcomputers and a variety of programs now on the market for such uses as inventory control for small businesses. Geared for people with no previous computer experience, the sessions included time to use ten microcomputers and programmable calculators and a chance to evaluate available software.

The availability of software for particular applications is an important consideration, participants learned. There are currently some programs written for commercial fishermen to aid in decision-making, such as one which analyzes what port to take one's catch to for the most profitable sale. Such factors as distance to ports, fuel costs and prices of fish need to be considered, and most fishermen do this figuring in their heads. A programmable calculator, easily kept on board a boat, is all that is needed to make an accurate calculation.



Letcher Ross, Applied Physics Laboratory

Marine field agents (left) Jim Humphreys, Bellingham, and (right) Steve Harbell, Montesano.

Advisory Services in Print

The Marine Advisory Service handles many requests for information by offering local workshops or individual assistance. However, when a new issue generates a great deal of public interest or concern, printing a bulletin for wide distribution may be a more effective response. Described here are four examples of recent MAS publications which have proven useful to a large number of people and institutions.

- To aid commercial fishermen who find charting a business course either more difficult or less interesting than going after fish, Washington Sea Grant published in August, 1982, a "Commercial Fishermen's Recordkeeping and Business Management Manual." Written by former North Puget Sound Marine Advisory field agent Pete Granger, the manual gives the whys, how-tos and specific examples of the records needed for tax purposes, loan application, and budgeting and business decision-making. The manual's three separate sections, "Recordkeeping and Checking," "Bookkeeping," and "Managing and Planning," permit the user to stick with the basics or delve further into management as he or she wishes. Its spiral bound pages, in ledger format, open flat for convenient use.

Reviewed in National Fisherman's 1983 *Yearbook*, the manual was termed "attractive and practical," with clear explanations and forms adaptable for use by most American commercial fishermen. More than 600 copies, at $5.00 each, have been sold so far to commmercial fishermen on the Pacific, Gulf and Atlantic coasts.

- Boaters operating on Puget Sound or in the San Juan Islands between August and November may find themselves in the same waters, at the same time, as commercial fishermen gillnetting for salmon. Because of the 1800-foot length of a gillnet and the difficulty in seeing one under adverse conditions, there is the possibility of an encounter resulting in costly damage to both gillnet and boat. To advise boaters on the best ways to detect and navigate around gillnets, North Sound marine field agent Jim Humphreys wrote "Navigating Through a Gillnet Fleet." Distribution of the report since publication in July, 1982, totals nearly 4,000 copies.
- During the past two years, as ex-vessel fish prices declined and fishing seasons shortened, some Washington fishermen tried to shore up their sagging profits by selling directly to consumers. Some who ventured into business, however, found themselves quickly shut down by city or state officials. The fishermen hadn't known about, or hadn't followed, the steps required to sell fish legally.

  In Washington, a wholesale fish dealer must be licensed, have a state tax registration number, and must also adhere to city or county health and sanitation requirements for wholesale fish dealers. In some jurisdictions, a business license is also required.

  Information on these regulations has in previous years been scattered among a number of agencies, contributing to confusion and ignorance of the requirements.

  In June, 1983, however, Sea Grant published a brochure listing the procedures, regulations and agencies involved in the process of starting a wholesale fish dealer's business. "Marketing Your Catch on Your Own: A Fisherman's Guide to Selling Seafood in Washington," was written by Charlotte Henry, Marine Advisory Services program assistant at the Fishermen's Terminal in Seattle. The report lists state requirements and breaks down by city and county the health and sanitation regulations across the state. It differentiates finfish and shellfish requirements and briefs the reader on related business matters, including registering for industrial insurance and unemployment security. Initial distribution of the brochure exceeded 1500 copies.
- Confusion about the safety of shellfish gathered in local waters, questions surrounding the term "red tide," and misconceptions about the shellfish species affected by, and the seasonality of, Paralytic Shellfish Poisoning (PSP), makes a new bulletin, "Gathering Safe Shellfish in Washington," immediately useful and informative. Written by fisheries biologist Louisa Nishitani and University of Washington fisheries professor Kenneth K. Chew, the report explains what paralytic shellfish poisoning is, its history of occurrence in Washington waters, and how the measures set up by the state Department of Social and Health Services work to protect shellfish consumers. Published in December, 1982, the report has been rated highly by the scientific community. A second printing was needed to fill the large number of requests for the bulletin. To date, more than 6500 copies have been distributed.

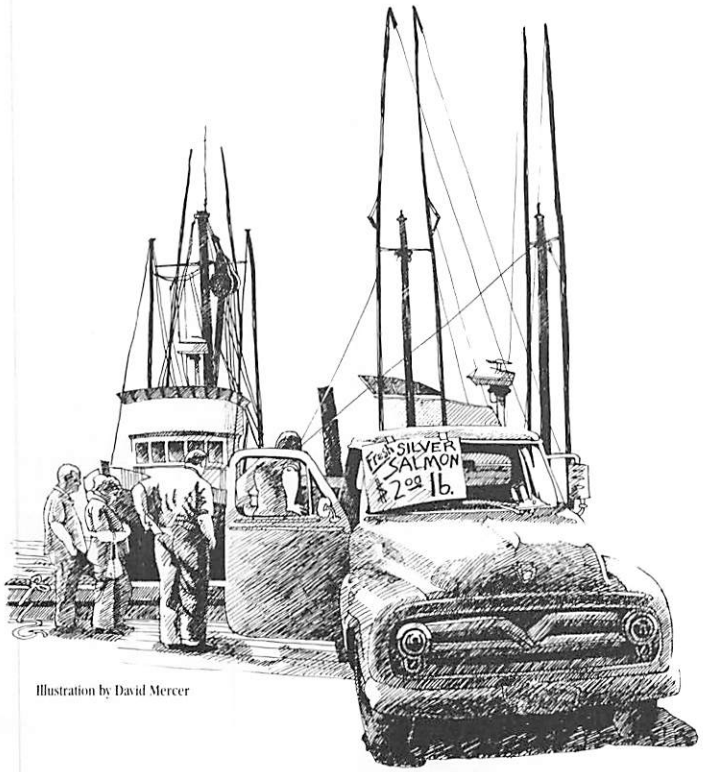


Illustration by David Mercer

PUBLICATIONS

Publishing the Results

The research, education, and advisory activities supported by Washington Sea Grant do not achieve their maximum potential unless the results are communicated to audiences needing that information. These audiences include specialized segments of marine industries and businesses, financial institutions, government agencies, marine scientists and engineers, recreational interests, marine editors, as well as the general public. Through its communications services Washington Sea Grant relays research results and information about program activities to these audiences through books, technical reports, advisory leaflets, and news releases and fact sheets for the media. These publications are distributed widely to targeted audiences usually by Sea Grant itself but at times through the University of Washington Press.

Of special note during the 1981-82 biennium was the publication of the first three volumes in the Puget Sound Books series. These books were commissioned by the staff in 1977 to provide the public and regional resource management institutions and agencies with a broad understanding of Puget Sound. When completed, the 14 volumes planned will cover the Sound's physical properties, its biological aspects, and its uses by man—both historical and present day. The series will constitute a major source of comprehensive and up-to-date information about Puget Sound and will be one of the few such series of books commercially available anywhere in the world on a specific geographic region.

The first two volumes to appear—*The Water Link* and *Governing Puget Sound*—have been adopted as college texts not only in Washington but also in Texas for courses related to coastal zone management. The third volume off the press—*Marine Birds and Mammals of Puget Sound*—was selected from hundreds of entries for a 1982 Western Book Award. As a result, this book will be displayed with other award winners in an exhibit that will tour 40 U.S. libraries during the next two years. This beautifully illustrated book is also generating a significant number of sales—nearly 4,000 in fewer than 10 months. A second printing appears likely.

Other publications and reports which resulted from Washington Sea Grant efforts in 1981-82 are listed below. A catalog of the program's publications produced in the Spring of 1983 is available from Washington Sea Grant Communications, University of Washington, 3716 Brooklyn Avenue N.E., Seattle WA 98105. Updates to the catalog are published periodically and are also available from the communications office.

BOOKS

The following books published by the Washington Sea Grant Program may be ordered through your local bookseller or from the University of Washington Press, Seattle, WA 98195. Please cite the International Standard Book Number (ISBN) when ordering. If ordering directly from the Press, please make checks payable to the University of Washington Press. Remittance must accompany orders from individuals. U.S. currency only. Washington State residents please add applicable sales tax. Minimum order is $10.00. Please add $1.75 postage and handling.

Tony Angell and Kenneth C. Balcomb, III. *Marine Birds and Mammals of Puget Sound.* ISBN 0-295-95942-8. $14.50

Robert L. Bish. *Governing Puget Sound.* ISBN 0-295-95886-3. $8.95

W. Nigel Bonner. *Seals and Man: A Study of Interactions.* ISBN 0-295-95890-1. $9.95

Gardner M. Brown, Jr. and James A. Crutchfield, editors. *Economics of Ocean Resources* ISBN 0-295-95982-7. $12.00

Daniel Jack Chasan. *The Water Link: A History of Puget Sound as a Resource.* ISBN 0-295-95782-4. $8.95

Reuben Lasker, Editor. *Marine Fish Larvae: Morphology, Ecology, and Relation to Fisheries.* ISBN 0-295-95883-9. $8.50

McKERNAN LECTURES IN MARINE AFFAIRS

These lectures may be ordered from Washington Sea Grant Communications, University of Washington, 3716 Brooklyn Avenue N.E., Seattle, WA 98105. Checks should be payable to the University of Washington. Remittance should accompany orders from individuals. U.S. currency only. Washington State residents, please add applicable sales tax.

Roy Jackson. *Extended National Fisheries Jurisdiction: Palliative or Panacea?* WSG 82-1. $3.00

H. William Menard. *Balancing Unknowns: A Decade of Controversy About Developing the Outer Continental Shelf.* WSG 82-2. $3.00

Joseph S. Nye. *Should We Cut Our LOSes? U.S. Foreign Policy and International Regimes.* WSG 81-2. $3.00

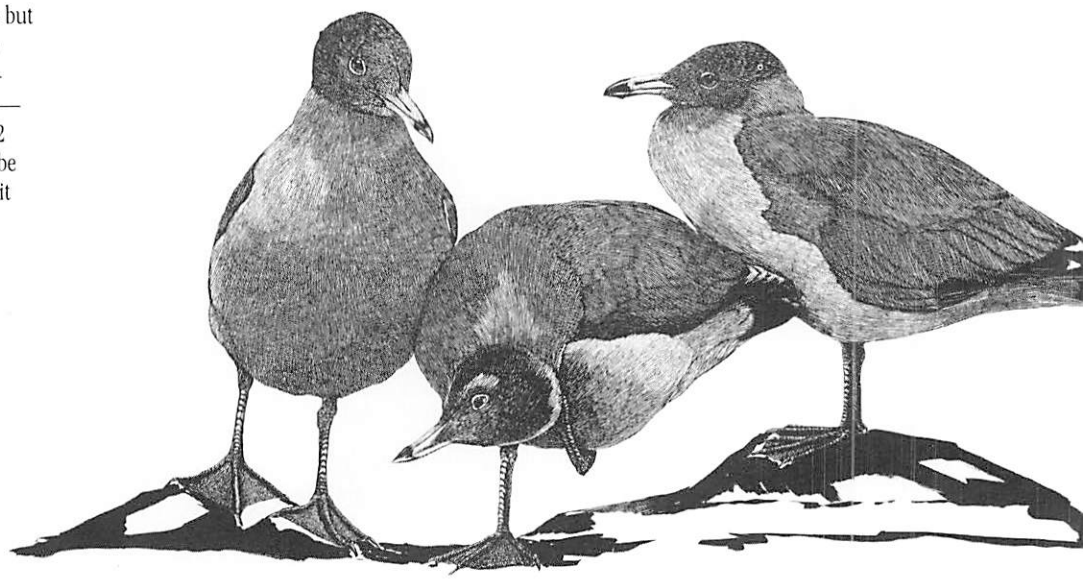


Illustration by Tony Angell

PUBLICATIONS

TECHNICAL REPORTS

These reports may be ordered from Washington Sea Grant Communications, University of Washington, 3716 Brooklyn Avenue N.E., Seattle, WA 98105. Checks should be payable to the University of Washington. Remittance should accompany orders from individuals. U.S. currency only. Washington State residents, please add applicable sales tax.

Gregory J. Anderson, Mark B. Miller, and Kenneth K. Chew. *Guide to Manila Clam Aquaculture in Puget Sound.* WSG 82-4. $3.50

Raymond M. Buckley and James M. Walton. *Fishing Piers: Their Design, Operation, and Use.* WSG 81-1. $2.50

C. A. (Pete) Granger. *Commercial Fishermen's Recordkeeping & Business Management Manual.* WSG 82-3. $5.00

Arthur W. Kendall. *Early Life History of Eastern North Pacific Fishes in Relation to Fisheries Investigations.* WSG 81-3. $1.50

Peri Muretta, Marc J. Hershman, and Robert F. Goodwin. *Waterfront Revitalization: Plans and Projects in Six Washington Cities.* WSG 81-4. $2.50

PROCEEDINGS

These proceedings may be ordered from Washington Sea Grant Communications, University of Washington, 3716 Brooklyn Avenue N.E., Seattle, WA 98105. Checks should be payable to the University of Washington. Remittance should accompany orders from individuals. U.S. currency only. Washington State residents, please add applicable sales tax.

Gregor M. Cailliet and Charles A. Simenstad, editors. *Gutshop '81: Fish Food Habits Studies.* Proceedings of the Third Pacific Workshop, Pacific Grove, CA, December 6-9, 1981. WSG-WO 82-2. $8.00

Robert F. Goodwin, Editor. *Boating & Moorage in the '80s.* Proceedings of a workshop, Seattle, WA, November 4-6, 1981. WSG-WO 82-1. $8.00

Charlotte Henry, Editor. *Black Cod--Boom or Bust?* Proceedings of a Seminar, Seattle, WA, February 27, 1980. WSG-WO 81-1. $1.50

ADVISORY PUBLICATIONS

A single copy of the following publications will be sent upon request to Washington Sea Grant Communications, University of Washington, 3716 Brooklyn Avenue N.E., Seattle, WA 98105. Bulk rates are available upon request to the same office.

Scott Harrington. *Rigging for Otter Trawling: An Option for your Boat.* WSG-AS 81-2.

Charlotte Henry, Editor. *Washington's Commercial Fishing Industry: Directory of Associations, Agencies, Publications.* WSG-AS 81-1. Out of print.

Charlotte Henry, Editor. *Washington's Commercial Fishing Industry: Directory of Associations, Agencies, Publications. WSG-AS 81-1. Revised edition.* Out of print.

Jim Humphreys. *Navigating Through a Gillnet Fleet.* WSG-AS 82-1.

Louisa Nishitani and Kenneth K. Chew. *Gathering Safe Shellfish in Washington.* WSG-AS 82-3.

Michael S. Spranger. *The Columbia River: A Time of Decision and A Question of Balance.* WSG-AS 82- 2.

PROGRAM REPORTS

The following reports may be ordered from Washington Sea Grant Communications, University of Washington, 3716 Brooklyn Avenue N.E., Seattle, WA 98105.

Washington Sea Grant Program: A Project Directory, 1981-82. WSG-PM 81-1.

Washington Sea Grant Program: A Report of Activities, 1979-80. WSG-PM 81-2.

Washington Sea Grant Program Description. WSG-PM 82-1.

Washington Sea Grant Program: North Sound Marine Advisory Services, 1982. WSG-UN 82-2.

JOURNAL ARTICLES

The following reports of research supported by Washington Sea Grant appear in the journals cited or in the proceedings of the scientific or engineering societies indicated. Please contact your nearest university or college library for assistance in locating these articles and reports.

K. Banse. On some Cossuridae and Maldanidae (*Polychaeta*) from Washington and British Columbia. WSG-TA 81-7. From: *Canadian Journal of Fisheries and Aquatic Sciences*, 38(6):633-637.

David Burch. Long distance ocean navigation without instruments. WSG-TA 81-6. From: *Proceedings of American Institute of Aeronautics and Astronautics, Ancient Interface XI*, Seattle, WA, September 12, 1981.

James L. Congleton, Steven K. Davis, and Steven R. Foley. Distribution, abundance and outmigration timing of chum and chinook salmon fry in the Skagit salt marsh. *Salmon and Trout Migratory Behavior Symposium*, June 1981. WSG-TA 81-12.

Jorge H. Crosa and Linda L. Hodges. Outer membrane proteins induced under conditions of iron limitation in the marine fish pathogen *Vibrio anguillarum* 775. WSG-TA 81-4. From: *Infection and Immunity*, 31(1):223-227.

Walton W. Dickhoff, Douglas S. Darling, and Aubrey Gorbman. Thyroid function during smoltification of salmonid fish. *Phylogenic Aspects of Thyroid Hormone Actions.* Gunma Symposia on Endocrinology, Vol. 19. Tokyo: Center for Academic Publications, Japan. WSG-TA 82-15

Walton W. Dickhoff, Leroy C. Folmar, James L. Mighell, and Conrad V.W. Mahnken. Plasma thyroid hormones during smoltification of yearling and underyearling coho salmon and yearling chinook salmon and steelhead trout. *Aquaculture* 28(1982) 39-48. WSG-TA 82-10.

John E. Ehrenberg. A review of in situ target strength estimation techniques. WSG-TA 82-1. *Proceedings of Symposium on Fisheries Acoustics*, Bergen, Norway, June 21-24, 1982.

John E. Ehrenberg. New methods for indirectly measuring the mean acoustic backscattering cross section of fish. WSG-TA 82-2. *Proceedings of Symposium on Fisheries Acoustics*, Bergen, Norway, June 21-24, 1982.

J. E. Ehrenberg, T. J. Carlson, J. J. Traynor, and N. J. Williamson. Indirect measurement of the mean acoustic backscattering cross section of fish. WSG-TA 81-3. From: *Journal of Acoustical Society of America*, 69(4):955-962.

Leroy C. Folmar and Walton W. Dickhoff. Evaluation of some physiological parameters as predictive indices of smoltification. *Aquaculture* 23 (1981) 309-324. WSG-TA-81-14.

Leroy C. Folmar, Walton W. Dickhoff, Conrad V.W. Mahnken, and F. William Waknitz. Stunting and Parr-reversion during smoltification of coho salmon (*Oncorhynchus kisutch*). *Aquaculture* 28(1982) 91-104. WSG-TA-82-11.

Leroy C. Folmar, Walton W. Dickhoff, Waldo S. Zaugg, and Harold O. Hodgins. The effects of Aroclar 1252 and No. 2 fuel oil on smoltification and sea-water adaptation of coho salmon (*Oncorhynchus kisutch*). *Aquatic Toxicology* 2(1982) 291-299. WSG-TA 82-13.

Leroy C. Folmar, Walton W. Dickhoff, Waldo S. Zaugg, and Conrad V.W. Mahnken. Freshwater development and smoltification in coho salmon from the Columbia River. *Proceedings of the Eighth U.S.-Japan Meeting on Aquaculture* at Bellingham, Washington, Oct. 17-18, 1979. WSG-TA 82-16.

V. F. Gallucci and B. B. Gallucci. Reproduction and ecology of the hermaphroditic cockle *Clinocardium nuttallii* (*Bivalvia: Cardiidae*) in Garrison Bay. WSG-TA 82-3. *Marine Ecology—Progress Series*, 7(1982):137-145.

PUBLICATIONS

Aubrey Gorbman, Walton W. Dickhoff, James L. Mighell, Earl F. Prentice, and F. William Waknitz. Morphological indices of developmental progress in the Parr-smolt coho salmon, (*Oncorhynchus kisutch*). *Aquaculture* 28(1982):1-19. WSG-TA 82-12

E. Gordon Grave, Walton W. Dickhoff, Richard S. Nishioka, Howard A. Bern, and Leroy C. Folmar. Lunar phasing of the thyroxine surge preparatory to seaward migration of salmonid fish. *Science*. 211:607-609. WSG-TA 81-15.

Lee A. Hadwiger, Jean M. Beckman, and Michael J. Adams. Localization of fungal components in the pea-Fusarium interaction detected immunochemically with anti-chitosan and anti-fungal cell wall antisera. WSG-TA 81-1. From: *Plant Physiology*. 67(1981):170-175.

R. N. Iwamoto, A. M. Saxton, and W. K. Hershberger. Genetic estimates for length and weight of coho salmon during freshwater rearing. WSG-TA 82-4. *Journal of Heredity*, 73(1982):187-191.

Mark G. LaRiviere, David D. Jessup, and Stephen B. Mathews. Lingcod spawning and nesting in San Juan Channel, Washington. *California Fish and Game* 67(4):231-229. 1981. WSG-TA 81-13

Ling Lin Liu and George M. Pigott. Preparation and use of inexpensive crude pepsin for enzyme hydrolysis of fish. WSG-TA 81-10. From: *Journal of Food Science*, 46(5):1569-1572.

C. M. Lynde. Economic feasibility of domestic groundfish harvest from western Alaska waters: a comparison of vessel types, fishing strategies, and processor locations. WSG-TA 81-8. From: *Fishery Bulletin*, 79(2):303-314.

Jack R. Matches. Effects of temperature on the decomposition of Pacific Coast shrimp (*Pandalus jordani*). WSG-TA 82-5. *Journal of Food Science*, 47(4):1044-1047 & 1069.

Doris S. Mugrditchian, Ronald W. Hardy, and Wayne T. Iwaoka. Linseed oil and animal fat as alternative lipid sources in dry diets for chinook salmon (*Oncorhynchus tshawytscha*). WSG-TA 81-5. From: *Aquaculture*, 25(1981):161-172.

James A. Perdue, John H. Beattie, and Kenneth K. Chew. Some relationships between gametogenic cycle and summer mortality phenomenon in the Pacific oyster (*Crassostrea gigas*) in Washington State. WSG-TA 81-11. From: *Journal of Shellfish Research*, 1(1):9-16.

Stephen Ralston. Influence of hook size in the Hawaiian deep-sea handline fishery. *Canadian Journal of Fisheries and Aquatic Sciences*. 39(9):1297-1302. 1982. WSG-TA 82-8.

David A. Somerton. Contribution to the life history of the deep-sea king crab, *Lithodes couesi*, in the Gulf of Alaska. WSG-TA 81-9. From: *Fishery Bulletin*. 79(2):259-269.

D. A. Somerton. Regional variation in the size and maturity of two species of tanner crab (*Chionoecetes bairdi* and *C. opilio*) in the eastern Bering Sea, and its use in defining management subareas. WSG-TA 81-2. From: *Canadian Journal of Fisheries and Aquatic Sciences*, 38(2):163-174.

Robert L. Stokes. The economics of salmon ranching. *Land Economics* 58(4). 1982. WSG-TA 82-9.

Robert M. White. Science, politics, and international atmospheric and oceanic programs. WSG-TA 82-7. *Bulletin of the American Meteorological Society*, 63(8):924-933. (Presented May 3-4, 1982 as the fifth in the series of McKernan Lectures in Marine Affairs at the University of Washington).

Randall P. Whitman, Thomas P. Quinn, and Ernest L. Brannon. Influence of suspended volcanic ash on homing behavior of adult chinook salmon. WSG-TA 82-6. *Transactions of the American Fisheries Society*, 111(1982):63-69.

THESES/DISSERTATIONS

The following theses and dissertations were written by students whose research was supported in whole or in part by the Washington Sea Grant Program. They may be borrowed from: Interlibrary Loan Office, Suzzallo Library FM-25, University of Washington, Seattle, Wa., 98195.

Aejaz Ahamed. Production of alcohol by bacteria and use of alcohol as a chemical index of decomposition in salmon. WSG-TH 81-9.

Brenda Beth Boone. Modified atmospheric packaging of fresh fish. M.S. Thesis, University of Washington. WSG-TH 82-5.

Kenneth Joseph Bruya. The use of different gravel depths to enhance the spawning of chum salmon, *Oncorhynchus keta*. M.S. Thesis, University of Washington. WSG-TH 81-6.

Mark Earl Caldwell. Spawning, early development and hybridization of *Haliotis kamtschatkana* Jonas. M.S. Thesis, University of Washington. WSG-TH 81- 4.

Michael L. Cohen. Shippers' councils and closed conferences in U.S. ocean shipping: an analysis of proposed policy changes. Master of Marine Affairs Thesis, University of Washington. WSG-TH 82-4.

Mark Stephen Hendrickson. Effect of dietary oysters on rat plasma lipoprotein cholesterol. M.S. Thesis, University of Washington. WSG-TH 81-5.

Virginia E. Johnson. Isolation, enumeration, classification and identification of bacteria recovered from the sediments of an anoxic fjord, Saanich Inlet, British Columbia, Canada. M.S. Thesis, University of Washington. WSG-TH 81-3.

Raynard Yoshihiro Kanemori. A microcomputer-based echo integration system for fish population assessment. M.S. Thesis in Electrical Engineering. University of Washington. WSG-TH 82-1.

Mark Gerard LaRiviere. Lingcod (*Ophidon elongatus*) population studies in northern Puget Sound, Wa ington. M.S. Thesis, University of Washington. WSG-TH 81-1.

Miguel Enrique Layrisse. Effects of modified and controlled atmosphere on the storage life of shrimp. M.S. Thesis, University of Washington. WSG-TH 82-6.

Mark Bradford Miller. Recovery and growth of hatcher produced juvenile manila clams, *Venerupis japo ica* (Deshayes), planted on several beaches in Pu get Sound. Ph.D. Dissertation, University of Was ington. WSG-TH 82-3.

Jose Miguel Ridelman. Effect of starvation and diet for mulation on ovarian development and egg viabi of steelhead x rainbow trout hybrids. M.S. Thesis University of Washington. WSG-TH 81-7.

Steven L. Schroder. The role of sexual selection in dete mining overall mating patterns and mate choice chum salmon. Ph.D. Dissertation, University of Washington. WSG-TH 81-8.

Steven Alan Swartz. The uptake and distribution of ery romycin phosphate in a drug-surfactant bath wi several species of salmonids. M.S. Thesis in Fish Resources, University of Idaho. WSG-TH 82-2.

Leonard Yee. A dual beam target strength data recorde M.S. Thesis, University of Washington. WSG-TH 81- 2.

Illustration by Tony Angell

MANAGEMENT

Program Management, 1981-82

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Director, July 1, 1983
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Assistant Director for New Programs
Alyn C. Duxbury

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James A. Crutchfield, Professor
Institute for Marine Studies
University of Washington

John DeMeyer, Manager
Division of Marine Land Management
Washington Department of Natural Resources

Ex Officio
D. James Baker, Jr., Dean
College of Ocean and Fishery Sciences
University of Washington

Accounting for the Dollars, 1981-82

	1981		1982	
	Sea Grant	**Matching**	**Sea Grant**	**Matching**
Research and Development				
Marine Studies Program	56,300	13,000	58,400	14,000
Coastal Resources Program	78,300	37,600	95,800	57,200
Research in Fisheries Mgmt.	66,800	37,300	74,800	41,100
Fisheries Assessment	105,600	103,800	90,600	74,400
Aquaculture	597,100	419,500	621,500	444,700
Marine Product Development	128,500	67,300	63,600	39,100
Ocean Engineering	249,100	174,000	197,000	128,500
Education and Training				
Education/University	35,200	29,400	31,400	29,100
Education/Other Institutions	78,200	80,600	56,800	67,100
Advisory Services				
Field Advisory Services	577,900	187,900	617,700	202,600
Program Communications	221,700		244,500	
Applied Marine Economics	20,000	37,500	21,100	40,000
Program Management				
Administration	131,100	182,600	136,600	195,800
Rapid Response	102,700	33,400	141,700	34,600
Total	$2,448,500	$1,403,900	$2,451,500	$1,368,200

This summary is only approximate. The official financial report will be submitted to the National Sea Grant College Program, National Oceanic and Atmospheric Administration, in accordance with the federal grant requirements.

Washington Sea Grant Communications
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