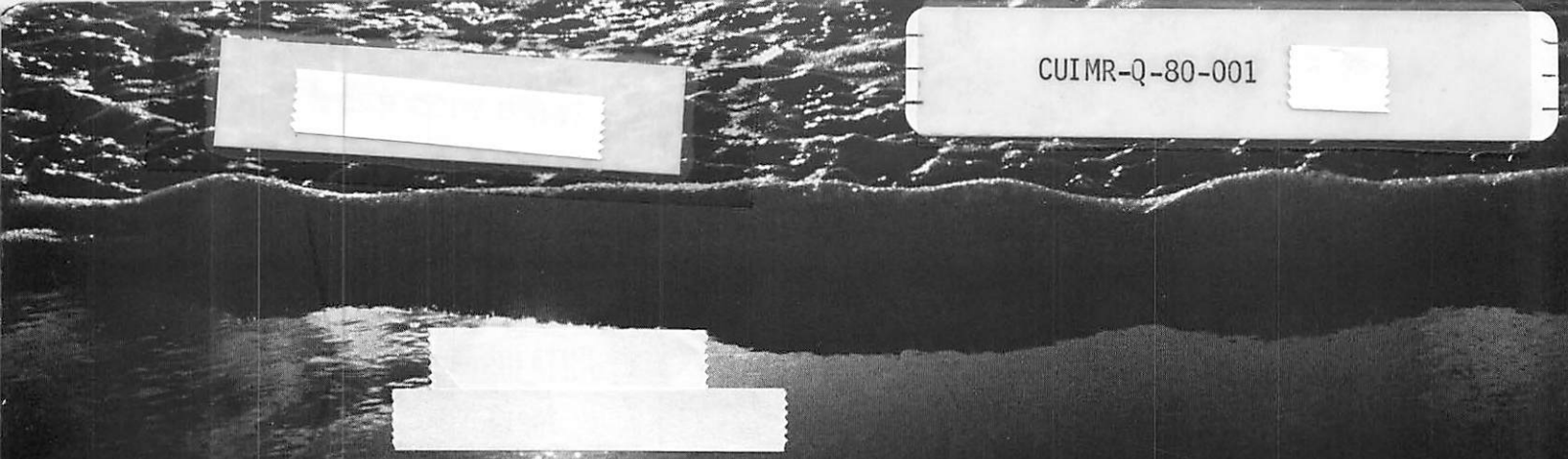

Using California's Marine Resources

A Summary Report on the
California Sea Grant College Program
1979-80

A
California Sea Grant College Program
Publication

SEA GRANT
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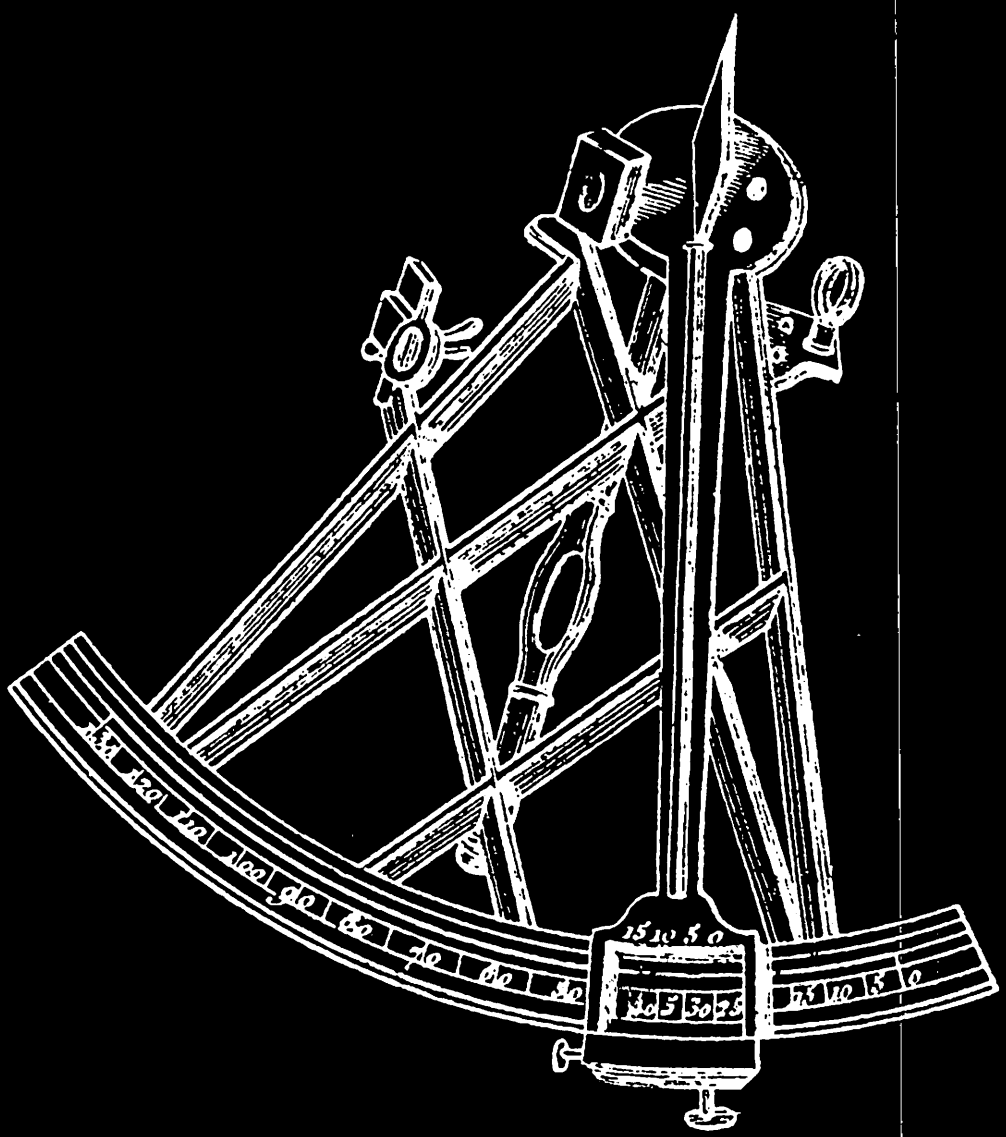


The California Sea Grant College Program is a statewide multi-university program of marine research, education, and advisory services, administered by the University of California Insitute of Marine Resources. Sea Grant-sponsored research contributes to the growing body of knowledge about our coastal and oceanic resources and to the solution of contemporary problems in the marine sphere. Through its Marine Advisory Program, Sea Grant transfers information and technology developed in research efforts to a wide community of users in California, the region and the nation. Sea Grant also supports a broad range of educational programs for university students, public school teachers and students, and the general public so our coastal and oceanic resources may be understood and judiciously used by this and future generations.

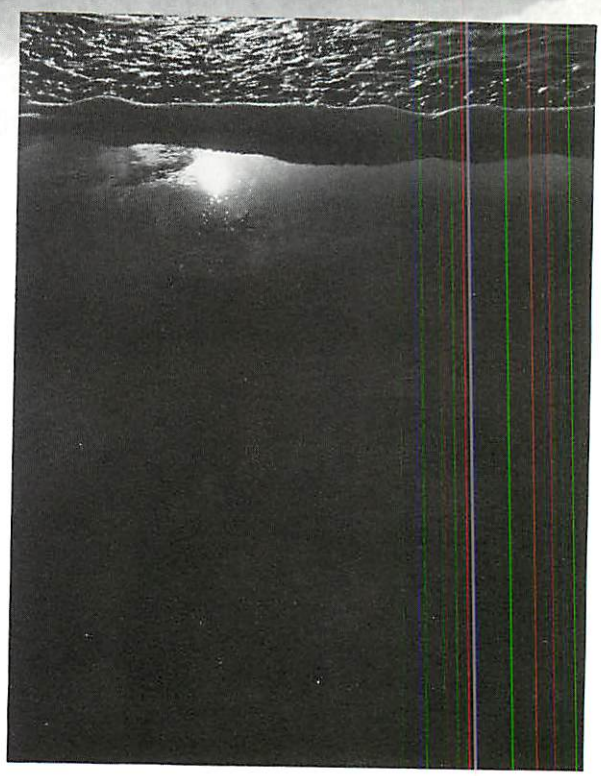
Using California's Marine Resources

A Summary Report on the
California Sea Grant College Program
1979-80

By Louise F. Eklund

California Sea Grant College Program
University of California
La Jolla, California

Report # R-CSGCP-005



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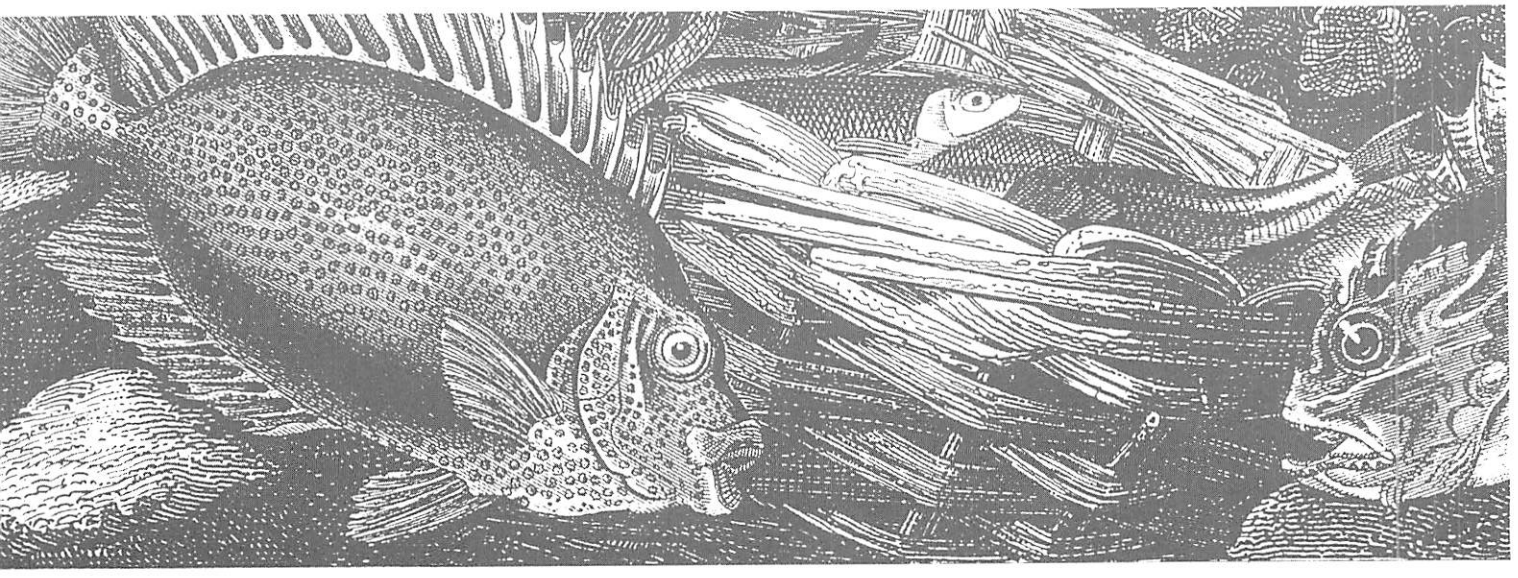

Introduction

In 1966, Congress created the National Sea Grant Program and charged it with responsibility for "accelerating national development of marine resources, including their conservation, proper management, and maximum social and economic utilization."

Sea Grant represents an uncommon partnership among universities, industry, and government--a partnership that can explore and develop the oceanic frontier, in the national interest. University-based Sea Grant programs are in a unique position, in collaboration with industry and with the states in which they exist, to promote innovative research efforts with potentially high returns. By conducting application-oriented research, resource assessments, and feasibility studies; and by developing prototype machines or by testing oceanic and coastal structures in specialized laboratories, Sea Grant taps the inherent resources and capabilities of the nation's universities in a systematic and coordinated way. Results of these studies, delivered by the advisory service, provide industry with the information base from which commercial development and application of research findings can proceed.

The California Sea Grant College Program supports research, education, and advisory services throughout the state, thus helping to carry out the national program's responsibilities mandated by Congress. The program--largest in the national Sea Grant network--is administered by the University of California's Institute of Marine Resources. It supports high-quality research and innovative investigators in public and private universities and colleges throughout the state. More than seventy projects were funded in 1979-80 involving about four hundred faculty, students, and professional, technical, and support staff at thirteen colleges and universities in California.

This summary report on the California Sea Grant College Program during 1979-80 focuses on a small sample of research projects that demonstrate Sea Grant's contribution to the development of marine resources for their maximum social and economic use. Sea Grant's contribution to this development is particularly critical at a time in our nation's history when terrestrial resources are declining; when dependence upon foreign imports for many of the essential materials in industry and commerce is on the rise; and when the accelerated interest of the 1960s in the oceans as a new frontier has brought us closer than ever before to meaningful use of largely untapped marine resources.

Tapping the sea's resources means making the maximum responsible use of its living and physical resources. It also means developing our technological resources and applying them to the challenges of marine resource development. And, it means developing human resources: today's students and tomorrow's marine scientists and engineers who will seek solutions to the problems of the future.

James J. Sullivan,
Program Manager

Editor's Note: This summary is a companion to a larger volume of technical reports on all of the projects funded by the California Sea Grant College Program from 1978-80. If you are interested in more detailed information on any of the projects described in the following chapters or listed at the end of this book, get in touch with the California Sea Grant College Program, University of California, A-032, La Jolla, CA 92093 (714)452-4444.


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Chapter 1 Living Resources

California's living marine resources are an industrial asset as well as a recreational one. Commercial use of living marine resources is of growing importance throughout the world. As the land becomes more densely populated and terrestrial resources decline, people are turning toward the sea as a source of animal protein, useful plants, and new chemical products.

The fisheries of California waters--indigenous plant and animal species, as well as the migratory visitors to the California Current--support significant commercial harvests. Some of these, like the giant kelp, could support greater commercial use if natural stocks could be expanded and enhanced. Others, like the purple-hinge rock scallop, could become the basis for a new industry through development of aquaculture techniques. Still others, like species of Pacific salmon, already support significant natural and cultured harvests, but face problems that hamper growth and expanded use. In addition, both Pacific Coast waters and distant tropical seas nurture unusual marine organisms that can yield new and beneficial chemical products.

Expansion and Enhancement of Kelp Beds

The giant kelp, *Macrocystis*, grows in submerged forests that extend from the subtidal zone out to depths of thirty-five meters. These kelp forests, or "beds," are unique to the Pacific Coast of North America in the northern hemisphere and are an important economic and recreational resource. They serve as nurturing habitats for abalone, lobster, sea urchins, and a variety of finfish, all of which contribute to both commercial and recreational fisheries. The kelp itself is also harvested for the algin it contains that is used in numerous common products, from toothpaste to chocolate syrup. More than 200,000 wet tons of kelp are taken from California beds every year. This harvest has gone on for more than fifty years, in ever-increasing amounts, and commercial kelp harvesters have frequently experienced shortages in the available standing crop.

At UC Santa Barbara, Michael Neushul, professor of marine botany, and David Coon, research associate, have long been aware of the need to increase the productivity of natural kelp beds to meet the growing commercial demand. As an initial step toward development of kelp aquaculture they designed a study to investigate factors that limit the distribution and standing crop of kelp. They selected two representative kelp forests near Goleta Point off Santa Barbara as a study site. Specifically, they wanted to determine what factors limit kelp plant establishment, growth, and survival in these areas.

To find answers to these questions, they grew juvenile kelp plants in the laboratory, then transplanted them to a location near the existing kelp beds. The plants were raised from gametophytes in the laboratory, then grown in bubbling and shaker culture systems until they formed small clumps (about one centimeter in diameter). The researchers separated the clumps, and transferred them to a marine greenhouse, where water motion could be controlled. When the plants grew to form a single blade four-to-ten centimeters long, they were attached to floats tethered to substrate systems placed on the sea floor. Nine outplantings of this type were made at six sites over an eighteen-month period. In all, more than seven hundred plants were put into the sea during this experiment.

Kelp forest. (Photo credit unavailable)

Neushul, Coon, and their associates then monitored the survival and growth of these plants in comparison with that of the natural stocks. By simultaneously observing variations in physical factors at the study site, they were able to relate plant survival to those variations. They examined the roles of a number of factors that influence kelp survival and growth, including outplant timing, storms and water motion, nutrient levels, grazing by predators, available light, and substrate characteristics.

The researchers successfully established and grew small kelp plants in locations, depths, and seasons in which no new plants were becoming established naturally. They developed a set of new laboratory and greenhouse culture methods that allow mass culture of genetically-defined plants, and they have developed new techniques for placing plants in the sea.

The information obtained in this research can be used to design strategies for planting kelp in specific areas while eliminating certain adverse factors that normally prevent kelp survival and growth. Also, culture and planting techniques developed by this group of researchers can be used to grow plants and establish them in new areas or on artificial "farm" structures.

Aquaculture of the Purple-Hinge Rock Scallop

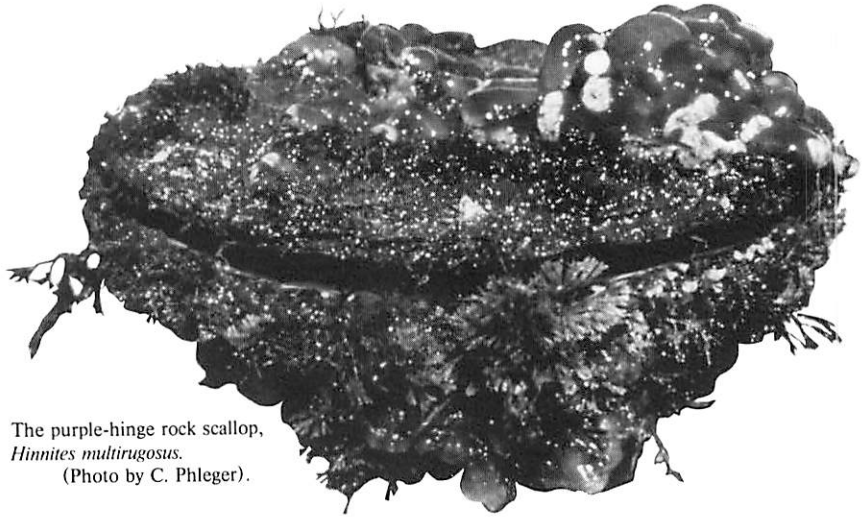
Aquaculture of filter-feeding molluscs, such as oysters, clams, mussels, and scallops, promises a level of economic and ecological efficiency yet to be reached in the culture of crustaceans and finfish. The purple-hinge rock scallop (*Hinnites multirugosus*) has been studied with Sea Grant support at San Diego State University for several years. Results of that research on the biology, culture, and growth of the rock scallop provide the basis for economical culture of this shellfish.

Commercial aquaculturists find this scallop to be a hardy, relatively fast-growing crop organism that is popular with consumers. At least one California company--the Johnson Oyster Company on Drake's Bay in Point Reyes--is growing rock scallops and successfully marketing them. Two other groups are culturing them on a preliminary basis and will soon be applying the San Diego State University research results in the field.

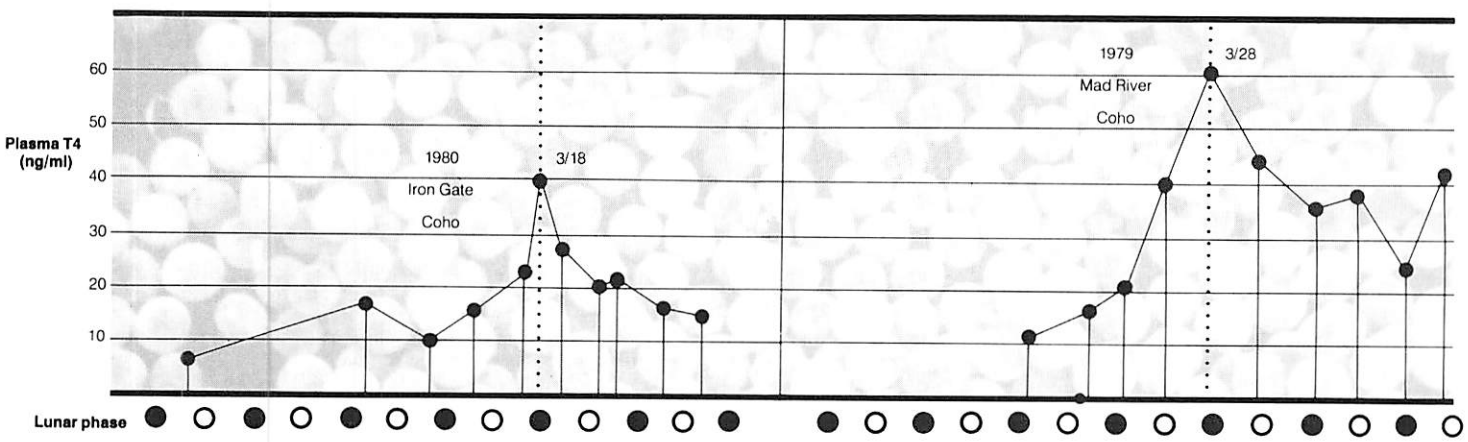
Before the rock scallop culturing industry can expand, however, a means must be found for supplying companies like Johnson Oyster with a dependable, large-scale source of seedstock, or spat. Researchers Charles Phleger and David Leighton, who conducted the previous studies, identified several limiting aspects of rock scallop culture, and worked last year toward eliminating those remaining barriers to large-scale commercial development. The rock scallop has only two, relatively short-term peaks of reproductive activity during the year. Controlling this activity through improved nutrition and refined culture techniques has been the researchers' primary goal.

A series of feeding experiments with larval, postlarval, and juvenile rock scallops has shown a Tahitian strain of *Isochrysis*, an easily cultured alga, to be an excellent diet for all three early life stages. Of six algal diets tested by the researchers, *Isochrysis* gave the best growth and the lowest mortality. The researchers also perfected a plastic rearing panel for containing and rearing scallops from early juvenile to market adult size. The panel can be used in bay or open-ocean culture and has produced significant results thus far: market-size scallops can be obtained within one and a half years of seeding the panel with juveniles.

Considerable interest in aquaculture of the rock scallop has recently developed among commercial enterprises. About a dozen groups, many of them engaged in oyster culture in the Pacific Northwest, have queried Phleger and Leighton about a source for seed stock. Once these sources are developed and become known, a new species of mollusc for marine aquaculture, with widespread acceptance, should become a reality.



The purple-hinge rock scallop, *Hinnites multirugosus*. (Photo by C. Phleger).



Patterns of plasma thyroxin (T_4) in two California coho salmon stocks plotted on a lunar calendar.

Note difference of ten days in new moon cycle in two successive years. ● – new moon; ○ - full moon.

Adaptation of Salmon to Seawater

Pacific salmon are a highly prized sport and commercial fish throughout the Pacific Northwest. Since the nineteenth century, Pacific salmonids have been reared in freshwater hatcheries for release into coastal streams and rivers. Salmon have complex biological systems that allow them to spend part of their lives in fresh water and part in seawater.

Several salmonid species, principally the coho salmon (*Oncorhynchus kisutch*), have been selected for sea pen culture to enhance their growth before they are harvested or released. The fish are transferred to sea pens from freshwater hatcheries when they weigh about fifteen grams and have undergone the physiological changes necessary for adaptation to seawater. (This developmental process is called smoltification.) If the young fish have not transformed fully into the seawater-adaptable stage before being transferred into seawater, there is a high initial mortality, and considerable stunting occurs among the survivors. As many as fifty percent of the transferred salmon may be lost because of this premature transfer.

This significant loss of young salmon transferred to sea pens attracted the interest of Howard Bern, professor of zoology, and his colleagues at UC Berkeley. They speculated that this serious stunting problem observed in sea pen culture might also be a major, unrecognized cause of mortality in the millions of fish annually released into coastal streams from federal and state hatcheries on the West Coast.

Initial examination of the stunted fish, using various morphological and physiological criteria, suggested to Bern and his group that the problem might lie in endocrine dysfunction. They have been examining the complex endocrine system of coho salmon and certain hormone-controlled tissues to determine what measures might be used to reduce this enormous loss of young salmon.

Studies of thyroid activity during smoltification have produced the most promising clues so far. Salmonids exhibit a surge of thyroid activity that coincides with their metamorphosis from freshwater- to seawater-adaptable organisms. Other investigators have shown that the salmon's ability to grow in seawater is directly related to the proportion of the thyroxin surge it completes before entering seawater. Consequently, this surge appears to be an excellent predictive indicator of readiness for entry into seawater. But, timing of the surge varies from year to year. This means that individual salmon stocks must be closely monitored, a time-consuming and expensive process.

In collaboration with the California Department of Fish and Game and colleagues at the University of Washington, the UC Berkeley team recently determined that the thyroxin surge coincides with the new moon phase of the lunar cycle, following the vernal equinox in California and occurring one month later in Washington State (See figure). This correlation was found to be highly

significant, according to several statistical criteria among twenty-nine different stocks. The ability to predict migratory readiness by the lunar calendar will minimize the need for sampling and the use of complicated technology, and should significantly improve the efficiency of culture procedures.

The UC Berkeley investigation of the endocrinology of coho salmon continues because much remains to be understood about this complex system. The study is providing information not only of fundamental but also of practical importance. Discovery of the relationship of the lunar cycle to the smoltification process already has generated considerable interest and excitement among hatchery management personnel in California, Oregon, Washington, Canada, and Japan. As a consequence, several regions of the California Department of Fish and Game are planning their hatchery salmon releases in consultation with Bern and his associates.

Marine Sources of Useful Chemicals

Since the discovery of morphine in the early 1800s, studies of potent substances derived from natural sources have been the foundation of the pharmaceutical industry. This contemporary industry has developed a wide variety of highly useful chemicals that have significantly reduced disease. New health problems have evolved, however, that have not been easily solved, and new pharmaceutical agents are constantly being sought to counteract these problems. Examples include antibiotic-resistant pathogenic fungi and bacteria and modern maladies such as hypertension, other heart diseases, and cancer.

Several approaches have been taken toward developing new medicines. These have involved the continued investigation of land-based natural sources as well as development of synthetic organic compounds. While some advances have been made, the development of new drugs has not kept pace with our need for them. In pharmaceutical development, marine organisms have been largely ignored as potential sources of new chemicals. Only in the recent past have we been able to investigate marine organisms as sources of new pharmaceuticals.

In an uncommon intercampus and interdisciplinary program, a team of UC researchers from San Diego, Santa Barbara, and Santa Cruz are collaborating with the pharmaceutical industry to explore marine sources of new and useful chemicals. In the broadest sense, their work is to define the biological properties and therapeutic value of chemicals derived from marine organisms, collected from widely dispersed geographic regions and including tropical soft corals, algae, sponges, and nudibranchs.

Since this program began in 1977, Robert Jacobs (UCSB), John Faulkner and William Fenical (UCSD), and Phillip Crews (UCSC) have studied 370 different marine products. They have identified 159 active chemical compounds, 25 of which they consider to be interesting in terms of biological activity.

Determining the therapeutic potential of any of these substances remains a long-term objective of the researchers and their graduate-student Sea Grant trainees. They must first assess the novelty of each substance's action against known chemicals. They need to know whether the substance derived from a marine organism represents something new in terms of its mechanism or site of action. Special studies, being conducted by the trainees, have thus far yielded certain knowledge that three distinctly interesting compounds are new and novel with respect to chemical structure and pharmacological activity.

Stypoldione, a substance isolated from a brown alga, has proved to be a potent inhibitor of cell division in tests with sea urchin eggs, mice infected with Erlich ascites tumor cells, and human cancer cells grown in tissue culture. The researchers are submitting the substance to the National Cancer Institute for further testing of its anticancer potential. Monoalide, another substance, extracted from a Pacific sponge, exhibits activity as both an analgesic and an anti-inflammatory agent. When topically applied, this compound has been shown to be somewhat less potent than hydrocortisone and more potent than indomethacin. Researchers isolated a third substance from a soft coral, Lophotoxin, a previously unknown neuromuscular toxin.

Many of the compounds the researchers isolate and find to have significant potential for development are submitted to Syntex Laboratories, Inc., a major pharmaceutical concern in California, for additional screening and evaluation. This industrial collaboration ensures a rapid and accurate evaluation of the new substances as well as a direct method for commercial development. In addition, the researchers have developed a new assaying technique that uses fertilized sea urchin eggs to detect potential anticancer activity of chemical compounds. The National Cancer Institute has added this assay to its group of screening procedures.

Chapter 2 Physical Resources

The physical resources of the sea are also attracting greater attention for their increased exploitation. The beaches, harbors, and rocky shores along California's 1200-mile coastline; the minerals on and beneath the sea floor; the gas and oil in concentrated pockets offshore; seawater itself, bearing nutrients for marine life, serving as a transportation medium for commerce, and modifying the climate--all of these resources are accessible for use by humankind, and we must be ingenious enough to use them wisely.

Sea Grant researchers are contributing in various ways to the development and use of California's physical marine resources. In one project, researchers are trying to alleviate navigation problems in a harbor of major importance on the north coast. In southern California, other investigators are evaluating the biological basis of regulations for coastal power plants that might be stricter than necessary. Innovative research in Davis is leading toward development of strains of food crops that are tolerant of salt water. And, an assessment of phosphorite deposits being conducted off the central California coast is yielding information about new marine sources of a valuable commercial product.

Entrance Problems at Humboldt Bay

Humboldt Bay is the largest, protected harbor along the north coast of California. It provides the most significant potential access to the biological and physical marine resources of the region. Its usefulness, however, is limited by hazardous entrance conditions, inlet shoaling, and by the bay's reputation as a dangerous navigational channel. The future development of extensive marine operations in this region depends on safe and easy access to the sea from the protected confines of Humboldt Bay. But annual efforts to maintain the bay as a viable port have been costly and only marginally successful.

These significant problems and the potential benefits to be gained from their resolution sparked the imagination of two California marine researchers: Theodore Kerstetter, biologist and former director of Humboldt State University's Telonicher Marine Laboratory, and the late John Isaacs, then professor of oceanography and director of the University of California's Institute of Marine Resources.

If the dynamics of Humboldt Bay could be accurately simulated, they believed, the resulting model could be used to test alternative methods for modifying the bay to reduce its hazards. Furthermore, they thought, if they could come to understand the dynamic processes of Humboldt Bay, some generalities might thereby be revealed about these processes for tidal inlets on sandy coasts.

Creating an accurate model of the system requires a careful description of the natural system of Humboldt Bay. The researchers, working with research associate James Stork and Steven Costa, began their work by defining the nature of the problems at the entrance to the bay. They observed three distinct but interrelated problems. Frequently, hazardous navigation conditions occur there because of severe wave action. This is partially a result of the inlet's orientation and location on one of the highest wave energy coastlines in the United States. Shoaling within the entrance is another significant problem, requiring extensive dredging of the navigation channel to maintain an adequate depth for commercial shipping. Finally, severe erosional problems exist at critical locations within the entrance, and eroded material is redistributed to other locations. Jetties used to stabilize the entrance and the deepening of the channel by dredging brought about these erosional conditions.

The investigators implemented a three-part research effort to clarify the dynamics of the bay in preparation for designing their model. They need to understand the operation of the beach processes along the adjacent coastline, because these processes supply sand to the inlet. They need to understand the motion of the waters of the bay itself, as this controls the temporal and spatial distribution of velocity through the inlet. Finally, they need to describe the sediment transport dynamics of the entrance to the bay, based on results from the first two parts of the study.

Though their ultimate objective of expanded marine operations in the north coast region is far off, the researchers' preliminary studies have already produced useful data. In their beach processes study, they have extensively sampled the material found on the beaches between Trinidad Head and False Cape and in the rivers that supply them. These data are now being analyzed and interpreted. With respect to the water motion studies, they have collected, processed, analyzed, and archived a large amount of tidal data, which represents the most extensive and best documented data base of its kind for the location. At present, the researchers are continuing to analyze these and other data, and are evaluating a variety of potential solutions to the entrance problems at Humboldt Bay.

The Effect of Thermal Effluent on Some Marine Organisms

Heated waste water produced by power plants in California coastal areas (and elsewhere) has long been presumed to be a serious threat to marine organisms in the nearshore environment. The assumption, in the absence of documented information, has been that the temperature tolerances of most marine organisms are very low and that the intrusion of heated waste water from power plants into coastal waters could cause severe, long-term damage to the animal life found there.

The lack of information that led to these assumptions has been particularly acute for the warm, temperate region of southern California, where the number of power plants is greater than elsewhere on the Pacific coast. It has led, in part, to the establishment of federal and state regulatory requirements that some feel are overly restrictive.

Richard Ford and John Van Olst, San Diego State University researchers, recognized the importance of obtaining this information to assist the utilities industry, regulatory agencies, and scientists in knowledgeably evaluating and controlling the effects of thermal effluent. They undertook a two-year study to acquire information about temperature tolerances and related effects on survival, growth, condition, and reproductive characteristics for a representative group of sixteen species of benthic (bottom-dwelling) marine invertebrates. Their research was conducted both in the laboratory at San Diego State University and in the field at San Diego Gas and Electric Company's Encina Power Plant in Carlsbad.

Laboratory work, for example, included duplicating cyclic effluent temperature conditions and their effects on the test organisms. They compared these effects with the survival, growth, body condition, and reproductive characteristics of control groups of organisms maintained in ocean waters of ambient temperatures.

With the exception of some echinoderms, the researchers found survival, growth, and reproductive characteristics of most test species were not adversely affected under the series of experimental conditions. Previous work of Ford's showed similar results for other invertebrate species, and established that chemicals, such as residual chlorine, in the effluent also demonstrated no apparent adverse effects.

Ford and Van Olst have used the information collected in their study to evaluate one California regulation that requires new coastal generating stations to use expensive, offshore discharge systems. The regulation stipulates that the water discharged from these systems "may not increase by more than 4°F the natural water temperature at the shoreline, sea floor, or water surface more than 1,000 feet from the discharge point more than fifty percent of the time." The researchers' findings in this project have led them to conclude that these requirements may be unnecessarily strong. They believe that properly designed across-the-beach discharge systems, such as that of the Encina Power Plant, appear to be an acceptable alternative, both from an ecological standpoint and in terms of engineering complexity and cost. Over the past several years, new units have been added at the Encina power station that use the existing discharge system at no additional cost. However, a new unit would cost an additional $30,000,000 (based on 1974 figures), according to San Diego Gas and Electric Company, if the new discharge requirements are to be met.

Development of Salt-Tolerant Plants

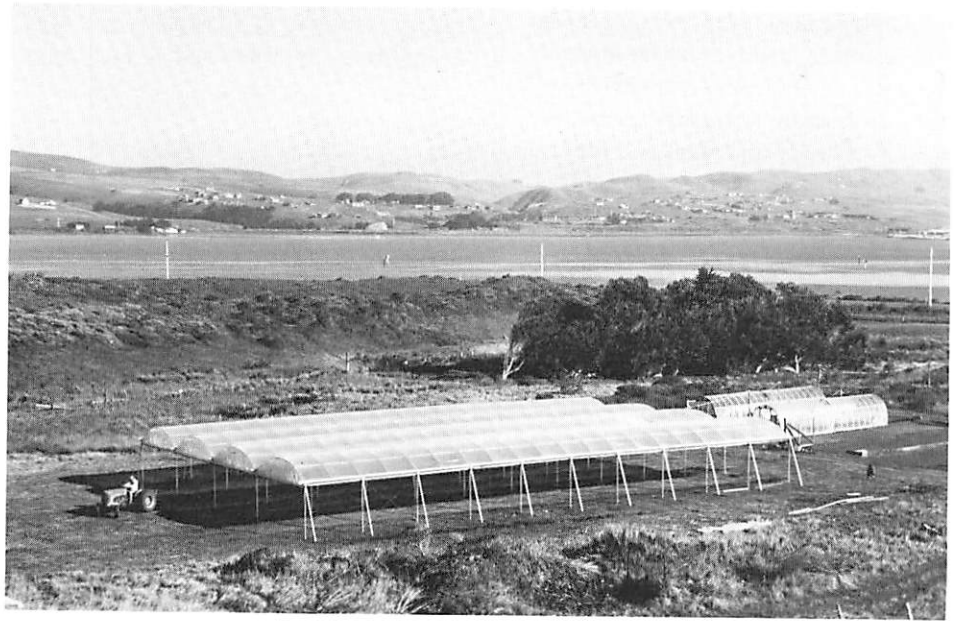
Where the sea borders on sandy coasts, there is a convergence of resources not presently used much for the production of food and fiber. These resources--solar energy, water and the mineral nutrients dissolved in it, and a sandy substrate that allows for ready drainage--are necessary materials for a hydroponics installation for soilless crop culture. The chief impediment to using this combination of resources for crop production, of course, is the source of nutrients: seawater and its high concentration of salt (sodium chloride), which renders it unusable for irrigation of conventional, salt-sensitive crops.

Emanuel Epstein, professor of plant nutrition and his colleagues at UC Davis have demonstrated that this impediment might be overcome by selecting and breeding genetic lines of salt-tolerant commercial plants suitable for seawater culture. The results of their work with wheat, barley, and tomatoes have significance not only for coastal environments but also for arid and semi-arid regions where soils and irrigation waters are frequently saline. Inland areas that might benefit include, for example, California's San Joaquin and Imperial Valleys, where available sources of irrigation water are becoming increasingly saline. This condition is a result of both natural phenomena and agricultural practices. The common approach to dealing with the agricultural problems posed by salinity has been to attempt to alter the environment. Some typical solutions have been to reclaim the soils, to install drainage tile to carry away excess salt in solution, or to convey high-quality water over great distances for irrigation.

Epstein and his colleagues took the opposite approach by using seawater, either full strength or somewhat diluted with fresh water, to produce crops genetically adapted to culture under highly saline conditions. Their efforts in recent years have been remarkably successful. They now have on hand, for both barley and wheat, several dozen lines, some of which are more salt-tolerant (at least of seawater) than any available elsewhere. They have also found that progeny of the original cross between a commercial tomato and a wild (commercially useless but salt-tolerant) species, when backcrossed with the commercial parent, can survive and bear edible tomatoes when irrigated with a solution that is seventy percent of seawater salinity.

The results of this research, including the techniques and methods developed for selecting and breeding salt-tolerant plants, have been widely disseminated and shared with crop researchers throughout the world. Agronomists concerned with problems in irrigation agriculture in California and elsewhere are now aware that Epstein's seawater-based techniques can be used for selection and breeding of salt-resistant plants for inland areas. Application of these techniques will not only open new areas to agriculture, but can resolve some key problems for inland areas that have long been developed for agricultural production.

Bodega Bay location of greenhouse for growing salt-tolerant plants. (Photo courtesy of E. Epstein)



Phosphorites off Central California

Phosphorites yield an economically important mineral resource that, for many years, has been mined from terrestrial sources for use in agricultural fertilizers, pesticides, and other chemical products. Scientists also have known since the mid-1950s that phosphorites tend to become enriched in uranium and that, depending on the level of concentration, this equally valuable resource can be extracted.

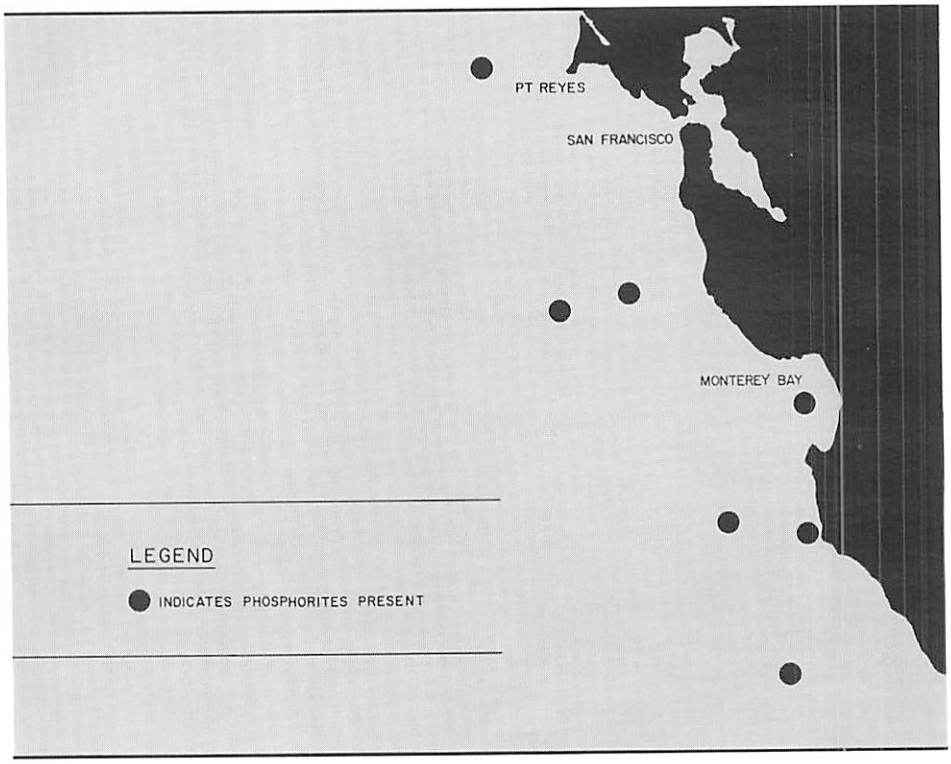
Existence of marine phosphorite deposits, both recent and fossil, have been reported from many parts of the world oceans on continental terraces and seamounts. The association of marine phosphorites with areas of oceanic upwelling has long been recognized. To date, however, marine phosphorite sources have not been commercially exploited because terrestrial resources are still relatively abundant and the technology for mining marine sources has not been developed. The day is likely to come, however, when these land-based sources of phosphorous are no longer accessible, as land-use priorities change. When such a time comes, it will be important to have at hand assessments of alternate sources of this valuable mineral.

In Sea Grant research at Moss Landing Marine Laboratories, investigators began such an assessment of the phosphorite deposits along the central California continental margin in October 1979. Henry Mullins, assistant professor of marine science, and his associates had reason to believe such an assessment might prove fruitful, given results of their earlier investigations of the area.

They sought information on the distribution, depth, and density of occurrence of phosphorites in a study area that extends from Cape San Martin to Point Reyes. During fourteen days at sea, they collected rock dredge and grab samples as well as bathymetric data at the study sites.

Returning to the laboratory, the researchers began the long process of accurately describing the samples, subsampling them for geochemical studies, and preparing them in other ways for analysis of their mineralogical and chemical composition as well as their elemental content.

All of these analyses are required for an accurate assessment of the resource. Mineral rights along the central California continental margin are the jurisdiction of state and federal government agencies, which will need adequate resource assessment before leasing any sites with potential for commercial development. Preliminary geochemical studies of the subsamples demonstrated that the phosphorite deposits off Point Sur are very high in phosphorous content--twenty-eight to thirty-three percent P_2O_5. (Values in excess of around fifteen percent are considered extractable on land.) So far, the investigators can conclude that rich phosphorite deposits are present offshore of Point Sur, Cape San Martin, and Pescadero Point. Whether these deposits will be economical to mine remains to be determined.



Chapter 3 Technological Resources

The efficient and economical use of the living and physical resources of the ocean depends, in large measure, upon highly developed and innovative technology. Whether our aim is to extract the sea's mineral resources from great depths, to use our coastal waters as submerged fields and pastures for growing plant and animal species, to discover new marine sources of therapeutic drugs, or to improve natural harbors for access to the sea's resources, we will always be limited if our technological capacities do not keep pace with scientific discovery and exploration.

Sea Grant Researchers are working to improve technologies to aid in developing marine resources for their maximum use. The comparative sensitivity of seafoods to spoilage requires new, innovative methods for processing, storing, and transporting them. Development of new mechanical processes for preparing visually unappealing marine species, like squid, can lead to wider utilization of these sources of protein. And, further development of gas and oil deposits found in earthquake-prone areas requires a precise understanding of optimum designs for construction and placement of offshore structures.

Seafood Stored in Modified Atmospheres

Fresh seafood is considered a treat in most parts of the country for both its delectable range of flavors and its high nutritional value. But the distribution of seafood products in the United States is severely limited by short shelf life and spoilage. Consumers tend to be wary of seafood that is not guaranteed to be fresh, and with good reason. Of the muscle foods generally distributed in the United States, seafood products are the most susceptible to postmortem deterioration caused by chemical or physical changes or by microbiological spoilage.

W. Duane Brown, professor of marine food science at UC Davis, and his associates have been investigating different methods of handling and storing seafood products to increase their shelf life. They have been particularly successful with their experimental use of modified atmospheres for storing of a variety of fish, fish products, and crustaceans. They have used different mixtures of air and carbon dioxide (CO_2) for refrigerated storage of rockfish fillets, salmon, Dungeness crab, dressed gray cod, gray cod fillets, Alaskan spot shrimp, and halibut steaks.

It has long been known that high levels of CO_2 inhibit microbial growth and allow prolonged storage of fish. The work of Brown, and of others before him, has clearly established the feasibility of commercially using modified-atmosphere storage. For example, samples of Dungeness crab meat were stored for more than a month in an atmosphere containing CO_2 without deteriorative microbial or chemical changes. Fresh rockfish fillets were held in refrigerated modified atmospheres of eighty percent CO_2 and twenty percent air for fourteen days. The CO_2 significantly inhibited microbial growth, though samples stored in unmodified, refrigerated air showed marked microbial growth after only seven days. Finally, in field tests with the TransFresh Corporation, modified atmospheres were used in commercial shipments of more than two million pounds of dressed salmon from Anchorage to Seattle in the summer of 1978. The salmon were refrigerated (not frozen) and shipped by steamship in Sea-Land vans gassed by TransFresh to sixty-five percent CO_2. There were no losses because of spoilage. TransFresh realized savings of more than $400,000 in this shipment.

Brown and his group have determined, however, that this promising modified-atmosphere technology cannot be applied simplistically or indiscriminately to any and all seafood products. They have found, rather, that a comprehensive and systematic evaluation is needed to determine which atmospheres work with which products under what conditions. This evaluation is being conducted now in collaboration with the seafood industry. The most significant result that will be obtained once this technology can be applied will be the possibility of shipping fresh (non-frozen) fish anywhere in the United States at a reasonable cost.

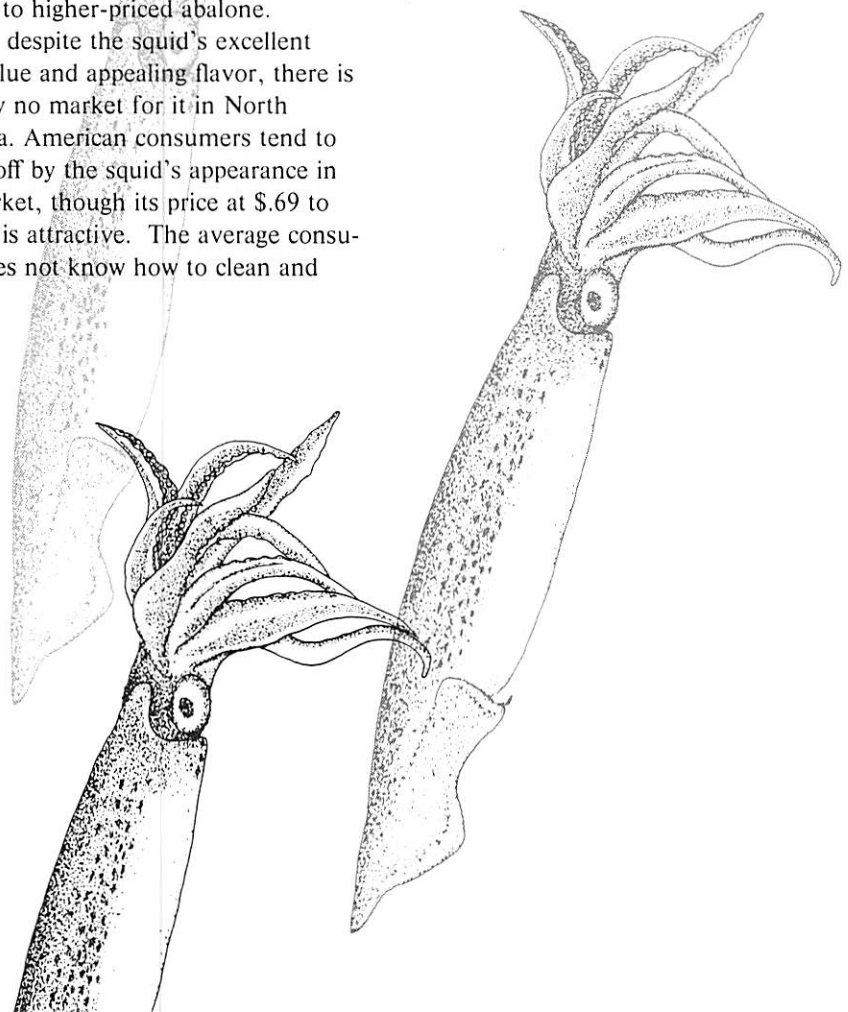
These Sea-Land vans contain a cargo of fresh salmon, stored in modified atmospheres containing a mixture of carbon dioxide and oxygen. The salmon, which in this instance are being shipped from Anchorage to Seattle, need only be refrigerated, not frozen, for shipment because the modified atmospheres effectively retard spoilage. (Photo courtesy of TransFresh Corporation.)

Mechanically Processing Squid

Squid is an important source of protein in many countries, particularly in the Orient and Mediterranean Europe. The current world catch is estimated at a half million tons, but it might be possible to sustain a fishery of more than one hundred million tons annually. Prepared foods made from cleaned squid meat have been well-received in preliminary tests in this country. Squid fillets, pounded and prepared in various ways--sautéed or deep-fried, for example--have been favorably compared in flavor and texture to higher-priced abalone.

But, despite the squid's excellent food value and appealing flavor, there is virtually no market for it in North America. American consumers tend to be put off by the squid's appearance in the market, though its price at $.69 to $.99/lb is attractive. The average consumer does not know how to clean and prepare squid and is, apparently, disinclined to learn. Seafood restaurants serving squid find the demand relatively low and the cost of hand-cleaning, high: hand-cleaning adds between $1.50 and $2.00/lb. to the price of squid for the restaurateur.

R. Paul Singh, food engineering professor, and other researchers at UC Davis have developed prototype squid-processing machinery that could transform this neglected source of high-quality protein into a familiar main course on American dinner tables. They designed a machine that automatically feeds and cleans the squid, removing the head, eyes, skin, viscera, ink sac, and "pen" from the body.



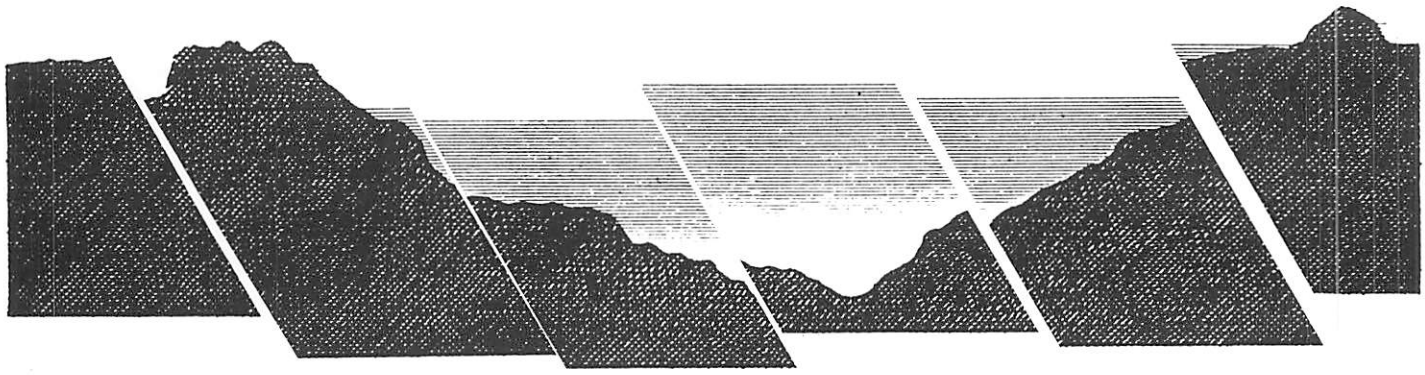
The prototype cleaning machine, which yields an amount of useable meat comparable to that from manual cleaning operations, now forms the basic unit from which an industrial-scale processing machine could be developed. The prototype automatic feeding component of the machine reached a level of ninety-two percent efficiency during experimental continuous operation, and the researchers claim it could automatically feed several squid-processing machines like the one they have already built. The researchers are currently seeking funds to build an industrial-scale unit.

Earthquake-Loading on Large Offshore Structures

Many undersea resources off the West Coast of the United States, particularly oil and gas deposits, are located in earthquake-prone areas. More and more large offshore structures of varying characteristics and shapes are being constructed to exploit these resources. Reliable analysis of seismic loading on such structures is of considerable interest to the offshore engineering community, including both private industry and regulatory agencies. There is particular interest because, under certain conditions, earthquake-induced foundation forces are very large--greater, even, than those induced by a thirty meter, fifteen second wave. A rational basis for assessing the safety of proposed offshore structures in locations of high earthquake risk is essential to both industry and government.

At UC Berkeley Joseph Penzien, professor of structural engineering and mechanics, and collaborators examined the effects of superstructure configuration and of the spacing of the individual, vertical circular cylinders ("legs") to determine how accurate current analysis techniques are in predicting earthquake-loading on these structures. As a consequence of their investigation, they developed a new analytical procedure and an associated computer program that permits the accurate determination of hydrodynamic forces acting on fixed axisymmetric underwater structures to earthquake excitations. This procedure and computer program are of great value in designing offshore structures in earthquake-prone areas. They can also be used by regulatory agencies, such as the Bureau of Land Management, the U.S. Geological Survey, the Army Corps of Engineers, and the California State Lands Commission to assess the safety of proposed designs.

In fact, results of earlier Sea Grant studies conducted by this group were essential to the construction of new offshore oil platforms in earthquake-prone areas. Without those researchers' findings no new platforms would have been built because oil companies would not have been able to meet environmental impact requirements.



Chapter 4 Human Resources

The challenges and problems of developing and using our marine resources have only begun to reveal themselves in the past few decades. As today's problems are resolved, through science and technology, new challenges continually emerge. In many ways, the most significant product of our nation's universities is a cadre of highly educated young people, trained in the skills of scientific and technological research, who will face those challenges in years to come.

The California Sea Grant College Program believes that developing these human resources for future exploration and exploitation of marine resources is an important responsibility. Through its graduate student trainee program, Sea Grant makes a valuable contribution to this development.

Nearly all of the application-oriented research projects supported by the California Sea Grant College Program involve one or more graduate students in the actual conduct of the research. In 1979-80, eighty qualified graduate students at thirteen California Colleges and universities were awarded traineeships. These traineeships offer students the opportunity to work side by side with highly respected research scientists and engineers, learning the techniques and methods involved in research while working toward advanced degrees. In this way the most recent techniques and knowledge of a variety of disciplines are transferred to industry as the students complete their training and begin their professional careers.

Trainees in Living Resources Research

Paul Culver, working with Robert Jacobs in the project on marine pharmacology at UC Santa Barbara, sees his role in organizing the research conducted in the laboratory as the most valuable element of his traineeship. Through this experience, he has learned the practical aspects of running a laboratory, including the acquisition of materials, the design of cost-effective experimental procedures, and the training and supervision of undergraduate assistants. All of these are invaluable skills that he hopes to apply in a teaching/research position.

Sally Look, working on marine pharmaceuticals, with William Fenical at the Scripps Institution of Oceanography is looking forward to completing her PhD degree next year. To carry out her research as a Sea Grant trainee, she has had to master a number of complicated laboratory techniques for separating various bioactive chemical compounds. These have included spectral interpretation, as well as column, high performance liquid, medium pressure, and gas chromatography. Finally, because chemical investigations in this project are interrelated with the biology of the marine organisms under study, she has also expanded her biological knowledge.

Trainees in Physical Resources Research

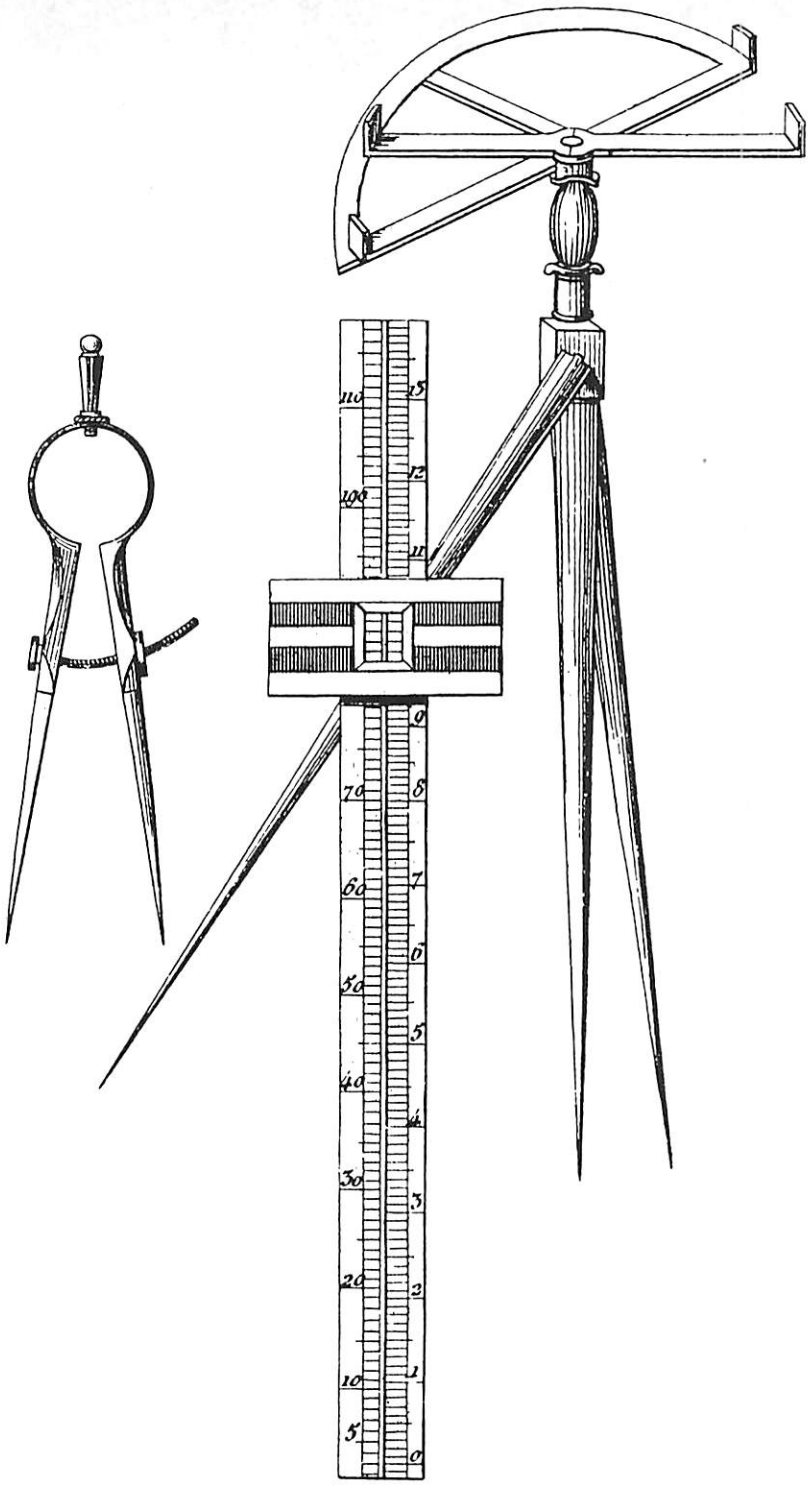
Richard Smith, who is nearing completion of his master's degree in marine biology, is already a professional biological consultant, applying the skills he developed as a Sea Grant trainee. Smith worked with Richard Ford at San Diego State University in studies of the temperature tolerances of marine invertebrates near coastal power plants. His work involved the installation and maintenance of ecological testing apparatuses, performance and analyses of long- and short-term ecological projects; measurement of environmental data; computer operation; and extensive research diving, which included animal collection, biological surveys, and use of environmental collecting devices.

Ralph Kingsbury worked with Emanuel Epstein at UC Davis in salt-tolerant crop research for several years while earning his PhD degree. Because of the nature of the traineeship, he was able to conduct original and independent research that resulted in a significant contribution to science and agriculture. He is now employed by the International Plant Research Institute, Inc., in San Carlos, California.

Trainees in Technology

At UC Davis, Carlos Zuritz worked with Paul Singh on development and design of the squid-processing machine. His plans, after he completes his degree program, are to return to his home in Argentina where he intends to work in the seafood processing industry. During his traineeship, Zuritz completed a comprehensive bibliographical review on the subject of seafood process engineering, with emphasis on the physiological components of fish. This research, along with the courses he took on advanced fluid engineering mechanics, heat transfer and process unit operations, among others, have prepared him to make a useful contribution to the seafood processing industry in his native homeland.

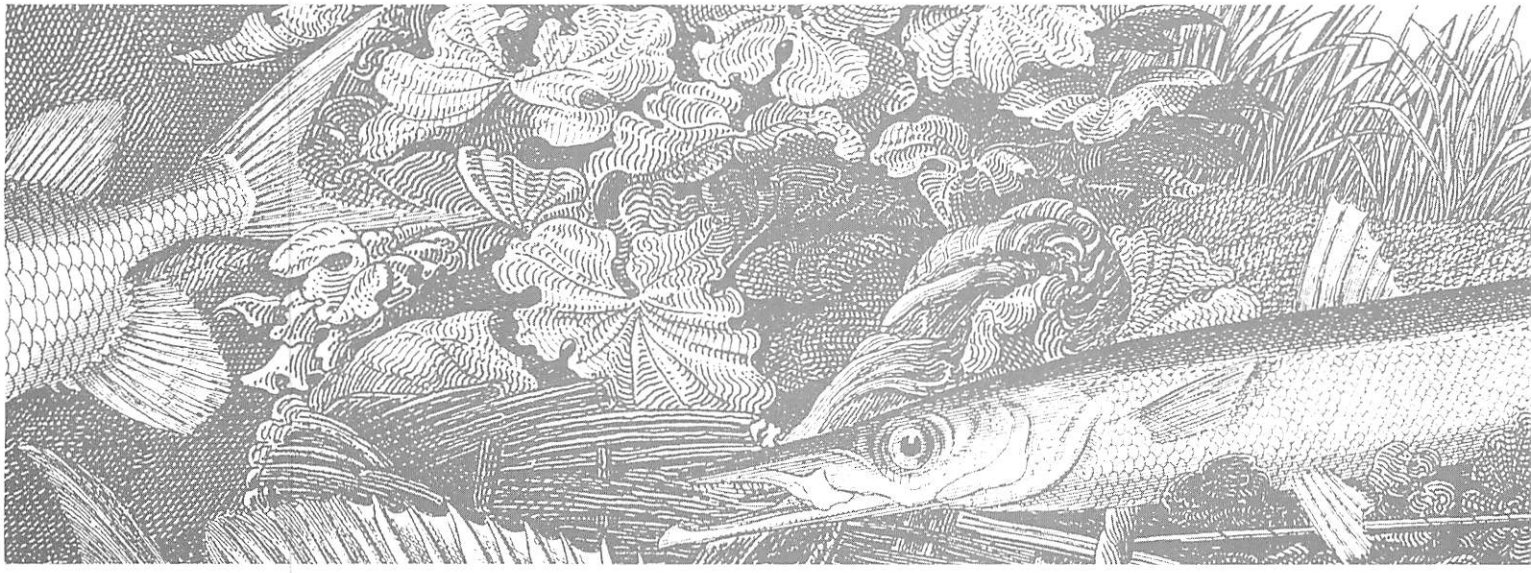
Weng-Gen Liao is working toward a PhD degree in structural engineering under Joseph Penzien at UC Berkeley. As a Sea Grant trainee, he learned how to go about solving a significant problem in offshore engineering. Specifically, he applied principles he had learned in structural mechanics courses to the problem of structure-fluid interaction. He also learned the techniques of data acquisition and processing by analysis of time series. All of these educational experiences, he feels, are good preparation for a career in the field of offshore engineering.



Epilogue

In a time of declining terrestrial resources and of a growing national interest in development of domestic natural resources, Sea Grant's contribution has been significant. Its success thus far, during a relatively brief existence, can be attributed to the strong partnership it has forged among universities, industry, and government.

Sea Grant's contribution will continue to depend upon people with innovative ideas working together to convert those ideas into practical application in industry and government.



Sea Grant Program Summary

Project Title (Project Number, Project Leader)	FY78	FY79	FY80
MANAGEMENT			
Program Management (M/A-1, Sullivan)	O	O	O
Program Planning and Development (M/P-1, Sullivan)	O	O	O
EDUCATION			
Sea Grant Trainees (E/G-2, Sullivan)	O	O	O
Marine Education: Undergraduate Independent Research (E/UG-1, Doyle)	O	C	--
Development of a Prototype Course in Marine Policy (R/NP-1-8D, Sorensen)	--	N/C	--
A History of the Santa Barbara Channel (E/UG-2, Talbott)	--	--	N
Ocean Engineering and the Future: Long-Range Planning A Graduate Seminar (E/G-8, Webster/Tulin)	--	--	N/C
ADVISORY			
Ocean Education for the Public (A/PE-1, Wilkie et al.)	O	O	O
Marine Advisory Program (A/EA-1, Cummings)	O	O	O
Publications and Public Advisory Services (A/P-1, Frautschy)	O	O	R
Communications, Publications, and Public Advisory Services (A/P-1, Sullivan)	--	--	R
The Golden Gate Marine Center (R/NP-1-9D, Caya)	--	--	N/C
Mobile Marine Science Outreach Program (R/NP-1-9J, Bauer)	--	--	N
COASTAL RESOURCES RESEARCH			
Coastal Wetlands Management: Biological Criteria (R/CZ-33A, Holmes et al)	O	C	--
Coastal Wetlands Management: Effects of Disturbance on Estuarine Function (R/CZ-33C, Zedler/Mauriello)	O	C	--
Coastal Wetlands Management: Opening of Coastal Lagoons by Sand Fluidization (R/CZ-33D, Inman/Nordstrom)	C	--	--
Thermal Variability in Coastal Waters in the Southern California Bight (R/CZ-31, Winant)	O	C	--
Internal Waves Over Shelf and Canyon (R/CZ-32, Cox)	C	--	--
Development of Interpretive Methods and Materials for Marine Parks in Northern California (R/MR-1, DeMartini)	C	--	--
Geological and Historical Analysis of Coastal Zone Environmental Hazards and Liability for Losses Caused by Them (R/CZ-43, Shepard/Hildreth)	N	C	--
Kelp Bed Mariculture and Resource Management (R/A-16, Neushul et al.)	C	--	--
Kelp Forest Ecology of Central California (R/A-16C, Pearse)	O	C	--
Coastal Governance 1977-1978: First Steps in Implementing California's 1976 Legislation (R/CZ-41, Lee/Scott)	N/C	--	--
Coastal Zone Management: Methods for Plan Development, Evaluation and Monitoring of Local Programs (R/CZ-42, Dickert)	N/C	--	--
Wetlands Management in Coastal Zone Planning: A Prototype Framework for Relating Natural Science and Land-Use Planning (R/CZ-45, Dickert/Nybakken)	--	N	C
An Experimental Program to Develop Methods for Kelp Bed Expansion and Enhancement (R/CZ-46, Neushul/Coon)	--	N	C
A Study of the Entrance Problems at Humboldt Bay (R/CZ-47, Isaacs/Kerstetter)	--	N	C
Coastal Governance in California, with Special Reference to State-Local Collaborative Planning (R/CZ-49, Lee/Scott)	--	N/C	--

Project Title (Project Number, Project Leader)	FY78	FY79	FY80
COASTAL RESOURCES RESEARCH (continued)			
Feasibility Study of *in situ* CPR Using SCUBA-ERR (Emergency Regulator Resuscitation) and Closed-Chest Cardiac Massage (R/NP-1-8A, West)	--	N/C	--
Dioxins--Historical Record of Fluxes in Lake Michigan Sediments (R/NP-1-8C, Goldberg)	--	N/C	--
Coastal Wetlands Management: Review of and Recommendations about Local Plans (R/NP-1-8E, Onuf)	--	N/C	--
Methods of Increasing Diver Effectiveness Through CO_2 Absorbers and Decompression Computers (R/NP-1-8F, Mote)	--	N/C	--
Wetlands Restoration Option Study--Ballona Wetlands (R/NP-1-8G, Clark)	--	N/C	--
Recreation Transportation Analysis for Coastal Planners: A Technical Report on the Methods Used in California (R/NP-1-8H, Kanafani)	--	N/C	--
Feasibility Study to Assess the Development of an Applied Marine Research Directory (R/NP-1-8K, Sorensen)	--	N/C	--
Acoustic Tomography (R/CZ-P-1, Munk et al.)	--	N/C	--
Coastal Wetlands Management: Restoration and Establishment (R/CZ-51, Zedler)	--	--	N
Coastal Wetlands Management: Application of Biological Criteria (R/CZ-52, Onuf et al.)	--	--	N
Investigation of Coastal Bluff Retreat for the Trinidad Headland Area of Northern California (R/CZ-53, Carver)	--	--	N/C
Analysis of Coastal Ocean Mixing Models (R/CZ-48, List/Morgan)	--	--	N
Phosphorites along the Central California Continental Margin (R/CZ-54, Mullins)	--	--	N
Evaluation of the Mad River Estuary (R/NP-1-9C, Crandell)	--	--	N/C
The Role of Nutrients in Supporting Phytoplankton Productivity in Humboldt Bay (R/NP-1-9E, Pequegnat)	--	--	N/C
Sea Cliff Erosion and Beach Accretion Along San Onofre State Park and Camp Pendleton, San Diego County, California (R/NP-1-9G, Shepard)	--	--	N/C
Aerial Survey of Humboldt Bay, California (R/NP-1-9I, Stork/Costa)	--	--	N/C
AQUACULTURE RESEARCH AND DEVELOPMENT			
Protective Measures for Shellfish Aquaculture (R/A-15, Steenbergen)	C	--	--
California Aquaculture Law (R/A-13, Bowden)	C	--	--
The Development of the Science and Technology of Aquaculture (R/A-19, Hand)	C	--	--
Use of Thermal Effluent in the Culture of Crustacea and Fishes (R/A-21, Van Olst/Ford	O	O	--
Biochemical and Genetic Control Applied to the Critical Stages in Culturing Abalone (R/NP-1A, R/A-25, Morse)	C	--	--
Aquaculture of the Purple-Hinge Rock Scallop (R/R-7, R/A-24, Phleger/Leighton)	C	--	--
Carrageenophyte Cultivation, Genetics, Population Dynamics, and Development of Agar Substitutes (R/A-17, Doyle et al.)	C	--	--
Genetic Program for Improvement of Carrageenan Production in *Gigartina* (R/A-17B, West)	O	C	--
Toward Seawater-Based Crop Production (R/A-22, Epstein)	O	C	--
Astaxanthin from Yeast for Fish Diets (R/R-11, R/A-27, Lewis)	C	--	--

Project Title (Project Number, Project Leader)	FY78	FY79	FY80
AQUACULTURE RESEARCH AND DEVELOPMENT (continued)			
Control of Reproduction in the Lobster (R/NP-1-7B, Talbot)	N/C	--	--
Development of the Science and Technology of Crustacean Aquaculture (R/A-28, Clark/Hand)	--	N	O
Control of Reproduction in the Decapod Crustaceans (R/A-29, Talbot)	--	N	O
Studies to Refine Hatchery and Ocean Rearing Methods for the Purple-Hinge Rock Scallop (R/A-31, Phleger/Leighton)	--	N	C
Biochemical and Genetic Control of Critical Physiological Processes in Molluscan Life-Cycles: Basic Mechanisms, Water-Quality Requirements, and Sensitivities to Pollutants (R/A-32, Morse)	--	N	C
Aquaculture of Red Algae (R/A-34, Abbott)	--	N	C
Culture of Marine Bivaves: Effects of the Uptake of Amino Acids (R/A-33, Stephens)	--	N	O
An Exploratory Study of the Vegetative Propagation of Benthic Marine Algae (R/A-37, Gibor/Neushul)	--	N	O
Investigations of Population Genetic Structure in Abalones (R/NP-1-8B, Hedgecock/Morse)	--	N/C	--
Procurement of Wildstock Sturgeon (R/NP-1-8J, Clark/Doroshov)	--	N/C	--
Protective Measures Against *Fusarium* Disease in Shrimp (R/A-38, Steenbergen/Lightner)	--	--	N
Assessment of Sperm-Egg Interactions During Fertilization and Hybrid Formation of California Abalones (R/A-39, Vacquier)	--	--	N
Food and Fiber from Seawater, Sand, and Solar Energy (R/A-42, Epstein)	--	--	N
Regulation of the Production of Dormant Cysts by the Brine Shrimp, *Artemia salina*, and Factors Influencing the Viability of Such Cysts (R/A-41, Crowe)	--	--	N
Pathology and Bacteriology of a Disease of Crustaceans Caused by a Marine Bacterium (R/NP-1-9H, Baumann/Bowser)	--	--	N/C
Ova Development Success as a Function of Temperature and Delay in Fertilization Post Spawning (R/NP-1-9L, DeMartini)	--	--	N/C
FISHERIES RESEARCH AND DEVELOPMENT			
The California Market Squid Fishery R/F-15, Recksiek/Frey)	C	--	--
Optimal Leasing Agreements for Marine Resource Development (R/F-35, Quirk/Lewis)	C	--	--
The Effects of Food Availability on the Growth and Survival of California Jack Mackerel Larvae (R/F-44, Mullin/Lasker)	O	O	C
An Ethnography of the San Pedro Wetfish Fishing Fleet (R/NP-1U, Velez)	C	--	--
Coordinated Management of the Pacific Coast Salmon Fisheries and the Implications of Extended Jurisdiction (R/F-24, R/F-31, Moore et al.)	C	--	--
Protective Immunization of Anadromous Salmonids against *Aeromonas salmonicida* and *Vibrio anguillarum* (R/F-29, Kerstetter)	C	--	--
Development of a Mechanism to Allow Release of Dungeness Crabs from Lost or Abandoned Pots (R/F-27, Jolly)	C	--	--
Endocrinology of Salmon Smoltification and Adaptation to Seawater (R/F-25, Bern)	C	--	--

Project Title (Project Number, Project Leader)	FY78	FY79	FY80
FISHERIES RESEARCH AND DEVELOPMENT (continued)			
Comparative Analysis of the Social and Political Systems of the Tuna Fleets of San Diego and Ensenada (R/F-30, D'Andrade/Bailey)	C	--	--
Development of Multispecies Management for Kelp Bed Resources with an Emphasis on Sea Urchins (R/F-36, Tegner)	N	O	O
Improved Marine Food Products and Marine Food Technology (R/F-32, Brown)	N	O	C
Amine Toxicity of Fish Products (R/F-43, Bjeldanes)	N	C	--
Design and Development of a Squid Processing Machine (R/NP-1J, R/F-33, Singh)	N	O	C
Bioconversion of Chitin Wastes (R/F-34, Carroad)	N	O	C
An Economic Study of the U.S. Pacific Albacore Jig Boat Fishery (R/F-38, Holt)	N/C	--	--
Santa Barbara Inshore Partyboat Fishery: Emphasis on the Olive Rockfish (R/F-39, Ebeling)	N/C	--	--
Re-establishment of Anadromous Fishes in Southern California (R/F-42, Van Olst/Ford)	N/C	--	--
A Multispecies Bioeconomic Fisheries Model under Uncertainty (R/F-37, Just)	N/C	--	--
Experimental Abalone Enhancement Program (R/NP-1-7A, Tegner)	N/C	--	--
Limited Entry in the California Abalone Fishery: A Longitudinal Analysis (R/NP-1-7C, Cicin-Sain/Moore)	N/C	--	--
Endocrinology of Normal and Abnormal Salmon Smoltification and Adaptation to Seawater (R/F-45, Bern)	--	N	O
Artificial Imprinting of Chinook Salmon in a Multispecies Hatchery (RF-46, Hassler)	--	N	C
Experimental Abalone Enhancement Program (R/F-47A, Tegner)	--	N	O
Experimental Abalone Enhancement Program (R/F-47B, Connell)	--	N	C
Sensory and Behavioral Effects of Pollutants on the Crab and Lobster Fishery (R/F-48, Case)	--	N	C
Genetic Improvement of a Chitinase-Producing Microorganism (R/F-50, Ogrydziak)	--	N	C
Coordination of Federal, Regional, and State Policies for Managing Marine Fisheries (R/F-51, Moore/Wyner/Cicin-Sain)	--	N	C
Economics of Fisheries and Aquaculture Development (R/F-52, Johnston/Hand)	--	N	O
An Economic Analysis of the California Abalone Fishery (R/F-53, Deacon)	--	N	O
Economics of Swordfish Vessel Participation and Catch (R/F-54, Holt)	--	N/C	--
Assessment of Aging Techniques and Their Application to Elasmobranch Fisheries (R/F-57, Cailliet)	--	--	N
Multiple Species Utilization of the Herring Eggs-on-Seaweed Fishery (R/F-58, Abbott)	--	--	N
Storage Stability of the Purple-Hinge Rock Scallop, *Hinnites multirugosus* (R/F-59, Josephson)	--	--	N/C
Demographic Analysis of Porpoise Populations Subject to Time-Varying Tuna-Net Mortality (R/F-56, Goodman)	--	--	N
Economics of Multipurpose Fishing Vessels: Assessment and Policy (R/F-61, Holt)	--	--	N

Project Title (Project Number, Project Leader)	FY78	FY79	FY80
FISHERIES RESEARCH AND DEVELOPMENT (continued)			
An Economic Analysis of the Gains from Joint Management of Fishery Stocks (R/NP-1-9A, Johnston/Howitt)	--	--	N
Feasibility of Mechanical Skinning of Blue Shark (R/NP-1-9B, Singh/ Katz)	--	--	N/C
Multispecies Aspects of CalCOFI 1955-59 Ichthyoplankton Data: A Source of Information for Variations in California Current Fisheries Resources (R/NP-1-9F, Loeb)	--	--	N
NEW MARINE PRODUCTS			
Antiviral compounds from Algae (R/MP-12, Vedros)	C	--	--
Marine Plants as a Source of Insect Growth Inhibitors (R/MP-14, Crews)	O	O	C
Pharmacological Evaluation Program (R/MP-15, Jacobs)	N	O	C
Marine Natural Products for Pharmacological Evaluation (R/MP-16, Faulkner)	N	O	C
New Agricultural Chemicals from Marine Organisms (R/MP-18, Fenical)	N	O	C
Antileukemia Compounds from the Brown Seaweed *Dictyota* (R/MP-17, Fenical)	N/C	--	--
Neuronal Blocking Substances from California Gobiidae (R/MP-19, Fuhrman)	--	N/C	--
Antiviral Compounds from Algae (R/MP-20, Vedros)	--	N	C
ENERGY			
Stray Electrical Current Hazards to Prestressed Concrete Construction in Seawater (R/E-12, Cornet)	C	--	--
Earthquake Loading on Large Offshore Structures in Deep Water: A Study for the Correlation of Analytic and Physical Models (R/E-14, Wiegel)	O	R	--
Seismic Hazards to the Development of Offshore Oil Resources (R/E-15, Prothero)	O	C	--
Power from Salinity Gradients (R/NP-1B, R/E-16, Isaacs)	C	--	--
Studies on Thermophilic Microorganisms Located from Undersea Hot Springs, Electric Power Plant Condensers and Ships' Heat Exchangers (R/NP-1P, R/E-21, Isaacs)	C	--	--
Placement of Underwater Mass Concrete by the Tremie Method (R/NP-1Q, Gerwick)	C	--	--
Marine Vehicle Safety Analysis (R/E-17, Webster)	C	--	--
Side-Scan Sonar Mapping and Computer-Aided Interpretation of the Geology of the Santa Barbara Channel (R/E-18, Luyendyk/Simonett)	N	O	C
Nearshore Wave Power Source (R/E-19, Seymour)	N/C	--	--
Power Generator Inertially Coupled to Seawaves (R/E-20, Lee/Manalis)	N/C	--	--
A Condensing Turbine for the Distillation of Seawater (R/E-22, Manalis/Lee)	--	N	C
Temperature Tolerances of Benthic Marine Invertebrates and Their Relationship to Regulatory Requirements for Thermal Effluent (R/E-23, Ford/Van Olst)	--	N	C
The Politics and Policy Implications of Deep Seabed Mining: U.S. Options (R/NP-1-8I, Mann)	--	N	O
OCEAN TECHNOLOGY			
Bioelectric Toxicity Assaying (Phase I) (R/NP-1-9M, Anderson)	--	--	N

Project Title (Project Number, Project Leader)	FY78	FY79	FY80
MARINE AFFAIRS			
A Preliminary Survey of the impact of Limited Entry Regulations upon California Fishermen (R/NP-1-9K, Petterson/Bailey)	--	--	N/C
A Preliminary Investigation of Indochinese Refugee Adaptation to the Monterey Bay Fishing Industry (R/NP-1-9N, Orbach)	--	--	N
The Deep Seabed Hard Mineral Resources Act: Was There a Need to Precede the Development of International Law Through U.S. Unilateral Action? (R/NP-1-9"O", Lynch)	--	--	N/C
RAPID RESPONSE			
Rapid Response Capability (R/NP-1, Sullivan)	O	O	O

C = Completed Project; N = New Project; O = Ongoing Project;

R = Restructured Project; T = Terminated Project

Activity Budget, 1979-1980

	NOAA Grant Funds	Matching Funds
Marine Resources Development		
Aquaculture	$425,425	$474,148
Living Resources	259,742	223,450
Mineral Resources	18,403	34,600
Marine Biomedicinals and Extracts	164,456	82,716
Socio-Economic and Legal Studies		
Marine Economics	4,420	8,307
Socio-Political Studies	30,564	20,397
Marine Technology Research and Development		
Ocean Engineering	58,128	59,053
Resources Recovery and Utilization	69,465	66,110
Marine Environmental Research		
Research and Studies in Direct Support of Coastal Management Decisions	182,229	81,049
Ecosystems Research	100,873	70,272
Pollution Studies	39,855	49,056
Environmental Models	26,052	9,342
Marine Education and Training		
College Level	12,038	9,808
Other Education	360,356	50,600
Advisory Services		
Extension Programs	495,631	249,555
Other Advisory	158,584	112,292
Program Management and Development		
Program Administration	236,270	200,384
Program Development	197,509	46,546
TOTAL	**$2,840,000**	**$1,847,685**

Matching Funds Sources 1979-80

Aquarium-Museum Docents	25,627
Bristol-Meyers	3,930
California Institute of Technology	1,781
Counties: Monterey, San Diego, San Francisco, San Luis Obispo, San Mateo, Santa Barbara and Sonoma	78,449
Donations	71,553
Foundation for Ocean Research	875
Humboldt Bay Fishing Association	300
Humboldt State University	29,758
Humboldt State University Foundation	2,757
Marine Colloids	34,380
San Diego Gas & Electric	25,790
San Diego State University	82,012
San Diego State University Foundation	2,854
San Jose State University/Moss Landing Marine Laboratories	47,939
Stanford University	27,517
State of California:	
California Resources Agency	392,500
Department of Fish and Game	113,293
Union Oil	3,561
University of Arizona	4,634
University of California	895,119
University of North Carolina	3,056

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James J. Sullivan, Chairman
Program Manager
Sea Grant College Program
A-032
University of California
La Jolla, California 92093

Victor C. Anderson
Deputy Director
Marine Physical Laboratory
P-001
University of California, San Diego
La Jolla, California 92093

William Doyle
Associate Director
Insititute of Marine Resources, and
Director, Center for Coastal Marine Studies
University of California
Santa Cruz, California 95064

Joy B. Zedler
Associate Director
Center for Marine Studies
San Diego State University
San Diego, California 92181

Jeffery Frautschy
Deputy Director
Scripps Institution of Oceanography
A-010
University of California, San Diego
La Jolla, California 92093

Cadet Hand
Director
Bodega Marine Laboratory
P. O. Box 247
Bodega Bay, California 94923

Robert Holmes
Associate Director
Institute of Marine Resources
University of California
Santa Barbara, California 93106

Bernard Schweigert
Associate Director
Institute of Marine Resources, and
Chairman, Department of Food
Science and Technology
University of California
Davis, California 95616

George Shor
Professor
Marine Physical Laboratory
A-005
University of California, San Diego
La Jolla, California 92093

Robert Thompson
Professor of Oceanography and
Sea Grant Coordinator
Humboldt State University
Arcata, California 95521

Ellen Weaver
Professor of Biological Sciences
San Jose State University
San Jose, California 95192

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